50.7 ABBOTT, EM*; AZIZI, E; Univ. of California, Irvine; *emily.m.abbott@gmail.com*

The effect of muscle relaxation rate on tendon recoil during energy dissipating tasks

Series elastic elements, such as tendons and aponeuroses, can amplify muscle power, minimize energy consumption and limit injury susceptibility. Specifically, during energy dissipating tasks, muscles initially store energy in tendons before recoil of the tendon stretches the fascicles as muscle force declines. This mechanism is thought to reduce the rate of stretch directly applied to a muscle fascicle and may function to protect the muscle from stretch−induced damage. We hypothesized that the rate of muscle relaxation determines the rate of tendon recoil. Previous studies have shown that the rate of muscle relaxation can vary as a function of temperature as well as muscle fiber type composition. Here, we used a temperature manipulation protocol in an *in vitro* muscle−tendon preparation to examine how relaxation rate alters the rate at which tendons recoil and subsequently stretch the muscle fascicles. We measured muscle fascicle lengths by instrumenting the plantaris muscles of *Rana catesbeiana* (bullfrog) with sonomicrometry crystals. MTU force and length were measured by a servomotor. To determine the twitch kinetics, we characterized the rate of force development and relaxation during twitches at 10, 20 and 30ºC. The MTU was also actively lengthened at the various temperatures with a 50ms tetanic stimulation and a simultaneous 100ms stretch. As expected, the rate of force development and relaxation increased with increasing temperature. We also observed that the rate of tendon recoil correlated positively with rising temperature during eccentric contractions. These data imply that factors that alter relaxation rate can influence the rate of fascicle stretch in a muscle tendon unit and thus alter the likelihood of muscle damage. Supported by NSF grant 1051691.

P2.8 ABBOTT, J.*; VANLEUVEN, A.; SKOPEC, M.; Weber State University; *abbotjames@gmail.com*

Caching behavior of non−food items in woodrats (Neotoma albigula)

Woodrats (genus *Neotoma*) are commonly referred to as packrats due to their characteristic behavior of caching both food and non−food objects from their surroundings. We conducted a series of experiments to evaluate the caching behavior of non−food items in *Neotoma albigula*. Trials were run to see if the woodrats showed a preference for brilliance, color or scent of a non−food object, jingle bells. The brilliance trial investigated whether woodrats prefer shiny over dull objects, as anecdotal evidence suggests that woodrats prefer shiny objects and sometimes will even trade dull objects for shinier ones. Woodrats were placed in cages that had two external compartments where jingle bells were offered. Jingle bells were painted with either a shiny or matte finish of the same color. The woodrats showed no preference for bells exhibiting more brilliance which indicates that woodrats do not necessarily prefer shiny objects. In the color trials, the woodrats were given access to gold or blue jingle bells. The blue color resembled the juniper berries that woodrats consume, and preference for the blue−colored bells may be evidence that they cache non−food items that are similar in color to food items. The woodrats, however, showed no preference for color and cached blue and gold bells at an equal rate. Scent trials were conducted to determine if woodrats potentially raid conspecific's caches. The woodrats were given access to jingle bells scented by a same or opposite sex woodrat or unscented jingle bells. The woodrats showed no preference between the scented and unscented bells, however, woodrats in the scent trials cached significantly fewer bells overall than those in the brilliance or color trials suggesting that woodrats may not be raiding conspecific's caches.

125.1 ABOLINS−ABOLS, M*; KETTERSON, E D; Indiana University, Bloomington; *mabolins@indiana.edu*

Shift in a life history trade−off linked with change in hormonal cross−talk

Perhaps the most fundamental life history trade−off is that between reproduction and self−maintenance. This trade−off is mediated by the interaction of two major endocrine systems, the hypothalamic−pituitary−gonadal (HPG) axis, which regulates reproduction, and the hypothalamic−pituitary−adrenal (HPA) axis, which regulates metabolism and the stress response. Environmental change may alter optimal allocation of resources to reproduction and self−maintenance, shifting the trade−off, thus giving rise to selection on the interaction of the HPA and HPG axes. Recent independent colonization events of an urban environment by the typically mountain−breeding Oregon junco (*Junco hyemalis thurberi*) in California has dramatically altered timing of breeding and stress ecology, resulting in increased allocation to reproduction and reduced response to stressors. We investigated the direction and strength of the interaction between the HPA and HPG axes in two locations of recent independent montane−urban colonization events. We injected wild birds with corticotropin releasing hormone (CRH), a major activator of the HPA axis, and measured corticosterone. We then injected birds with of gonadotropin releasing hormone (GnRH), a major activator of the HPG axis, and measured testosterone. We will compare and contrast findings from the two city−mountain comparisons and show that in at least one colonization event, CRH negatively affects the ability of birds to release testosterone in the mountain population but not in the city population, indicating greater sensitivity to stressors on reproduction in the mountain population. Interestingly, corticosterone and testosterone are positively, not negatively, correlated in both populations. We conclude that hormonal interactions are plastic, complex, and reflective of environmentally induced changes in life−history trade−offs.

123.7 ABRAMYAN, J*; CHENG, J; RICHMAN, JM; University of British Columbia, UBC; *abramyan@dentistry.ubc.ca*

Comparative studies on the ontogeny of the primary palate and nasal cavities in birds and mammals

A critical period in craniofacial ontogeny involves the proper development of the primary palate and nasal cavities. Nasal cavities initiate as external nasal pits which grow dorsally and connect with the oral cavity via paired choanae. However, this developmental process has diverged between mammalian and reptilian (including birds) embryos. A key characteristic of choana development in mammals is the presence of a transient oronasal membrane which initially separates oral and nasal cavities and subsequently ruptures during developmental progression. The breakdown of this membrane is essential for respiration and ultimate survival. Interestingly, the presence of this membrane in non−mammalian amniotes is still a contentious subject in the literature. This is compounded by the scarcity studies of primary palate formation in reptiles. In this study, we used optical projection tomography and histology to obtain 3D reconstructions of the nasal cavities and associated choanae in chicken and mouse embryos. We found that avian embryos do not form an oronasal membrane. Instead, the outgrowing frontonasal and maxillary processes leave a groove between them which connect the oral and nasal cavities. Furthermore, we measured relatively lower cellular proliferation in the mesenchyme at the base of invaginating groove and higher proliferation within the outgrowing processes. The groove remains while the facial processes outgrow and subsequently fuse, leaving a choanal tube connecting the external nares to the oral cavity. These results, along with a similar choanal development described in amphibians, suggest that the formation of a groove is the basal condition in vertebrates and that mammals have derived a divergent ontogenetic process for the development of the primary palate and connection of external nares to the oral cavity.

23.7 ACKERLY, KL*; WARD, AB; McGill University, Adelphi University ; *kerri.ackerly@mail.mcgill.ca*

The role of vertebral morphology in a fish eat fish world

Many selective factors work together to determine the optimal body morphology to maximize swimming performance in fishes. The vertebral column is one of the most important morphological elements in determining maximum swimming performance. Variation in vertebral morphology has been shown to significantly impact escape swimming performance, leaving individuals more susceptible to predation. Our previous work in zebrafish (*Danio rerio*) has shown that individuals with fewer vertebrae and a higher vertebral ratio have decreased escape response performance. This performance variation is a result of a decreased number of intervertebral joints present within individuals with a lower number of vertebrae, which decreases the range of axial skeleton flexion. The evaluation of the effects of morphology on performance and the subsequent effect of this performance on fitness is crucial for determining the adaptive nature of these various morphologies. We are currently working to make the connection between the ecological importance of vertebral variation and identify the selective factors behind it. To do this, we are exposing populations of zebrafish with various vertebral morphologies to native predators, needlenose garfish (*Xenentodon cancila*), to identify selective predation for certain vertebral morphologies. Comparison of vertebral morphology between the zebrafish that survived the trials and those consumed by the predators revealed temperature specific selective predation for individuals of different vertebral morphologies. These findings highlight the multifaceted nature of predator−prey interactions and the predator−specific nature of selection, while also giving insight into possible selective pressures that these and other ectothermic aquatic vertebrates may face as new threats arise in a rapidly changing climate.

S4.2−2 ADAMO, Shelley A; Dalhousie Univ., Halifax; *sadamo@dal.ca*

Stress/immune interactions: A pathological relationship or an adaptive response to adverse conditions?

Both the stress response and immune response defend animals against organisms that can cause catastrophic declines in fitness. When resources are abundant, having these two systems work synergistically with each other would seem adaptive. However, negative interactions between the stress and immune responses are common and phylogenetically widespread even under ad lib conditions. It seems unlikely that these negative interactions are simply pathological as they are partly driven by stress hormone effects on immune cells. In crickets (Gryllus texensis), the stress neurohormone octopamine shifts molecular resources towards flight−or−fight (e.g. the protein apolipophorin III), while at the same time altering immune cell activity to minimize the impact of this molecular theft (e.g. increased immune cell phagocytosis). There is also a shift away from immune responses that generate high levels of reactive molecules (e.g. phenoloxidase activity and nitric oxide production) and a shift towards responses that rely on other mechanisms such as lysozyme−like activity. Both the stress response and immune response increase the level of lipid peroxides in the hemolymph (blood) of G. texensis, suggesting increased oxidative stress. Reducing the production of reactive molecules by the immune system during an on−going stress response probably reduces immunopathology due to oxidative stress. Although these stress hormone−induced changes to immune function result in an overall decline in resistance to disease, without them the decline in disease resistance would be steeper and immunopathology would be greater when conditions are suboptimal.

S7.1−3 ADAMO, Shelley A*; KOVALKO , Ilya; STOLTZ, Don; Dalhousie Univ., Halifax; *sadamo@dal.ca*

Love sick: a viral aphrodisiac in the cricket Gryllus texensis

We identified the iridovirus CrIV/IIV−6 as a pathogen of the cricket Gryllus texensis using electron microscopy (EM) and polymerase chain reaction (PCR) analysis. Electron microscopy (EM) showed that the virus attacks the fat body, an organ important for protein production, immune function and lipid storage. During infection the fat body hypertrophies, but egg production withers, leaving the lateral oviducts empty of eggs. The females are effectively sterile. EM of the testis of infected males suggests that the testis is not invaded by the virus, although sperm taken from the spermatophores of infected males shows little or no motility. Nevertheless, males and females continue to mate when infected. In fact, infected males are quicker to court females than uninfected controls. The virus benefits from the continued sexual behaviour of its host; transmission studies show that the virus can be spread through sexual contact. Typically infected crickets court less than controls, but sickness behaviour (i.e. illness−induced anorexia) is absent in infected crickets. Total hemolymph protein is reduced, as is phenoloxidase activity, suggesting a reduction in immune protein production by the fat body. The behavioural and biochemical evidence suggests that the virus reduces immune/neural communication, increasing the likelihood of its transmission.

129.5 ADDIS, E.A.*; REDING, D.M; SCHWARTZ, T.S.; PALACIOS, M.G.; BRONIKOWSKI, A.S.; Gonzaga University, Luther College, University of Alabama, Birmingham, CENPAT−CONICET, Iowa State University; *addis@gonzaga.edu*

The insulin−like signaling pathway (IIS) as a regulator of life histories in Western terrestrial garter snakes

Western terrestrial garter snakes (*Thamnophis elegans*) living around Eagle Lake, California have evolved two distinct ecotypes, differing in growth, maturation and reproduction rates, lifespan and skin morphology. While these ecotypes nicely conform to life history theory of trade−offs between lifespan and reproductive output, little is known about the underlying mechanisms. Studies in model organisms have hinted at a role of the insulin−like signaling (IIS) pathway in regulating these trade−offs. We raised neonates from birth of both ecotypes under two rearing conditions that differed in thermal availability for 1.4 years. At the end of the rearing period, we tested for differences among four constituents of the IIS pathway in these snakes in response to our 2 x 2 design (ecotype x thermal availability): insulin−like growth factor 1 and 2 (IGF−1 and IGF−2) and associated receptors (IGF−1R and IGF−2R) correlating with growth. We analyzed protein levels of IGF−1 and IGF−2 and mRNA levels of IGF−1, IGF−2, IGF−1R, IGF−2R among the brain, liver, and muscle for significant ecotype, thermal availability and ecotype x thermal availability interactions. The effects of ecotype and treatment varied across tissue types, genes, and protein expression. IGF−1 and IGF−2 mRNA levels were highest in the liver and IGF−1R and IGF−2R mRNA levels were highest in the brain; muscle levels were intermediate. Unexpectedly, both circulating protein and mRNA levels of IGF−2 were higher than those of IGF−1. Birth size (SVL) and sex also affected mRNA and protein levels. In this talk, we will explore the implications of these results.

S4.1−1 ADELMAN, JS; Virginia Tech; *adelmanj@vt.edu*
How radio telemetry and radio frequency identification can help link individual immune responses and disease dynamics in wild animals
Revealing how immunological variation influences pathogen transmission is a fundamental and unifying challenge in disease ecology and ecoimmunology. To meet this challenge, researchers must choose their metrics of immune defense carefully, favoring those most relevant to the pathogens a host faces. Fever and sickness behaviors, including lethargy and anorexia, are whole−organism responses to diverse types of infection, integrating myriad inflammatory immunological signals and processes. As such, the accurate measurement of these responses can help us understand both the benefits and dangers of inflammatory immune defenses (e.g. pathogen clearance versus the potential for immunopathology). Moreover, both anorexia and lethargy can be measured remotely with radio telemetry or radio frequency identification, enabling data collection at fine temporal scales while minimizing handling of animals, the number of captures required, and time in captivity. In this presentation, I will review recent applications of these remote monitoring technologies in ecoimmunology studies, focusing on insights into within−host disease dynamics. I will also propose extended uses of these technologies to directly link variation in responses to infection with pathogen transmission in natural disease systems.

P2.94 ADJERID, K*; KENNY, M; PENDAR, H; HARRISON, J.F.; SOCHA, J.J.; Virginia Tech, Arizona State University; *adjerid@vt.edu*
A test of functional compartmentalization in the grasshopper Scistocerca americana using internal pressure recordings
The open circulatory system of insects is often conceived as a single compartment, especially in species that lack a petiole. However, recent work in grasshoppers shows evidence of possible segmental compartmentalization, suggesting that these insects can actively regulate inter−segmental hydrostatic pressures. Here, we test the hypothesis of functional valving in the coelom by directly measuring hemolymph pressures in two regions of the body in the American grasshopper (*Schistocerca americana*). Pressures were recorded at 100 Hz using two fiber−optic pressure sensors (Samba Preclin 420), separately inserted into the thorax and abdomen of living grasshoppers, while also recording abdominal pumping using an infrared proximity sensor. Our preliminary results indicate substantial variety in pressure patterns. Thorax and abdominal pressures exhibited: 1) near−identical pressure pulses in both segments; 2) correlated pressure pulses of different magnitudes; and 3) completely different pressures. The third pattern suggests that the animal can isolate pressures between segments and perhaps can voluntarily control the onset of pressure release to the other segments. These results lend support to the hypothesis of functional compartmentalization within the grasshopper's coelom, and further demonstrate that such compartmentalization is flexible. This ability to regulate pressures between segments may result from actions of the intersegmental muscles that can compress the exoskeleton against the gut, or conversely, movements of the gut relative to exoskeleton. Supported by NSF 0938047.

65.6 ADKINS−REGAN, E; Cornell University; *er12@cornell.edu*
Endocrinology of Avian Social Behavior
John Wingfield's contributions to our current understanding of avian biology are vast and diverse. This tribute will begin by exploring the links between his research ideas and the work of the members of the Adkins−Regan lab. Next, the importance and impact of his contributions to an understanding of hormones in relation to vertebrate social behavior will be discussed. Finally, some hopes will be shared for future advances of three kinds: discovery of the neuroendocrine mechanisms of avian pairing, improvements in hormone measurement, and a comparative and macroevolutionary understanding of hormone levels.

11.4 ADOLPH, SC; Harvey Mudd College ; *adolph@g.hmc.edu*
Thermal Performance Curves: Modeling and Detecting Patterns of Individual Variation
Thermal performance curves depict how physiological performance varies with temperature. The evolution of performance curves depends on the pattern of selection and on the quantitative genetic basis of individual variation. In principle, we should expect to observe trade−offs in the location of thermal performance curves along the temperature axis. However, phenotypic variation among individuals within a population most commonly occurs in absolute performance (curve height), rather than along the temperature axis (curve location). As a result, phenotypic correlations between performances at different temperatures are almost always positive, even at the coldest and hottest temperatures where we might expect to see trade−offs. Here, I present a model that includes both temperature trade−offs and variation in overall performance within a population. The model shows how trade−offs at temperature extremes can be masked by individual variation in overall performance. The model also makes predictions about the pattern of phenotypic correlations that should be observed under different scenarios of individual variation in performance curves. I then evaluated data on individual performance across temperatures from several species of lizards, frogs and insects. In the majority of cases, performance correlations became weaker as temperature difference increased. This indicates that performance is less tightly coupled at temperature extremes than at similar temperatures; this result is consistent with expectations from biochemistry. I will describe the implications of these findings for detecting trade−offs and for the evolution of physiological performance curves.

66.1 AGOSTA, SJ*; BERNARDO, J; Virginia Commonwealth University, Texas A&M University; *sagosta@vcu.edu*
New macrophysiological insights into old macroecological patterns: energetic constraints on geographic range size in mammals
Geographic range size varies over 12 orders of magnitude in mammals. At macroecological scales, variation in range size is related to body size, which is highly correlated with basal metabolic rate (BMR). In species−rich analyses, the body size−range size correlation is weakly positive. On a log−log scale, the relationship has been described as a triangular constraint space, where small species can have small or large ranges, but as species get larger, they are increasingly restricted to larger ranges. A widely hypothesized mechanism for this pattern is the Energetic Constraint on Minimum Range Size Hypothesis (ECMS): large species have high per capita energy demands and, therefore, require large distributions to avoid demographically−driven extinction. Here, we first present a modified version of the ECMS based on novel analyses of the body size−range size relationship in mammals (n = 3,286). Second, we evaluate the ECMS directly using combined data on body size, basal metabolic rate, range size, phylogeny and latitudinal position of the range for 574 species. We examined energetics in two dimensions: absolute energy demand (BMR) and relative, mass−independent energy demand (MIBMR). Similar to the body size−range size relationship and as predicted by the ECMS, the relationships between range size and BMR and range size and MIBMR were weakly positive and fit into a roughly triangular constraint space, where species with high BMR or high MIBMR are increasingly restricted to larger ranges. Synthesizing our results suggests the mammal species most vulnerable to range size reductions and changes in energy landscapes (e.g., from habitat loss and climate change) are both large−bodied and have supra−allometric MIBMR, but also, small−bodied species with supra−allometric MIBMR are at heightened risk.

25.4 AGUILAR, JJ*; GOLDMAN, DI; Georgia Institute of Technology; *jjaguilar1@gmail.com*
Jumping off flowable ground
Many organism behaviors such as sprinting, jumping and hopping involve impulsive ground interactions. On hard ground, these behaviors can be described as transient bursts of actuation coupled with internal elastic elements to create movement. On flowable ground like granular media, however, the performance of these behaviors changes due to the dynamical ground reaction forces generated by substrate yielding upon foot intrusion. The relationships that govern these forces vary with size and shape of foot, material compaction and speed/acceleration of intrusion; however, we do not have detailed understanding of such interactions. To remedy this, we study the performance of an actuated spring mass robot during vertical jumping on granular media. The robot consists of a linear motor in series with an elastic element coupled to a foot with varied shapes. The robot performs jumps via one−cycle sinusoidal internal movement. We record jump height using a high speed camera, and control the substrate properties using an air−fluidized bed. We systematically vary the forcing frequency (0 to 12 Hz) and the compaction (volume fraction 0.58 to 0.63) and find that, at 8 Hz forcing, there is 743% increase in jump height with only a 5% increase in volume fraction using a 5 cm foot. Including a short, high speed downward push, or "preload", prior to the main sine−wave movement nearly doubles the jump height at high volume fractions. A depth dependent intrusion force model captures some features of the experiment: reduced height compared with hard ground and optimal jumping when forced near mass−spring resonance. However, the model cannot describe how the jump height changes with compaction and foot size, and is unable to match experimental preloaded jump heights, suggesting nontrivial dependence on intrusion kinematics.

44.4 AIDALA, Z*; HAUBER, ME; Hunter College, City University of New York; *zaidala@gc.cuny.edu*
Reproductive consequences of nest rebuilding in the eastern phoebe (Sayornis phoebe)
Nest building is a major behavioral component of avian parental investment, as nests serve to house, thermoregulate, and protect eggs and nestlings from predators. Because nest building is costly in time and energy, reusing an existing nest may increase fitness relative to losing a nest and subsequently having to rebuild it. In a prior study of the eastern phoebe (*Sayornis phoebe*), experimentally induced nest loss between breeding seasons resulted in a shorter breeding season with fewer females initiating second clutches. We investigated the potential breeding impacts caused by nest loss between breeding seasons and between first and second clutches within the breeding season. We experimentally removed phoebe nests prior to and during the 2011 − 2013 breeding seasons in a wild population of eastern phoebes and collected morphological indices of nestling quality throughout the breeding season. Clutch size was not dependent on experimental nest removal treatments. Across years, the likelihood of initiating a second clutch was contingent on the timing of breeding onset such that later first clutch initiation dates resulted in fewer second clutches, irrespective of experimental nest loss or parasitism by the obligate brood parasitic brown−headed cowbird (*Molothrus ater*). Second clutch nestlings had consistently lower growth rates than first clutch nestlings irrespective of treatment group. These data do not support a consistent causal relationship between nest reuse and increased fitness, and instead suggest that female phoebes initiate a second clutch based on the timing of breeding onset. Nonetheless, the results confirm prior conclusions that phoebes may engage in life history tradeoffs between current and future breeding attempts to maximize their future reproductive output.

93.7 AIELLO, B.R.*; IRIARTE−DIAZ, J.; BLOB, R.W.; BUTCHER, M.T.; ESPINOZA, N.R.; MAIN, R.P; ROSS, C.F.; Univ. of Chicago, Clemson Univ., Youngstown State Univ., Clemson Univ., Purdue Univ.; *braiello@uchicago.edu*
Modulation of strain magnitude in the limb bones of tetrapods
Variation in bone strain magnitude can be correlated with variation in duration of the load cycle, load rate, or both. In the feeding system, mammalian mandibular strain magnitude is correlated strongly with strain rate, and only weakly with load duration. The goal of this study was to expand the evaluation of strain magnitude modulation to the tetrapod locomotor system. We performed new analyses of strain data that had been collected from the limb bones of terrestrial vertebrates from a range of tetrapod lineages employing different locomotor habits (frog, turtle, tegu lizard, emu, goats, and opossums). We hypothesized that strain magnitude is correlated with strain rate in limb bones, as in mandibles, and that the modulation of bone strain magnitude primarily by strain rate is therefore a common feature of the bones of all tetrapods. Bivariate correlations across all study taxa and all bones, including the femur, tibiotarsus, and radius reveal that principal strain magnitudes are always significantly correlated with strain rate but usually not correlated with the duration of the load cycle. Furthermore, in multivariate analyses, beta coefficients for load rate were usually twice those calculated for load duration. These results suggest that, across all taxa and all bones studied, variation in strain magnitude is best explained by variation in strain rate and not the duration of the load cycle. In combination with the results from mammalian mandibles, this broad survey across vertebrates suggests that strain modulation by loading rate is a common feature of all vertebrate bone.

6.1 AKANYETI, O.*; YANAGITSURU, Y.R.; LIAO, J.C.; Whitney Laboratory for Marine Bioscience, University of Florida, University of California, San Diego; *otarakanyeti@yahoo.com*

Distributed pressure detectors for underwater robotic locomotion and sensing: insight from direct measurements in swimming trout

Arrays of bio−inspired pressure sensors offer unique sensing capabilities in underwater applications by detecting local pressures around moving platforms such as robots. Two fundamental sensing schemes are: 1) to detect a robot's own motions and provide feedback signals to maintain a desired motion course, and 2) to detect relevant events in the surrounding environment. However, these two sensing schemes are mutually exclusive, given that sensitivity to self−motion typically compromises the ability to sense environmental stimuli. Here we demonstrate that both benefits can be realized by analysing pressure signals from different sensor array subsets. We employed miniature sensors and high−speed video to directly measure the pressure profiles on a freely swimming rainbow trout (*Oncorhynchus mykiss*, n = 6 fish). We were able to detect when the fish rolled, pitched, yawed or changed its depth, by analysing absolute pressure measurements. During steady swimming, the frequency of the sinusoidal pressure differentials between the sensors across the head matched the tail beat frequency. The amplitude of the pressure differentials was around ~20 Pa at swimming velocity of 3 $L\ s^{-1}$. We found that it was possible to filter out self−generated pressures and accurately detect external events simply by analysing pressure differentials instead of absolute pressure measurements. In addition, during steady swimming pressure differentials on the same side of the head were five times smaller than those across the head. Our findings show how the efficient and robust mechanisms of distributed pressure sensing in biological systems can inspire the design of underwater autonomous robots.

68.4 AKRE, K.L.*; JOHNSEN, S.; Duke University; *karin.akre@gmail.com*

Proportional psychophysics and the evolution of behavior: The broad influence of Weber's law

Animal decision−making guides reproduction, foraging, predator avoidance, navigation, aggression, and every area of behavior. Sensory systems that translate physical stimuli into perceived quantities allow animals to make decisions such as choosing the greater amount, matching a given quantity, or recognizing a particular stimulus as meaningful. Frequently, nervous systems use a logarithmic scale to reduce the enormous variation in magnitude of physical stimuli, such that sensory systems notice smaller amounts of change when stimuli are small in magnitude, and larger amounts of change as stimuli increase in magnitude. As a result, animals compare physical quantities using their proportional difference, as described by Weber's law. This proportion−based perceptual and cognitive processing imposes selection on behavioral evolution. We review instances where adherence to Weber's law influences the evolution of behavior, and make predictions about other areas where this is likely to occur. We then discuss the consequences of a Weber−wired brain in a broader context, such as in the evolution of musicality and mathematics.

P2.133 AKUMA, D.C.*; PIERMARINI, P.M.; GILLEN, C.M.; Kenyon College, Gambier OH, Ohio Agricultural Research and Development Center, Wooster; *gillenc@kenyon.edu*

Tissue and developmental expression of three putative Na−coupled cation−chloride cotransporters in Aedes aegypti

We evaluated the expression of three genes encoding putative Na−coupled cation−chloride cotransporters (CCCs) in the mosquito *Aedes aegypti*. Phylogenetic analysis reveals that the protein predicted by VectorBase gene AAEL006180 (tentatively named aeCCC1) groups closely with *Drosophila melanogaster* bumetanide−sensitive Na−K−Cl cotransporter dmNCC69 (CG4357) and shares strong similarity to mammalian Na−coupled CCCs. In contrast, proteins predicted by AAEL009888 (aeCCC2) and AAEL009886 (aeCCC3) group closely with *Manduca sexta* msBSC and *Drosophila* CG31457 and not with aeCCC1. All 3 genes cluster distinctly from mosquito and mammalian K−Cl cotransporters. We quantified expression levels of aeCCC1, aeCCC2, and aeCCC3 using quantitative PCR. Expression of aeCCC1 was similar among whole adults, pupae, and larvae, whereas aeCCC2 was expressed about 35−fold higher in larvae and adults than in pupae. aeCCC3 was predominately found in larvae, with about 500−fold greater expression than in pupae and adults. In adult female mosquitoes, aeCCC1 was expressed most highly in head, with 2.5−fold greater expression than in Malpighian tubules, 4.5−fold greater expression than in hindgut, and 20−fold greater expression than in midgut. In contrast, aeCCC2 was predominantly found in the hindgut of adult females, with more than 200−fold greater expression than in other tissues. In larvae, aeCCC3 was expressed 6,000−fold more highly in anal papillae than in Malpighian tubules. On the other hand, aeCCC1 and aeCCC2 were more highly expressed in larval Malpighian tubules compared to anal papillae. The different tissue and developmental expression patterns of aeCCC1, aeCCC2, and aeCCC3 suggest diverse functional roles for these transporters.

P1.96 ALANAZI, A.; KHALILI, S.; WHALEN, W.; MAGIE, C.R.*; Quinnipiac University, California State University, Fresno; *craig.magie@quinnipiac.edu*

Small GTPases and the cell biology of early development in the cnidarian, Nematostella vectensis

Understanding how morphogenesis is controlled in early−branching metazoans, coupled with comparisons across the animal kingdom, will help clarify the evolution of morphogenetic mechanisms. To this end we are examining the cell biology underlying gastrulation in the sea anemone, *Nematostella vectensis*, which is a member of the Cnidaria and therefore a valuable sister taxon to the Bilateria. Gastrulation strategies require the precise control of cell dynamics, making gastrulation an excellent context in which to study the molecular mechanisms underlying morphogenesis. Gastrulation in *Nematostella* occurs through invagination, though the molecular details underlying this process remain to be elucidated. To this end we are examining the expression and function of a number of small GTPases (including Rho, Rac, and Cdc42) during gastrulation in *Nematostella*. Rho GTPases have been shown to be important regulators of cellular behavior through their effects on a variety of processes, including actin cytoskeletal rearrangement, transcriptional activation, and regulation of cell adhesion. We are currently utilizing a morpholino−based approach to perturb function of these small GTPases, as well as a pharmacological approach to inhibit the function of their downstream effectors. Our data suggest that the molecular mechanisms underlying Rho function in *Nematostella* may be distinct from those in bilaterian taxa.

108.4 ALBA, D.M.*; JEYASINGH, P.D.; TOBLER, M.; Oklahoma State University; *danielle.alba@okstate.edu*

Patterns and ecological implications of intraspecific stoichiometric variation in the livebearing fish, Poecilia mexicana

Ecological stoichiometry (ES) uses the study of elemental mass balance in biological systems to integrate physiology, ecology, and evolutionary biology. A central tenet of ES is that organisms of higher trophic levels have a more tightly regulated ratio of elemental content than that of lower trophic levels. Relatively few studies have tested intraspecific stoichiometric variation that may potentially affect ecosystem processes such as elemental cycling. Here, we studied intraspecific stoichiometric variation in the extremophile live bearing fish, *Poecilia mexicana*, to measure stoichiometric variation in these vertebrate consumers. We measured carbon, nitrogen, phosphorus and sulfur content of somatic tissue using an Elementar microvario cube and modified sulfuric acid digestion method on *P. mexicana* inhabiting sulfidic and non−sulfidic habitats of Tabasaco, MX. We found greater sulfur content in the sulfidic populations as well as variation in carbon, nitrogen and phosphorus content. This supports the existence of intraspecific variation in what has been presumed to be tightly regulated stoichiometric content. Data on nutrient excretion indicate such variation in somatic stoichiometry is ecologically relevant which may affect elemental availability to other trophic levels within ecosystems.

33.3 ALBERTSON, RC*; POWDER, KE; HU, Y; COYLE, KP; ROBERTS, RB; PARSONS, KJ; UMass, NCSU, Univ. Glasgow; *albertson@bio.umass.edu*

Pax3 and the genetic basis of variation in levels and integration of pigmentation in cichlid fishes

Variation in pigmentation type and levels is a hallmark of myriad evolutionary radiations, and biologists have long been fascinated by the factors that promote and maintain variation in coloration across populations. Despite this interest, however, little is known about the underlying genetic basis for continuous variation in vertebrate coloration. We examined this question in cichlid fishes, which offer a vast diversity of pigmentation patterns that have evolved in response to both natural and sexual selection. Specifically, we crossed two divergence species to generate an F2 mapping population that exhibited extensive variation in pigmentation levels and patterns. Our experimental design is unique and robust in that it combines traditional QTL analysis with population genomics, which allowed us to move efficiently from QTL interval to candidate gene. In total, we detected 41 QTL and 13 epistatic interactions that underlie melanophore and xanthophore based coloration. We also identified 2 QTL and 1 interaction for variation in the magnitude of integration among these color traits. This finding is notable as there are marked differences, both within and between species, with respect to the complexity of expressed pigmentation patterns. While certain populations are characterized by more uniform "integrated" color patterns, others exhibit many more degrees of freedom with respect to the distribution of color "modules" across the fins and flank. Our data reveal, for the first time, a genetic basis for this difference. Finally, we provide strong support for several candidate genes underlying these QTL, including *pax3*, a know mediator of vertebrate coloration.

P2.119 ALCOVER, K.C.*; SHISHIMI, G.; COUVILLON, P.A.; Univ. of Hawaii at Manoa; *karlchri@hawaii.edu*

Same−Different Discrimination in Honeybees (Apis mellifera)

Honeybee learning is so similar to that of vertebrates that the basic associative learning principles may be the same invertebrates and vertebrates. Recent research is focused on more complex cognitive phenomena. In two experiments, we explored the ability of honeybees to learn same−different relationships. Individual free−flying bees were trained to visit a laboratory window for sucrose solution, fly back to the hive to unload and return to the window. In Experiment 1, 8 bees were trained in an oddity discrimination. On each visit to the window, the bee found three stimuli, two identical and one different. Choice of the odd stimulus was rewarded with sucrose, and choice of the non−odd stimuli was punished with an aversive solution. The stimuli on each trial were unique and could vary in color, shape, size and pattern. To choose correctly, the bees had to learn the relationship of the stimuli. Performance was better than chance. In Experiment 2, bees were trained in a same−different discrimination. On each visit, the bee found two pairs of stimuli, one same and the other different. For 8 bees in the Same Group, choice of the same pair was rewarded and choice of the different pair was punished. For 8 bees in the Different Group, choice of the different pair was rewarded and choice of the same pair was punished. The pairs on each trial were unique, so to choose correctly, the bees had to learn the relationship of the pairs. Performance was better than chance. The results indicate learning about stimulus relationships which could be interpreted as concept learning.

P2.85 ALLEN, J.J.*; BELL, G.R.R.; KUZIRIAN, A.M.; VELANKAR, S.S.; HANLON, R.T.; Brown University, Providence, RI, Marine Biological Laboratory, Woods Hole, MA, University of Pittsburgh, PA; *Justine_Allen@brown.edu*

Functional morphology of changeable skin papillae in octopus and cuttlefish

Benthic cephalopods are renowned for their adaptive camouflage behavior, including changing the 3−dimensional texture of their skin *via* malleable dermal papillae. We used brightfield, scanning electron and confocal microscopy to study papillae of different shapes, sizes and degrees of extension in six species: cuttlefish *Sepia officinalis* and *S. apama* and octopuses *Octopus vulgaris, Macrotritopus defilippi, Abdopus aculeatus*, and *O. bimaculoides*. Our results suggest two distinct biomechanic mechanisms of papilla extension: muscular hydrostatic movement and flexible tissue buckling. Most papillae are extended by the contraction of two sets of muscles: concentric circular dermal erectors lift the papilla away from the surface of the body while horizontal dermal erectors draw the papilla's perimeter toward its core to determine shape. Retractor muscles attached to the papilla's apex radiate basally toward its periphery; their contraction pulls the papilla flat by drawing the apex down toward the surface of the body while opposing and stretching the circular erectors. In these species, connective tissue infiltrated with mucopolysaccharides assists with structural support. Face ridge papillae in *S. apama* are different: contraction of underlying erector muscles causes buckling of the overlying skin layers, resulting in papilla extension. Flattening is achieved by the contraction of retractor muscles inserted at the edges of the reflective elements. In this species, leucophores are embedded in mucopolysaccharide−rich connective tissue, which contributes structural support. Study of papillae in the many so far unexamined species of cuttlefish and octopuses might reveal additional methods of soft tissue actuation.

P3.41 ALLEN, J.D.*; ESQUELA−KERSCHER, A; College of William and Mary, Eastern Virginia Medical School; *jdallen@wm.edu*
Parasite Pal: A Rare Occurence of Human Infection by Gongylonema pulchrum
We describe a rare case of human infection by the nematode *Gongylonema pulchrum*. The parasite was isolated from the oral cavity of a resident of Williamsburg, Virginia who was serendipitously trained as an invertebrate biologist. Following isolation of the worm, we verified the identity of the parasite as *Gongylonema* through both morphological and molecular genetic approaches. Our data provide the first genetic confirmation of infection by this genus of nematode in humans. We highlight here both the occurrence of this parasite as well as the obstacles to obtaining an accurate medical diagnosis of gongylonemiasis. We discuss the possibility of widespread infection of humans by nematode worms and provide suggestions for approaches to rapidly and accurately detect the prevalence of *Gongylonema* in human subjects. We present no data on host phenotypic manipulation by the parasite, but cannot rule out the possibility.

P3.52 ALURU, N*; KARCHNER, S.I.; Woods Hole Oceanographic Institution, Woods Hole; *naluru@whoi.edu*
Role of DNA methyltransferases (DNMTs) in environmental adaptation to stressors.
DNA methylation is one of the widely studied mechanisms of epigenetic regulation in vertebrates. It involves covalent modification of DNA by the addition of a methyl group to the cytosine nucleotide, when cytosine occurs next to a guanine nucleotide (CpG dinucleotide). This reaction is catalyzed by DNA methyltransferases (DNMT) and involves the transfer of a methyl group from S−adenosylmethionine (SAM) to cytosine. Evidence from recent studies in several species (e.g.,eusocial insects) demonstrates that DNA methylation plays an important role in phenotypic plasticity and environmental adaptation to stressors. Populations of killifish (*Fundulus heteroclitus*) inhabiting highly contaminated coastal habitats have acquired a heritable resistance to the toxic effects of these pollutants. In this study, we hypothesize that altered DNA methylation is one of the potential mechanisms of acquired resistance. To understand the role of DNA methylation in the resistant phenotype, we cloned and sequenced all six DNMT genes in killifish. We also quantified the expression pattern of DNMTs during development in embryos from contaminated and pristine sites. We observed temporal differences in the DNMT expression during development. *In vitro* studies are under way to characterize the functions of the different DNMTs. In addition, we are quantifying global methylation levels in the two killifish populations by mass spectrometry.

S1.2−3 ALVARADO, S*; SZYF, M; RAJAKUMAR, R; STOREY, KB; ABOUHEIF, E; FERNALD, R; Stanford University, Palo Alto, McGill University, Montreal, Carleton University, Ottawa; *salvarad@stanford.edu*
Dynamics of DNA methylation in continuous trait variation, seasonal change, and social environment.
All animals have developed a variety of strategies to adapt to a dynamic environment by adjusting their development, physiology and/or behavior. However, little is known of the underlying molecular mechanisms and their plasticity in regulating such phenomena. One epigenetic mechanism, the reversible covalent modification of DNA by methylation, has been extensively characterized to regulate gene function through transcriptional repression. While this mechanism has been classically studied in cancer and disease states, few studies have examined the role that dynamic DNA methylation in adult tissues could play in natural biological phenomena, thus emphasizing its importance to other fields of organismal and ecological biology. Here I will discuss in three separate animal models where DNA methylation is shown to play a dynamic role in determining the continuum of a trait (in carpenter ants), seasonal change (in adult hibernating squirrels), and social environments (in adult male African cichlids). In addition to characterizing these changes at the genomic level we further resolve these changes to the transcriptional regulation of individual genes and their function within different tissues. While each of these animals may adapt to different environmental cues, they all share similar mechanisms in regulating gene function, thus underlining the importance of DNA methylation in responding to environmental signals in general and at different stages of life.

P3.45 AMADI, C*; RENDON, N.M; KEESOM, S.M; DEMAS, G.E; HURLEY, L.M; Cornell University, Indiana University; *ca329@cornell.edu*
Siberian hamster vocalizations during aggressive encounters: Influence of sex and season
Social context varies across seasons; thus, communication may also vary. For example, the use of song by male passerine birds changes across season in accordance with reproductive state. Less is known about seasonal variation in mammalian communication, including whether the sexes differ in vocal production. Here, we studied vocal behavior during same−sex agonistic encounters of a seasonal mammal, the Siberian hamster (*Phodopus sungorus*). Hamsters are an excellent model to study seasonal vocal behavior because they display a suite of physiological and behavioral changes across seasons, including aggression in both sexes, and vocalize during social encounters. We predicted that vocalizations would vary across the seasons and correlate with individual levels of aggression. To test this prediction, we housed male and female hamsters in long "summer" days or short "winter" days and recorded video and audio from 5−minute resident−intruder interactions. Aggression was measured by chases and attacks. We characterized two types of vocalizations: high frequency, narrowband syllables as "ultrasonic vocalizations" (USVs) and audible, broadband syllables as "broadband calls" (BBCs). Both male and female hamsters produced USVs and BBCs across seasons. More BBCs were emitted during encounters between short−day animals, and females produced more BBCs than males. BBCs were related to aggression, both across time and with the intensity of the interaction. Collectively, these findings demonstrate a relationship between a particular call type and aggression, which change seasonally. Characterization of vocal behavior across seasons and between sexes contributes to a greater understanding of context−dependent social behavior.

14.4 AMADOR, GJ*; DURAND, F; MAO, W; ALEXEEV, A; HU, DL; Georgia Institute of Technology; *gamador3@gatech.edu*

How flies clean their eyes

Flying insects face a barrage of foreign particles such as dust and pollen, which threaten to coat the insect's eyes and antennae, limiting their sensing abilities. In this study, we elucidate novel aerodynamic and elastic mechanisms by which insects keep these organs clean. The compound eye of many species of insects is covered by an array of short bristles, or setae, evenly spaced between each photoreceptor unit. Among these insect species, setae length is triple their spacing. We conduct numerical simulations and wind tunnel experiments using an insect eye mimic to show this critical setae length reduces shear rate at the eye surface by 80%. Thus, the setae create a stagnant zone in front of the eye, which diverts airflow to reduce deposition of particles. Setae can also act as springboards to catapult accumulated particles. In high speed videography of insects using their limbs to groom, we observe deflected and released setae hurling micron scale particles at accelerations over 100 times earth's gravity. The dual abilities of setae to divert airflow and catapult particles may motivate bio−inspired designs for dust−controlling lenses, sensors, and solar panels.

P1.50 AMADOR, M.D.*; RHODES, A.C.; LAVELLE, K.A.; MONTAGNA, P.A.; WOOD, J.S.; Texas A & M University Corpus Christi; *arhodes2@tamucc.edu*

Constructing a Biogeographic Database for Visualization in GIS

This study was designed to construct a complete list of species occurrences catalogued by depth and geographic location based on historic records of Tanaidacea (Crustacea: Peracarida) in the northern Gulf of Mexico. One of the challenges to constructing a biogeographic analysis for any taxa is that online databases often lack complete and/or accurate information, e.g., location, depth, or taxa name. To address this challenge, we constructed a comprehensive database by downloading and correcting online sources. In addition, data from recent research cruises led by US Geological Survey and Texas A&M University−Corpus Christi, Harte Research Institute were added to historic records to facilitate biogeographic and biodiversity analyses. Data on tanaidacean species occurrences were extracted from multiple online databases (IOBIS, GBIF, GulfBase, Chess, and U.S. National Museum of Natural History). When geographic coordinates were available, but depths were not provided, depths were calculated from contour maps overlaid in a geographic information system (GIS). After an extensive review of literature on tanaidaceans and their distribution in the Gulf of Mexico, we found discrepancies between the published literature and online databases. These discrepancies were corrected in our database based on the published literature. The new comprehensive database is formatted for GIS, which allows for detailed visualizations of species diversity based on taxonomic levels, depths and coordinates in the northern Gulf of Mexico. As a result of this study, we have created a more complete and accurate database of tanaidacean species occurrences that will be useful to researchers studying crustacean diversity in the Gulf of Mexico.

P3.42 AMATULI, KC*; ROSEN, DAS; RICHMOND, JP; University of North Florida, Jacksonville, University of British Columbia, Canada; *kris.amatuli@unf.edu*

Seasonality of metabolic hormones in a seasonal carnivore, the Steller sea lion Eumetopias jubatus

Seasonal changes in body mass, nutrient partitioning, and food intake are strongly influenced by metabolic hormones. As a part of normal life history patterns, Steller sea lions (SSL) exhibit dynamic seasonal changes in intake during the summer breeding season. Previous research found seasonality of metabolic hormones in males but not female SSL likely due to the artificially consistent feeding regime during the study. The current study investigates seasonal patterns of growth hormone (GH), insulin−like growth factor (IGF)−I, and ghrelin in adult female SSL, fed a diet reflective of normal life history patterns. Specifically, SSL were fed ad libitum during most of the year, but intake was reduced in early summer. Following increased intake in fall and winter (74575±2101kJ; $p<0.01$), mass was greatest in winter and spring (159.5±1.9kg; $p<0.01$). Known to stimulate GH release, ghrelin was positively correlated to GH ($p<0.01$) in the spring; however, exhibited a negative correlation in winter and fall. Ghrelin stimulates appetite, especially during periods of fasting. SSL ghrelin was negatively correlated with intake ($p<0.01$) in winter and spring, but positively correlated in summer and fall. IGF−I concentrations were positively correlated ($p<0.01$) with intake independent of season. The inverse relationship between GH and ghrelin during the breeding season likely suppresses the urge to feed (reduced ghrelin) during these extended periods of restricted intake and facilitates use of adipose for energy (increased GH). Increased ghrelin with reduced GH in the winter is likely a mechanism to facilitate winter fattening. Dynamic seasonality in metabolic hormones was observed in female SSL suggesting seasonal change in nutrient partitioning priorities.

P2.25 AMAYA, J; YANG, A*; WOLF, B/O; MCCUE, M/D; St. Mary's University, University of New Mexico; *mmccue1@stmarytx.edu*

Targeted ^{13}C enrichment of lipid and protein pools in the body reveals circadian changes in oxidative fuel mixture during prolonged fasting: a case study using Japanese quail

Many animals undergo extended periods of fasting during their annual cycle. During these fasts, animals use a mix of macronutrients related to the nutritional, energetic, or hydric requirements of the fasting period. The use of specific macronutrients can vary widely with the time course and duration of the fast. In this study, we use Japanese quail, a bird with natural intermediate fasting periods, to examine macronutrient use during a six day fast. We raised quail on isotopically labeled materials (^{13}C−1−leucine, ^{13}C−U−glucose, or ^{13}C−1−palmitic acid) with the intent of labeling specific macronutrient/tissue pools in each treatment, and then traced their use as a fuel by measuring the $\delta^{13}C$ values breath CO_2. Based on changes in $\delta^{13}C$ values during the fast, it appears that the carbohydrate label, ^{13}C−U−glucose, was largely incorporated into the lipid pool and thus breath samples ultimately reflected lipid use rather then carbohydrate use in this treatment. In the lipid treatment, ^{13}C−1−palmitic acid, faithfully labeled the lipid pool and was reflected in the kinetics $\delta^{13}C$ values in breath CO_2 during the fast. The protein label, ^{13}C−1−leucine, showed apparent diurnal periods of protein sparing and use, with the use occurring, we hypothesize, during periods of relatively high metabolic demand. This labeling/breath tracer method provides a relatively noninvasive approach to studying the nutrient dynamics of fasting animals and should provide new insights into how different taxa use specific nutrient pools during short and long−term fasts.

P1.137 AMBARDAR, M.*; GRINDSTAFF, J.L.; Oklahoma State University, Stillwater, OK; *medhavi@okstate.edu*
The roles of sex, parental care and aggression on testosterone production in eastern bluebirds (Sialia sialis)
In many animals, the hormone testosterone (T) generally promotes territorial aggression while reducing parental care. In socially monogamous species where both sexes defend the nest, short term elevations in T might facilitate aggression, and thus, the likelihood of successfully defending the nest. Alternatively, T might remain low during aggressive interactions because of the suppressive effects of that hormone on parental care. Because costs associated with aggression and parental care differ between the sexes, there might also be differences across sexes in the relationships between T, aggression, and parental care. We used a wild population of eastern bluebirds (*Sialia sialis*) to examine how T production differed between sexes during parental and aggressive contexts. We quantified parental care by videotaping feeding behavior by adult bluebirds when nestlings were 5−7 days old. To quantify aggression, we performed simulated territorial intrusions (STIs) using a common nest site competitor, the house sparrow (*Passer domesticus*) when nestlings were 7−9 days old. Following parental care and STI trials, we collected a blood sample from either the male or female bird to determine circulating levels of T within parental and aggressive contexts. We also performed gonadotropin releasing hormone (GnRH) challenges to test the responsiveness of the hypothalamic−pituitary−gonadal (HPG) axis in male and female bluebirds. The results of this study will provide insight into sex differences in T production during social interactions, and how T relates to the trade−off between aggressive behavior and parental care.

18.6 ANDERSON, R A; Western Washington Univ.; *Roger.Anderson@wwu.edu*
Locomotor performance of lizards during pursuit of prey and evasion from predators
A robust, comprehensive study of locomotory capabilities in a terrestrial vertebrate requires adequate observation and testing in the field as well as in the lab. Terrestrial lizards in desert scrub are useful model systems for studying locomotory adaptedness because they can be observed and tested easily in the field as they pursue prey and evade predators. The long−nosed leopard lizard, *Gambelia wislizenii* is a mesopredator that preys on highly mobile insects and lizards, including the highly evasive western whiptail lizard, *Aspidoscelis tigris*. The bipedal and quadrupedal running, leaping, and turning performances of these coevolved lizards were examined, primarily on natural substratum in the field.

8.2 ANDERSON, C.V.*; HUDSON, D.S.; DEBAN, S.M.; Brown University, Providence, Rhode Island; University of South Florida, Tampa, University of South Florida, Tampa; *Christopher_V_Anderson@brown.edu*
Tongue projection in aquatic and terrestrial environments: The effect of drag on a high−powered ballistic movement
Adult plethodontid salamanders can inhabit both terrestrial and aquatic environments, and while most taxa typically use jaw prehension while feeding underwater, some will use tongue projection, which is generally more typical of terrestrial feeding strategies. Performance of tongue projection during underwater feeding events, however, is likely to be heavily affected by increased drag. To better understand how the environment affects tongue projection performance in adult salamanders inhabiting both terrestrial and aquatic habitats, we examined feeding performance in four plethodontid taxa feeding in and out of water: *Desmognathus marmoratus* (aquatic; low−powered tongue), *D. quadromaculatus* (amphibious; low−powered tongue), *Psuedotriton ruber* (amphibious to terrestrial, high−powered tongue), and *Eurycea guttolineata* (largely terrestrial; high−powered tongue). We found that taxa with a high−powered tongue projection mechanism showed greater relative performance declines in the aquatic environment than those with a low−powered tongue projection mechanism. The performance decline of the high−powered tongue projection suggests that a more significant impact of drag from water on the high−powered mechanism, which is likely due to the increased velocity of their movements, could be a reason why a low−powered tongue projection mechanism seems to be favored among the more aquatic taxa. This trade−off between high performance and reduced performance loss due to drag could possibly show that the transition from water to land played a significant role in the evolution of the high−powered tongue projection mechanisms within the Plethodontidae.

P1.7 ANDERSON, C.*; JONES, R.; MOSCICKI, M.; CLOTFELTER, E.; EARLEY, R.L.; Univ. of Alabama, Univ. of Alberta, Amherst College; *ctanderson@crimson.ua.edu*
Breeding convict cichlids (Amatitlania siquia) display differential aggression based on conspecific intruder coloration
Convict cichlid (*Amatitlania siquia*) females exhibit orange carotenoid−based ventral coloration that males lack. The signaling potential of female coloration has yet to be fully established and few field studies have addressed this issue. In this study, three−dimensional female convict cichlid models were presented to naturally occurring breeding pairs in Lake Xiloa, Nicaragua. We predicted that aggressive responses to the models would increase with increasing model size and with increasing size of the ventral orange patch. Model treatments consisted of three sizes and three color classes (two patch sizes and no color). In support of our predictions, breeding pairs exhibited significantly higher aggression toward larger models and toward models that had orange coloration. However, within the color patch treatments, only small patches elicited significantly more aggression than models lacking color.

14.7 ANDERSON, P*; CLAVERIE, T; PATEK, S; Duke University, Durham, NC, University of California, Davis;
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Biomechanical trade−offs in a power−amplified system

Mantis shrimp generate ultrafast feeding strikes by coupling a 4−bar linkage, lever and spring. The 4−bar linkage and lever work together to transmit stored elastic energy to the rapid predatory strike. We tested whether these coupled mechanical systems co−evolve such that both are varying consistently with each other to achieve an additive output or whether they follow the many−to−one mapping patterns (i.e. multiple configurations yield the same output) identified in single mechanisms such as the 4−bar linkage in fish jaws. Coupled mechanical systems should allow for even more pronounced many−to−one mapping patterns given that the mechanisms are morphologically independent, but functionally linked. Both 4−bar linkages and lever systems follow a force−displacement tradeoff. Tandem evolutionary variation in these systems would consist of additively matching shifts to high displacement in both the linkage (high kinematic transmission; KT) and lever system (long out−lever) whereas many−to−one mapping would consist of variable combinations of KT and out−lever lengths to maintain a particular output. We examined the evolutionary variation of the 4−bar and lever systems within and across two broad groups of mantis shrimp: fish−catching "spearers" and snail−crushing "smashers". We compared 4−bar displacement (KT), lever force amplification (Mechanical Advantage: MA) and appendage extension during a strike (Reach) using phylogenetic comparative methods. Models of character evolution show that mantis shrimp appendage evolution is disparate, but the biomechanical changes occur in tandem: spearers evolve towards high KT, high reach and low MA while smashers do the opposite. Thus, both groups consistently combine KT and lever to achieve either high displacement or high force and do not follow a many−to−one pattern.

62.3 ANDERSON, RC*; NOWICKI, S; Duke Univ.;
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Cognitive performance predicts strength of sexual preference in a songbird

Understanding variation in female mating preferences is a central issue in behavioral ecology. In songbirds, female mate choice is influenced by male song qualities. Female assessment of male song is, in part, a cognitive task: preferences are the result of learning, memory and comparative evaluation processes. Developmental and environmental factors have been shown to influence various aspects of cognition in birds, suggesting mechanisms by which song preferences and other cognitive abilities could become associated. We tested whether variation in the strength of female song preference, which may reflect ability to assess song quality, is related to problem solving ability. We measured preference for local versus foreign song in wild−captured female swamp sparrows using an operant design where females indicated song preference by triggering playback of preferred songs. We then tested their performance on a battery of cognitive tasks measuring motor learning, color association, reversal learning, spatial learning, and inhibitory control. Females preferred local over foreign song but varied in the strength of this preference. Choosiness for local song correlated with the speed at which females learned to associate a particular color with food; choosier females solved the task in fewer trials. Performance on a task measuring inhibitory control has been shown to predict song repertoire size in male song sparrows (faster learners had larger repertoires). We found that choosier females required more trials to solve this task. Females did not show consistent performance across cognitive tasks. Further work is needed to understand the mechanisms that may link female mating preferences with other cognitive abilities.

115.6 ANDERSON, GE*; SECOR, SM; University of Alabama;
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Differential growth rates of body segments explain ontogenetic shifts in heart position

Relative heart position in snakes has been hypothesized to be adaptively correlated with habitat and shown to be conserved phylogenetically. For snakes, relative heart position also shifts ontogenetically, becoming relatively closer to the head with size. We asked whether the shift in heart position occurs independently of body segment or is fixed to body segment and segments develop differentially with age. To explore this question we used the diamondback water snake (*Nerodia rhombifer*), a medium sized colubrid snake that experiences a noted shift in heart position with length (from 23% to 17% of snout−vent length). From the dissections of over 100 snakes (18.5 − 107cm SVL), we found that the heart was closely aligned with the 26th to 29th vertebrae with no trend between vertebrate number and body size. From the prepared skeletons of over 100 snakes (18.5 − 118cm SVL) we measured the length, width, height, and mass of eight vertebra positioned at equal intervals of the snake's body. We found that the vertebra in the middle region of snakes grew 75.5% faster than vertebra of the anterior body. We conclude that heart position is largely fixed to body segment and that the ontogenetic shift in heart position is due to the differential growth of body segments. Body segments grow relatively larger in the middle portion of the body compared to near the head, resulting in a seemingly anterior movement of the heart with increased snake length.

124.3 ANDREW, N*; HEMMINGS, Z; University of New England;
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How is dung beetle biology, resource competition and responses to environmental change currently being assessed?

The great challenges in predicting how biological organisms will respond to a rapidly changing climate is determining if responses of organisms are idiosyncratic, or whether there are underlying generalities that can be made based on evolutionary relationships, or ecological associations. Dung beetles (Coleoptera: Scarabeinae) are important ecosystem service providers and are also used for comparative studies and the assessment of a variety of ecological theories relevant to all animal taxa. A worldwide meta−analysis will be carried out to assess how dung beetles are being studied, the findings gathered, the literature cited, how these trends have changed over time and among research groups, will be carried out. Data collected will include biotic and abiotic information, species, location, key experimental traits, and responses that can be developed and assessed using network analysis.

44.5 ANDREW, J.R.*; GARLAND, T. JR.; CHAPPELL, M.A.; SALTZMAN, W.; University of California, Riverside; *jandr010@ucr.edu*

Energetic and Metabolic Consequences of Fatherhood in the Biparental California Mouse (Peromyscus californicus)

Although the effects of motherhood on mothers' health have been well documented in mammals, the effects of fatherhood on fathers' health are virtually unknown. In this study, we evaluated some of the potential energetic and metabolic effects of being a father. We used California mice (*Peromyscus californicus*) because they are genetically monogamous in the wild and because fathers show similar post−partum parental behavior to mothers, with the exception of lactation. We studied three groups: males paired with an intact female, males paired with a tubally ligated female, and males paired with another male. Starting 3−5 days after the birth of each breeding pair's first litter, males were tested for exercise performance (maximum sprint speed, treadmill endurance), basal metabolic rate, and maximum oxygen consumption. At the conclusion of testing, males were euthanized, blood was sampled for future hormone assays, and organs were weighed. This study will provide novel insights into potential energetic and metabolic costs of fatherhood in a biparental mammal. (Funded by NSF IOS−1256572 and NIH 1R21HD075021)

1.8 ANGELI, N. F.*; FITZGERALD, L. A.; Texas A&M University; *nangeli@tamu.edu*

Biophysical and landscape homogenization leads to a reduction in habitat available to an endangered endemic lizard population

Biophysical constraints that determine habitat use of species are affected by landscape change associated with invasive species and climate change. Here, we compare two islands with one genetically distinct population of the critically endangered St. Croix Ground Lizard, *Ameiva polops*. On Buck Island National Monument, USVI, more than 20 years of intensive ecological restoration has left a complex forested habitat matrix, while on Green Cay National Wildlife Refuge large monoculture patches of invasive grasses (i.e., *Bothriochloa pertusa*) have increasingly developed. We mapped the thermal environment of the substrate, operative temperatures of lizards, and quantified population density of lizards on each island. Our results indicate that loss of habitat complexity on Green Cay alters the spatial configuration of operative temperatures. Specifically, extensive thermal environments have been created that are below the thermal optima of lizards. We infer that this type of environmental homogenization has already impacted this critically small population of *A. polops* by reducing available habitat and that these effects may be exacerbated in the future.

53.2 ANGELIER, F*; WINGFIELD, JC; CHASTEL, O; Centre d'Etudes Biologiques de Chizé, CNRS, France, Univ. of California, Davis, USA; *frederic_angelier@yahoo.fr*

How do corticosterone and prolactin govern parental behavior in seabirds?

In vertebrates, corticosterone has been suggested as one of the main mediators of allostasis. Indeed, corticosterone secretion and elevated plasma corticosterone levels are expected to mediate physiological and behavioral adjustments that aim at restoring homeostasis. In the context of reproduction, elevated corticosterone levels are therefore considered to promote homeostasis and immediate survival by reducing breeding effort. Although an experimental elevation of corticosterone levels is clearly associated with reduced parental effort, the relationship between natural variations in corticosterone levels and parental behavior appears inconsistent and, therefore, the exact role of corticosterone on parental behavior remains to be clarified. By studying multiple indices of the stress response (behavior, corticosterone and prolactin), we investigated the hormonal determinants of parental behavior in seabirds. Although we found that corticosterone levels are clearly associated with individual energetic status (body condition), we did not report any evidence for a direct and straightforward link between natural variations in corticosterone levels and the expression of parental behavior in seabirds. On the other hand, we found that prolactin levels can be a good predictor of parental behavior but do not necessarily co−vary with individual energetic status. In addition, baseline corticosterone and prolactin levels are not correlated. However, experimentally elevated corticosterone levels reduce prolactin levels, demonstrating that these two hormonal mechanisms are functionally linked. Our study suggests that corticosterone could govern parental behavior under some circumstances through an indirect effect on prolactin levels.

72.2 APPLEBAUM, S.L.*; PAN, F.; HEDGECOCK, D.; MANAHAN, D.T.; University of Southern California; *sappleba@usc.edu*

Genetically determined shifts in metabolic energy allocation in response to ocean acidification

Current evidence suggests that future scenarios of ocean acidification (OA) will impact the metabolism of marine organisms. Genetically determined variation in allocation of energy to essential physiological processes could differentially impact the adaptive potential of individuals under environmental stress. Predicting the impact of OA and other environmental changes on natural populations will require an understanding of the mechanisms of variation in biological responses and the adaptive potential of different genotypes. We used controlled crosses of inbred lines of the Pacific oyster *Crassostrea gigas* to produce F1 hybrid families. Such families are equivalent to non−inbred wild types but are genetically defined and permit natural biological variation to be experimentally partitioned. Hybrid larvae were analyzed for phenotypic variation in growth and allocation of ATP to major energy−consuming processes − protein synthesis and ion homeostasis (Na^+, K^+−ATPase). Combined, these two processes accounted for up to 75% of ATP utilization in larvae. Under present−day conditions (380 ppm CO_2) contrasting phenotypic patterns of metabolic allocation were evident between hybrid families growing at significantly different rates. Larvae of a single family exposed to either present−day or near−future OA conditions (800 ppm CO_2) substantially changed phenotypic metabolic allocation in the OA−treated larvae. Further, the response of metabolic reallocation in OA varied between families. These genotype−by−environment interactions suggest that some individuals have greater physiological resilience to environmental stress. Understanding the mechanistic basis of genetically determined resilience will greatly improve abilities to predict potential to adapt to environmental change.

P1.23 ARAUJO, A.M.*; WARNE, R.; Southern Illinois University; *alessandra@siu.edu*

THE EFFECTS OF SIZE HIERARCHY STATUS AND BEHAVIOR ON RANAVIRUS SUSCEPTIBILITY AND TRANSMISSION IN WOOD FROG Rana sylvatica LARVAE

Across taxa, chronic stress generated by high levels of competition within size ranked hierarchies is associated with higher basal levels of glucorticoids in smaller individuals. Elevated GC levels, in turn, reinforce expression of phenotypes exhibiting increased metabolism, anorexia, compromised immune function, and submissive behavior. Within tadpole populations, variance in growth and development rates often results in well structured size hierarchies, with even greater size stratification occurring in populations exposed to limited resources. Size dependent physiology and behavior, therefore, should affect population infection dynamics by shaping individuals' competitive success, exposure, transmission, and recovery rates. Here, we use Ranavirus, an emerging and directly transmitted pathogen in ectotherms, to test if size differences were associated with subsequent displays of behaviors that could alter disease susceptibility and transmission in Wood frog (Lithobates sylvaticus) larvae. We hypothesize larger individuals within hierarchies would display more aggressive behaviors with higher exposure and contact rates than their smaller counterparts, functioning as "super spreaders" of disease. We also hypothesized that smaller tadpoles would be more susceptible to infection because of consistently higher concentrations of glucocorticoids; immunosuppressive hormones under chronically elevated levels. The main goal of this study is to develop a social−neuroendocrine model through which stress physiology and individual response to imposed environmental conditions are integrated in order to better understand the role of size structured populations in epidemic disease outbreaks.

78.5 ARCHIE, J.W.*; HOOPER, C.; California State Univ., Long Beach; *James.Archie@csulb.edu*

A mechanism for extinction: Recruitment failure in a sky−island population of Sceloporus occidentalis

Population extinctions are likely common, but seldom observed in the wild. We document the likely extinction of a sky−island population of western fence lizard, *Sceloporus occidentalis*, due to failure of annual recruitment of juveniles. Populations of WFL on Ord Mountain in the Mojave Desert have been monitored over a period of 4 years (2010−2013) on two 1−hectare sampling grids, one at 1450m and the other at 1850m. The frequency of captured and marked first−year lizards in the population varied from 13% to 54% of all marked lizards during the first 3 years of study (from 55−83 total lizards captured annually). During 2013, this frequency dropped to 0% as no first−year lizards were found either on the sampling grids or anywhere on the mountain (10 sampling days and 225 person−hours of searching). During the 2011−2012 and 2012−2013 wet seasons (November−March), the Mojave Desert experienced extreme drought conditions which resulted in highly reduced annual and perennial plant production and reduced insect abundance. Adult survivorship on the sampling grids increased during 2013 and may be a result of lack of dispersal from the sampling grids or lack of avian or other predators. A total of 3 hatchling lizards have been seen during July and August 2013. While the high elevation population remains robust, lack of juvenile recruitment is the likely mechanism for extinction of the low elevation population.

S5.1−3 ARELLANO, C.J.*; KRAM, R; Brown University; *arellanoc@gmail.com*

Partitioning the Metabolic Cost of Human Running: A Task−by−Task Approach

Humans are very tractable and thus an ideal "model system" that allows us to better understand locomotion energetics. In this talk, we review our current understanding of the biomechanical basis for the metabolic cost of running. Running can be modeled as a simple spring−mass system whereby the leg acts a linear spring, storing and returning mechanical energy during stance. However, if running can be modeled as a simple spring−mass system, why does running incur a metabolic cost at all? C.R. Taylor and colleagues (1980) proposed the cost of generating force' hypothesis, which was based on the idea that muscles transform metabolic energy into force, not necessarily mechanical work. Kram and Taylor (1990) then demonstrated that the rate of metabolic energy was proportional to body weight and inversely proportional to the time of foot−ground contact for a variety of animals ranging in size and running speed. Kram and colleagues then adopted a task−by−task approach to study human running and found that the metabolic cost can be partitioned into body weight support (65−75%), propulsion (37−40%), and leg swing (7−10%). In our recent human running experiments, we have continued to refine this task−by−task approach, demonstrating that lateral balance exacts a modest cost of only 2%. In contrast, arm swing reduces the cost by 3%, thereby acting as a mechanism that saves metabolic energy during running. Summing all these biomechanical tasks, the lower and upper bounds for the metabolic cost of running are paradoxically 111% and 126%, respectively. To end this talk, we will discuss the interactive nature of these biomechanical tasks to try to explain this overestimation. We also discuss future experiments aimed at exploring *in−vivo* measurements that will allow us to characterize muscle−tendon function related to these biomechanical tasks.

P2.128 ARMSTRONG, E.J.*; WATSON, S−.A.; CALOSI, P.; MUNDAY, P.; STILLMAN, J.; University of California, Berkeley, James Cook University, University of Plymouth, University of California, Berkeley and San Francisco State Univeristy; *armstrong@berkeley.edu*

Increased Temperature and Lowered pH Alter Shell Mineralogy of the Scaled Giant Clam (Tridacna squamosa)

Elevated temperature and decreased oceanic pH are products of increased atmospheric $p\mathrm{CO_2}$, and have been shown to alter mineral structure of carbonate exoskeletons in many marine taxa. The potentially synergistic effects of these stressors are likely to be particularly severe for tropical molluscs like giant clams that may currently live at or near their respective thermal maxima, and that produce the largest exoskeleton of all extant bivalves. We investigated the effects of increased temperature and $p\mathrm{CO_2}$ on mineral composition and organic content of shells of the scaled giant clam (*Tridacna squamosa*). Juvenile clams were reared under one of four treatment conditions in a 2x2 temperature (28.5°C and 31.5°C) crossed with CO_2 (395 ppm and 950 ppm) experimental design. Clams were exposed to experimental conditions for 60 days before samples of both new and old growth shell were collected. Shell mineralogy (Ca^{2+}, Mg^{2+}, K^{+}, Mn^{2+}, Sr^{2+}, P^{3-}, Si^{4+}) and organic content (%C, %H, and %N) were examined using ICP−MS and elemental analysis respectively, and compared across all treatments. Under elevated temperature, Ca^{2+}:Mg^{2+} in new shell decreased by 21.6% and 24.4% when compared to old growth under high and low $p\mathrm{CO_2}$ respectively. %C and %H did not differ significantly between any of the treatments, but %N of new shell decreased by 62.8% under high $p\mathrm{CO_2}$ and temperature. These results suggest alterations in both the organic and inorganic matrices of new shell formed under elevated temperature and $p\mathrm{CO_2}$ and are consistent with an increased proportion of polysaccharides and amorphous CaCO3 present relative to proteins and aragonite respectively.

P3.143 ARTHUR, L.*; MCLELLAN, W.; WOODWARD, B.; PISCITELLI, M.; WINN, J.; PABST, D.; UNC Wilmington, Univ. of Maine, Univ. of British Columbia, New River Kinematics; *LHA8694@uncw.edu*

Estimating force outputs of cetacean axial locomotor muscles

Cetaceans are streamlined swimmers that span a large range of body sizes [total length (TL) 1.5 − 25 m] and include species, such as the sperm and mysticete whales, with the largest locomotor muscles of any vertebrate. These marine vertebrates utilize their axial muscles to power swimming. To date, total body force output has only been measured in bottlenose dolphins swimming against a force plate (Williams et al. 1993, Goforth 1992), although thrust forces have been hydrodynamically modeled for a number of species. Our goal was to estimate epaxial muscle force output using directly measured morphological features of the musculoskeletal system, including muscle cross−sectional area (A_m) and mass (M_m), for cetaceans ranging in size from bottlenose dolphins to blue whales. Maximal A_m, directly measured from whole body cross−sections of a bottlenose dolphin, could be modeled as a half ellipse, with vertebral transverse and spinous processes forming its major axes. These maximal vertebral dimensions were measured for 89 specimens (21 species, TL 1.7 − 22.7 m). Force output based upon muscle area (F_A) was calculated as A_m x muscle stress (70 kPa) (Biewener 2005). M_m was also collected for 21 of these specimens (12 species, TL 1.8 − 9.7 m). Force output based upon muscle mass (F_M) was calculated as M_m x 57 N/kg (Marden and Allen 2002). Both methods yielded scaling relationships less than those predicted for geometric similarity ($F_{,A} \pm TL^{1.6}$; $F_M \pm TL^{2.5}$). "Musculoskeletal fineness ratio" (defined here as $TL/A_m^{0.5}$) also increased with increasing body size; i.e. larger cetaceans possessed relatively smaller muscle dimensions. These results all suggest that length specific locomotor force output decreases with increasing body size in cetaceans.

125.5 ASHLEY, N.T.*; WINGFIELD, J.C.; Western Kentucky University, University of California, Davis; *noah.ashley@wku.edu*

Testosterone at the Top of the World: Disparate hormone−behavior interrelationships between two high−arctic breeding populations of Lapland Longspurs (Calcarius lapponicus)

Interrelationships between testosterone and aggression are dynamic and change in relation to life cycles even in polar environments where the breeding season is extremely truncated. At the Toolik Lake Field Station in Alaska (68°N), male Lapland Longspurs (*Calcarius lapponicus*) show a brief peak in plasma testosterone early in the season that coincides with aerial displays and song, but not aggressive behavior towards simulated territorial intrusion (STI). Males then mate−guard females for approx. 10 days, respond to STI, but exhibit lower testosterone levels. In addition, previous studies have shown that testosterone implants increase song but not aggression. These data suggest a temporal disassociation between testosterone and aggression. We report studies from a population of Lapland Longspurs breeding at higher latitudes (71°N; Barrow, AK) where males display extended aggressive behavior to STI over a period of three weeks, and increase testosterone levels in response to STI. These differences in hormone−behavior relationships between Toolik and Barrow longspurs could reflect habitat differences (coastal vs. inland), and duration of the breeding season that could alter synchrony of breeding and/or territory density.

P3.150 ASHLEY−ROSS, M.A.*; PERLMAN, B.M.; GIBB, A.C.; EARLEY, R.L.; Wake Forest University, Northern Arizona University, University of Alabama; *rossma@wfu.edu*

Terrestrial jumping performance differs among genetically isolated populations of mangrove rivulus, Kryptolebias marmoratus

Kryptolebias marmoratus (Cyprinodontiformes) is distributed from the Atlantic coast of central Florida throughout the Caribbean as far as southern Brazil. It is notable for (1) making regular excursions onto land as part of its life history, and (2) being one of only two vertebrate species known to consist primarily of self−fertilizing hermaphrodites. We asked whether populations of *K. marmoratus* that are both geographically and genetically isolated from one another differ in terrestrial jumping performance. Six genetic lineages originally collected from three sites in Florida and three in the Caribbean (mainland Honduras, Belize, and Roatan Island) and maintained for multiple generations in the lab were assayed, thus ensuring that any differences observed would be attributable solely to genetics. Eight individuals per lineage were, one at a time, placed on a damp substrate inside a shallow wading pool, and observed without disturbance for two minutes, followed by 30 seconds in which the fish were repeatedly approached in order to elicit a maximal jump. Trials were recorded from above by a video camera (60 fps). The following measurements were made by analysis of the video using ImageJ: number of jumps, latency to first jump, average and maximum jump distance, angular trajectory of the jump, and total and net distances moved during the voluntary trial. Principal component analysis revealed that populations differed significantly in jump performance, with Florida populations having a higher propensity to jump, and longer jumps, than Caribbean populations. *K. marmoratus* may thus serve as a model system in which to examine the genetic basis of locomotor performance.

P1.34 ASMUS, AL*; GOUGH, L; BOELMAN, NT; WINGFIELD, JC; SWEET, SK; KRAUSE, JS; PEREZ, JH; CHMURA, HE; Univ. of Texas at Arlington, Columbia Univ., Univ. of California, Davis, Columbia Univ.; *ashley.asmus@gmail.com*

Multi−trophic impacts of shrub dominance on arctic arthropod assemblages

In Arctic tundra, woody shrubs are increasing in size and spread as an indirect consequence of climate change. The Ecosystem Exploitation Hypothesis (EEH) predicts that increased primary producer productivity, such as a shift towards shrubbier tundra, should support greater animal biomass and potentially more trophic levels because of greater energy availability at the food chain's base. Here, we test this hypothesis by comparing the ground−dwelling arthropod assemblages in existing shrub−dominant tundra with the assemblages in "open" tundra dominated by mosses and graminoids. We sampled arthropods with pitfall traps at four sites near Toolik Lake, Alaska. Traps were set for 10 weeks in 2012 through the summer peak of insect abundance. We captured approximately 10,000 individuals representing 80 arthropod families and a variety of trophic guilds. Overall, our results did not match the expectations of EEH. Averaged across all sites, per−trap biomass was lower in the more productive shrub tundra areas. Relative to open tundra, shrub tundra had less herbivore, predator and parasitioid biomass; however, shrub tundra did support slightly more pollinator biomass in the form of pollinating flies and bumblebees. Therefore, we suggest that aboveground plant production does not seem to be the limiting factor for the ground−dwelling arthropod assemblage. Other mechanisms, such as differences in habitat structure, plant quality or soil food webs, may be the cause of the lower biomass in shrub tundra. Regardless, a reduction in ground−dwelling arthropod biomass associated with increased shrub cover could lead to cascading negative effects for other members of the tundra food web, such as insectivorous birds and mammals.

69.5 ASTLEY, H. C.*; ROBERTS, T. J.; Georgia Institute of Technology, Brown University; *henry.astley@gmail.com*

The mechanics of elastic loading and recoil in anuran jumping

Many animals use catapult mechanisms to produce extremely rapid movements for escape or prey capture, resulting in power outputs far beyond the limits of muscle. In these catapults, muscle contraction loads elastic structures, which then recoil to release the stored energy extremely rapidly. Many arthropods employ exoskeletal latches to lock the joint in place during the loading period, which can then be released to allow joint motion via elastic recoil. However, jumping vertebrates lack a clear anatomical catch, yet face the same requirement to load the elastic structure prior to movement. There are several potential mechanisms to allow loading of vertebrate elastic structures, including the gravitational load of the body, a variable mechanical advantage at the ankle, and forces generated by the extension of proximal joints. To test these hypothesized mechanisms, we collected simultaneous 3D kinematics via XROMM and single−foot forces during the jumps of three *Rana pipiens*. We calculated joint mechanical advantage, moment, and power using inverse dynamics at the ankle, knee, hip and ilio−sacral joints. We found that the hip moment exerts a downward force at the knee which counteracts the moment of the ankle, and the reduction in this downwards force allows the ankle to extend using elastic recoil. Mechanical advantage also changes throughout the jump, with the muscle contracting against a poor mechanical advantage early in the jump during loading and a higher mechanical advantage late in the jump during recoil. These mechanisms both serve to oppose joint motion during elastic loading then allow it during elastic recoil, facilitating increased elastic energy storage and improved jump performance.

15.4 ATKINS, J*; FRANZ−ODENDAAL, T A; Saint Mary's University, Halifax, NS, Canada, Mount Saint Vincent University, Halifax, NS, Canada; *atkins.jade@gmail.com*

Scleral ossicles: Evolutionary trends in squamates

Squamates are a diverse order of reptiles with a rich fossil record. Unfortunately, despite this rich history and monophyly, their phylogeny remains unresolved. While morphological data supports a split between the more ancestral Iguania and more derived Scleroglossa (which includes Gekkota and Scincomorpha); molecular data suggests Iguania is a more derived group. Additionally, many groups in Scleroglossa (e.g. Dibamidae, Serpentes, and Amphisbaenia) are inconsistently placed within the squamate phylogeny. The families that are difficult to resolve have limbless species, and many of these species additionally lack scleral ossicles (bones located in the sclera of the eye). Scleral ossicle presence and morphology is correlated with environment/behaviour in some vertebrates (e.g. teleosts, and diel activity in archosaurs and squamates), but this has not been well studied in squamates. Our research investigates the presence and absence of scleral ossicles over Gekkota and Scincomorpha species, and traces the lineage of these bones across evolutionary time, noting losses and secondary gains. In addition, we will discuss whether the presence/absence of these bones is correlated to environment and behaviour other than diel activity, as in other vertebrates. This research will help expand our knowledge of these fascinating bones and may also be useful for phylogenetic analyses. Funding provided by the Natural Sciences and Engineering Research Council of Canada.

P2.66 AUGUSTUS, G.J.*; SIMS, S.E.; TULENKO, F.J.; HUDSON, M.L.; DAVIS, M.C.; Kennesaw State University; *gaugustu@students.kennesaw.edu*

Expression of 5' HoxD paralogs in the paired fins of the actinopterygian Polyodon spathula

Our previous analyses of gene expression during paired fin patterning in a basal actinopterygian, the North American paddlefish *Polyodon spathula* revealed an inverted collinear expression of 5' HoxD genes. This HoxD expression pattern was long considered a developmental hallmark of the autopod and is shown in tetrapods to be controlled by a digit enhancer' regulatory region. Recently published data confirm the antiquity of this regulatory region in gnathostomes, which together with our previous results in *Polyodon* demonstrate that aspects of autopod development are primitive to tetrapods and that limb origins entailed only slight' modifications of ancient patterns of gene expression and their underlying regulatory landscapes. However, direct comparisons of expression data between tetrapods and paddlefish are complicated by the fact that *Polyodon* exhibits a taxon specific whole genome duplication (WGD), independent of the WGD that occurred in teleosts. In light of the independently duplicated genome in paddlefish, we have further investigated the expression patterns of their 5' HoxD genes to determine 1) if both "alpha" and "beta" paralogs co−express during paired fin development; and 2) whether differences in the relative timing, position, and/or quantity of expression exist that might suggest subfunctionalization of the two paralog's roles in paired fin development. A previous study, comparing synonymous and nonsynonymous substitutions rates among the paralogous *Polyodon* HoxA and HoxD clusters suggested that one of the two HoxA/D clusters may be transcriptionally inactivated, resulting in functional diploidization. We discuss this hypothesis in light of our gene expression results.

P3.61 AWAN, A*; WILLIAMS, CM; HAHN, DA; HATLE, JD; Univ. of North Florida, Univ. of Florida; *jhatle@unf.edu*

Respiratory exchange ratios in grasshoppers upon life−extending dietary restriction or ovariectomy

Reduced reproduction and dietary restriction each extend lifespan in many animals. Because the degree of dietary restriction needed for longevity usually reduces fecundity, it is thought that both manipulations act via the same mechanisms. Ovariectomy extended lifespan and reduced feeding ~35%, and sham−operated females restricted to eat the same quantity as ovariectomized females daily also have extended lifespan. We addressed metabolic mechanisms associated with extended longevity. Treatments were: 1) sham−operated & full diet, 2) ovariectomized & full diet, 3) sham−operated & dietary restricted (fed the same amount consumed by group #2), and 4) ovariectomized & dietary restricted (fed 70% of that consumed by group #2). Consumption of O_2 and release of CO_2 was measured 1 hr before feeding, 1 hr after feeding, 5 hr after feeding, and 8 hr after feeding. Respiratory Exchange Ratios (RER) of sham−operated & full diet (n=3, overall mean = 0.65), ovariectomized & full diet (n=3, mean = 0.69), and ovariectomized & dietary restricted (n=4, mean = 0.74) groups were low at all four time points, suggesting predominantly lipid metabolism. In contrast, the sham−operated & dietary restricted group (n=3, overall mean = 1.00) had a high RER throughout, and especially after feeding, suggesting predominantly carbohydrate metabolism. Two−way repeated measures ANOVA revealed a significant effect of diet at 1 hr (P=0.01) and 8 hr (P=0.02) post−feeding, and marginal effects of surgery (P=0.09, P=0.07) and the interaction of diet and surgery (P=0.08, P=0.055) at those same times. The data suggest these grasshoppers typically burn lipids, but that intact grasshoppers on life−extending dietary restriction burn carbohydrates, while ovariectomized grasshoppers on the same daily feeding burn lipids.

50.2 AZIZI, E*; DUNLEVIE, MD; Univ. of California, Irvine; *eazizi@uci.edu*

Boundaries of skeletal muscle instability at long sarcomere lengths

Skeletal muscles are thought to be unstable when operating at lengths beyond the plateau of the force−length curve. This instability is a result of variation in sarcomere length where sarcomeres at slightly longer lengths produce less force then their shorter counterparts. This disparity in force will tend to cause the longer and therefore weaker sarcomeres to be stretched rapidly compared to shorter and stronger sarcomeres. This mechanism will continue until the weaker sarcomere is stretched to a length where there is no overlap between actin and myosin and the sarcomere "pops". We developed a model that explores the instability of the descending limb of the force−length curve under varying conditions. We examined the effect of sarcomere velocity as a potential mechanism to counteract sarcomere instability. We also examined how the passive properties of sarcomeres may alter the level of sarcomere length variation that may result in instability. Our results show that small degrees of sarcomere length variation may be counteracted by the effect of velocity on force. We also show that muscles with increased passive stiffness may reach instability at relatively longer sarcomere lengths. Supported by NIH AR055295.

S3.3−3 BABONIS, L.S.*; MARTINDALE, M.Q.; Whitney Lab for Marine Bioscience, Univ of Florida; *babonis@whitney.ufl.edu*

Old cell new trick: cnidocytes as a model for studying the evolution of novelty

Understanding how new cell types arise is critical for understanding the evolution of organismal complexity. Questions of this nature, however, can be difficult to answer due to the challenge associated with defining the identity of a truly novel cell. Cnidarians (anemones, jellies, and their allies) provide a unique opportunity to investigate the molecular regulation and development of cell novelty because they possess a cell that (i) is unique to the cnidarian lineage, and (ii) has a very well−characterized phenotype: the cnidocyte (stinging cell). Because cnidocytes are thought to differentiate from the cell lineage that also gives rise to neurons, cnidocytes express many of the same genes expressed in their neural sister cells. Conversely, only cnidocytes posses a cnidocyst (the explosive organelle that gives cnidocytes their sting); therefore, those genes or gene regulatory relationships specific for the development of the cnidocyst can be expected to be expressed only in cnidocytes. Thus, this system provides an unparalleled opportunity to examine the developmental regulation of both the ancestral and novel components of the cnidocyte and to test the hypothesis that novel cell types evolve as a result of new regulatory relationships between conserved and derived genes. To this end, we review common challenges in the study of evolutionary novelty, introduce the utility of the model cnidarian *Nematostella vectensis* as a means to advance studies of cellular novelty, and provide evidence for novel regulatory relationships between ancestral genes and novel phenotypes.

54.6 BADGER, M.*; SMILEY, A.; YE, J.; MCCLAIN, K.; DUDLEY, R.; Univ. of California, Berkeley, Univ. of New Mexico; *badger@berkeley.edu*

Shape−shifting through apertures: kinematic strategies and correlated flight metrics in Anna's Hummingbirds (Calypte anna)

Hummingbirds frequently fly near or within foliage while foraging for flowers, pursuing arthropods and conspecifics, nesting, or evading predators. Within dense vegetation, a typical flight path consists of a sequence of maneuvers through consecutive small openings linked by translational flight segments. Because hummingbirds can fly sideways, ascend vertically, and also hover, multiple techniques may be used to negotiate constrictions. How do the shape and size of an opening affect a bird's technique? And how do metrics of flight performance such as translational and rotational velocities relate to aperture attributes? We trained foraging Anna's Hummingbirds to fly through elliptical apertures within a vertical partition. Aperture width and height ranged between one half and one wingspan in length. Using high−speed video to determine multiple kinematic parameters in three dimensions, we identified several different maneuvers that hummingbirds use to traverse small openings. Studying hummingbird flight within confined spaces and the clutter of natural vegetation will allow better understanding of their ecological capacity as pollinators, and can inspire new designs and kinematic strategies for small flying robots.

130.6 BAECKENS, S.*; EDWARDS, S.; HUYGHE, K.; VAN DAMME, R.; University of Antwerp, Stellenbosch University; *simon.baeckens@uantwerpen.be*

Interspecific variation in chemical signal devices in lacertid lizards − A family−wide comparison of femoral pore numbers

Animals communicate through an astonishing variety of signals and displays. The effects of the physical environment on various characteristics of the sensory channels have been studied extensively for visual and acoustic communication systems. Much less is known on how the environment affects the evolution of chemical communication. Lizards are known to possess a remarkable diversity of glands, but only recently the role of their chemicals became apparent in lizard social behavior, i.e. prey detection, predator avoidance and mate recognition. Femoral glands produce a secretion that finds its way to the external world through epidermal structures, the so− called *femoral pores*. With more than 250 species inhabiting a wide variety of habitats, the family Lacertidae constitutes an excellent model to study the effects of the physical environment on the evolution of chemical communication. Our preliminary inquiries revealed considerable among−species variation in the number of femoral pores (0−35 per limb), suggesting that chemical signalling systems of different species may be under strong divergent selection. In this study, we test the hypothesis that the number of pores (a proxy for the investment in chemical signalling) varies among species living on different substrates and in different climatic conditions. We expect that chemical communication will be more challenging for species living in complex, rapidly changing, ephemeral environments (e.g. moist vegetation, flimsy), on adsorptive substrates (e.g. sands versus rocks) or in warm, humid and windy environments, due to the lower detectability and/or signal persistence. This hypothesis is tested in an explicit phylogenetic context, by constructing a phylogenetic tree from available DNA sequences of 213 species covering all sampled lacertid genera.

33.7 BAGGE, L.E.*; KIER, W.M.; JOHNSEN, S.; Duke University, University of North Carolina at Chapel Hill; *leb47@duke.edu*

Clearly camouflaged: muscle architecture in transparent shrimp

Transparency is a common camouflage strategy for small, thin, or gelatinous animals inhabiting pelagic environments, but is rare among larger species with more complex body plans, especially those inhabiting benthic environments. Nevertheless, many shrimp species in the genus *Periclimenes* are extraordinarily transparent despite having a relatively large (>10 mm) body size and a benthic, commensal existence with anemones; they are clear enough to read a newspaper through their abdomen. Absence of pigment is insufficient for transparency as their tissues also must not scatter light. Because anemone shrimp are not extremely small or flat, and their tissues cannot be made of one component with one refractive index, we investigated whether other morphological and ultrastructural modifications for transparency were present. We examined the muscle tissue in three transparent species of *Periclimenes* (*P. rathbunae*, *P. yucatanicus*, and *P. pedersoni*), and in more opaque shrimp species (*Thor amboinensis* and *Lysmata wurdemanni*), which share the same ecology and microhabitat. All specimens were collected from anemones near Carrie Bow Cay, Belize. The shrimp were fixed in 2.5% glutaraldehyde, and tissue blocks were dissected from the posterior abdomen and embedded in glycol methacrylate to minimize distortion. Cross−sections of 3−7 ¼m thickness were cut with a glass knife and stained with Picrosirius Fast Green stain, which allowed for visualization of the arrangement of the muscle fibers. Examination of these sections showed that, at least at light level, the musculature in transparent shrimp is not grossly atypical; therefore, their transparency is likely to be a result of more subtle differences in ultrastructure, which we are investigating with transmission electron microscopy.

S6.2−1 BAGHERI, N; Northwestern University; *n−bagheri@northwestern.edu*

Computational analysis of signaling data elucidates dynamic regulatory networks that govern complex cellular responses.

A unique and evasive property of biological systems relates to their ability to move between multiple stable states, confer resilient responses, and respond consistently to dynamic inputs/stimuli despite an ever−changing, noisy environment. Such robust cellular responses are often attributed to complex underlying regulatory mechanisms that remain largely undefined.

In the past decade, emerging technologies have offered increasingly high throughput data with greater resolution to investigate cellular responses. To gain insight from dynamic gene expression, transcription factor activity, phospho−signaling or other data, improved computational strategies to analyze, integrate, and predict complex biological function must be developed. We employ a variety of inference and modeling algorithms to investigate the temporal and multifunctional evolution of various cellular responses. Specifically, we use perturbation data of cancer and stem cell models to gain insight on the signaling mechanisms that control highly integrated functions. By developing predictive models that are informed by novel experimental approaches namely, microwestern arrays and transcription factor arrays we are able to resolve the regulatory pathways responsible for complex biological response and cell fate decisions. We use such systems−level approaches to investigate how short−term transcription factor and phosphorylation dynamics govern cell phenotype. In this manner, we can generate informed hypotheses on the mechanism of action of potential drug candidates and gain insight for improved efficacy/specificity of treatment strategies, providing a unique opportunity to predict and modulate biological responses.

126.6 BAHLMAN, J*; LIPPE, H; BREUER, K; SWARTZ, S; University of British Columbia, Brown University; *batman@zoology.ubc.ca*

Diversity and functional consequences of reducing synovial joints in bat wings

Bat wings, like other mammalian limbs, contain many joints within the digits. These joints collectively affect dynamic 3D wing shape, thereby affecting the amount of aerodynamic force a wing can generate. Bats are a speciose group, and show substantial variation in the number of wing joints. Additionally, some bat species have joints with extensor but not flexor muscles. While numerous studies have examined the diversity in number of joints and presence of muscles, musculoskeletal variation in the digits has not been interpreted in phylogenetic, functional, or ecological contexts. To provide this context, we quantify the number of joints and the presence/absence of muscles for 44 bat species, and map them phylogenetically. We show that, relative to the ancestral state, joints and muscles were lost and regained multiple times in many lineages and on different digits. Comparison of species with contrasting feeding ecologies demonstrates that those that feed primarily on non−mobile food (e.g. fruit) have fewer fully active joints than species that catch mobile prey (e.g. insects). We hypothesize a functional tradeoff between energetic savings and maneuverability. Having fewer joints reduces the mass of the wing, thereby reducing the energetic requirements of flapping flight. The presence of more joints increases the spectrum of possible 3D wing shapes, potentially enhancing the range and fine control of aerodynamic force production and maneuverability.

P1.136 BAILEY, A.M.*; GREIVES, T.J.; LEGAN, S.J.; DEMAS, G.E.; Indiana University, Bloomington, North Dakota State University, Fargo, University of Kentucky, Lexington; *allibail@indiana.edu*

RFamide peptides differentially regulate HPG axis activity according to seasonal reproductive condition in female Siberian hamsters

Seasonally breeding mammals use photoperiod to limit reproduction to favorable conditions. Changes in day length trigger endocrine adjustments in the hypothalamo−pituitary−gonadal (HPG) axis, resulting in activation or suppression of reproduction. Recently, two RFamide neuropeptides, kisspeptin and RFamide related peptide (RFRP−3), have been hypothesized as seasonal regulators of the HPG axis. Exogenous kisspeptin imparts a robust stimulatory effect on the HPG axis, whereas the function of RFRP−3 is less clear and varies across species and reproductive conditions. In this study, we investigated the function of these two neuropeptides across photoperiods and subsequent reproductive states in female Siberian hamsters (*Phodopus sungorus*). We examined the HPG axis response to exogenous kisspeptin and RFRP−3 by administering each neuropeptide alone, as well as combining an effective dose of kisspeptin (10µM) with each of three doses of RFRP−3 (10µM, 20µM, 40µM). We measured serum luteinizing hormone in three groups of female Siberian hamsters: long−day (LD) reproductively active females, short−day responsive (SD−R) reproductively quiescent females, and short−day unresponsive (SD−NR) reproductively active females. Kisspeptin alone stimulated the HPG axis in all three groups of females. RFRP−3 alone appeared to generally have a stimulatory effect, particularly in SD−R females. When the two were combined, kisspeptin's stimulatory effect was attenuated in LD females, but enhanced in SD−NR females. These results suggest complex interactions of these peptides in relation to reproductive context and contribute to our understanding of the neuroendocrinology of seasonal reproduction.

74.7 BAIRD, A. J.*; MILLER, L. A.; University of Carolina, Chapel Hill; *abaird@live.unc.edu*

Electro−dynamic suction pumping in Ascidian Hearts

Dynamic suction pumping is characterized by a bidirectional elastic wave and a non−linear frequency flow relationship. This pumping mechanism has been proposed as the driving mechanism for the vertebrate embryonic heart at the tubular stage. In this study, we consider the tubular, valveless heart of a chordate, the Ascidian *Clavelina picta*. These hearts operate at a Womersley number of about 0.3. We investigate traditional dynamic suction pumping on these small scales and show computationally and experimentally that significant flow isn't achieved. We propose a different pumping mechanism that couples traveling waves of depolarization to the contraction of the boundary. Active contractile waves replace passive elastic waves, but the resulting kinematics are similar to dynamic suction pumping. This pumping mechanism can be computationally shown to drive fluid flow at the low Womersley numbers found in Ascidian hearts.

P3.139 BAKER, EM*; HESSEL, A; NISHIKAWA, K; Northern Arizona University; *emb324@nau.edu*

Salamanders Head Over Heels

In geckos, falling is like jumping because the tail corrects direction of movement. A study by Ardian et al. showed that geckos use their tails to keep from injuring themselves while falling. The geckos were released above the ground and filmed with high−speed cameras, which showed the tail alone generating righting maneuvers. After removal of the tail, geckos were unsuccessful at landing prone. Plethodontid salamanders jump using a unique mechanism. Jumping has mostly been observed in more developed vertebrates like geckos and lizards. Plethodontids' legs and tails have been considered too underdeveloped for vertical movement, but studies have shown that can be counteracted by using axial musculature during jumps. Therefore, the functionality of the salamanders' tail may be neglected. In a similar fashion, can plethodontid use their tails to adjust body posture in air? Do Plethodontids use their tails like geckos, or do they lack muscle development? We hypothesized that salamanders use the tail to right themselves in air, but not as well as geckos. We ran trials that mimicked the gecko study by filming falling salamanders. After retrieving successful trials from salamanders, we removed the tail and ran the experiment again to see if tail loss affected landing. We designated a successful fall as ending with the body in a prone position. Preliminary data shows that salamanders use their tails to correct orientation, like geckos. Salamanders show individual variability in how they correct their body orientation, including the timing and direction of tail rotations. Not all jumps were successful, showing a system that needs fine−tuning. Interestingly, successful fallers are often good jumpers, perhaps showing the importance of the tail in in−air stability as well. These results suggest that a new analysis of early tail functionality in non−arboreal amphibians should be pursued.

102.1 BAKKEN, G.S.*; KROCHMAL, A.R.; ANGILLETTA, M.J.; Indiana State University, Washington College, Arizona State University; *george.bakken@indstate.edu*

Avoiding Errors When Measuring Operative Temperature

Climate change may increase average air temperatures by 2 − 4° C by 2100. To predict the resulting shifts in life histories and species' ranges, we need to reliably measure microclimates with precision better than the expected change due to global warming, particularly at margins of distributions. These microclimates include wind and radiation, which change independently of air temperature. Operative temperature (T_e) is a useful integrated thermal parameter that combines air temperature and radiative heating as modified by wind. In principle, T_e can be measured directly using physical models as T_e thermometers. These models explore the environment at the spatial scale of the animal and are relatively inexpensive to produce in large numbers. Although many studies consider anatomical details as unimportant and use simple cylindrical sensors or TidBits® , these can yield errors in Te estimation ranging from 2 − 14° C. While random error decreases as sampling increases, poorly designed T_e thermometers create systematic errors that might be confounded with climate change. Model validation is thus essential. We demonstrate the importance of anatomical details by comparing temperatures of Eastern painted turtles against those of simple and detailed T_e thermometers. As tethering animals for such comparisons poses risks of heat stress, we developed an alternative approach where predicted and measured body temperatures of freely moving animals were compared for a simple habitat. This approach detects unanticipated effects of movement and tests the ability to predict body temperature from operative temperature.

43.6 BALABAN, J.P.*; WILGA, C.D.; Univ. of California, Irvine, Univ. of Rhode Island; *jbalaban@uci.edu*

Morphology of the Feeding Apparatus in Four Shark Species

Sharks have an incredible diversity of feeding mechanisms for a group with so few extant species. To understand the relationship between the morphology of the shark feeding apparatus and feeding style, length, width, and angle of the ten skeletal elements in the feeding apparatus are measured in four shark species (white spotted bamboo, *Chiloscyllium plagiosum*; spiny dogfish, *Squalus acanthias*; sandbar, *Carcharhinus plumbeus*; and dusky smoothhound, *Mustelus canis*). These species encompass a wide phylogenetic range, and include suction and bite feeders as well as two different orientations of the hyomandibula, the primary jaw support element. A principal components analysis is used to identify relationships among the skeletal elements by species, and linear regressions are then used to test the effect of hyomandibula length on the other morphological variables. Strong relationships were discovered between the length of the hyomandibula and the lengths of all other skeletal elements and the angle of the hyomandibula. Bite feeders have longer elements and appear to maximize the size of the oral cavity, allowing larger prey to be swallowed. Suction feeders have shorter elements, which restrict the size of the oral cavity and mouth opening, but can concentrate suction forces.

29.3 BALANOFF, A.M.; Stony Brook University School of Medicine; *amy.balanoff@stonybrook.edu*

The Deep History of the Avian Brain

Many of the characters that have historically been associated with living birds, crown group Aves, such as a feathers and a furcula and even behaviors like brooding nests of eggs are now known to have originated much deeper in the evolutionary history of the lineage than previously thought, among non−avian dinosaurs. An earlier origin also looks to be the case for the evolution of the avian brain. Volumetric analyses of the endocranium along the avian lineage reveal that a "bird−like" brain first appears early within maniraptoran dinosaurs, yet the morphology of the brain within this group, which includes living birds, has yet to be assessed. A modern bird brain exhibits a suite of characters that vary little across the avian tree. Such characters include but are not limited to laterally displaced optic lobes, retracted olfactory tracts and reduced bulbs, an enlarged cerebrum with a prominent sagittal eminence, and folded cerebellum. Using endocranial renderings derived from CT data of fossil and extant taxa, I examined the distribution of these and other characters along the entire maniraptoran lineage. Consistent with other character systems, most "bird−like" features of the brain are not restricted to the crown group but have a much longer evolutionary history. Furthermore, relatively few characters now diagnose the avialan clade. Instead, the base of Avialae as exemplified by the stem bird *Archaeopteryx lithographica* exhibits a generally plesiomorphic morphology that can be diagnosed by characters shared with maniraptorans and paravians.

60.6 BALAVOINE, G; Institut Jacques Monod, CNRS / Univ. Paris Diderot, Paris; *balavoine.guillaume@ijm.univ−paris−diderot.fr*

Annelid Segmentation Genes And The Origin Of Arthropod Parasegments

Segmentation is one of the most important characteristics of body plan organization. Broadly defined, it is present in most major animal groups. There is a vigorous debate about its evolutionary origin connected to the crucial question of the origin of complexity in animal evolution. We are studying the genetic networks responsible for the formation of segments in the marine annelid *Platynereis dumerilii* as a representative of the most extensively metamerized animal phylum and a member of the third great branch of bilaterians, Spiralia. We have identified a number of homeobox genes that displays segment polarity−like expression patterns, including *engrailed*. Likewise, components of the hedgehog and Wnt/^{2} −catenin signaling pathways are expressed in striped patterns prior to morphological segmentation. By using small molecule inhibitors, we have shown that both hedgehog and ^{2} −catenin pathways are required for establishing the axial properties of segments, similar to arthropods. The alignment of the expression patterns of segment polarity genes suggests a strong correspondence between the segmental boundary of *Platynereis* and the parasegmental boundary of arthropods. We interpret these data as showing that: (1) the last common ancestor of protostomes was a segmented annelid−like animal; (2) the parasegmental patterning of arthropods recapitulates the ancestral protostome metamerism. The cuticular segmentation of arthropods has evolved later on, both in evolution and embryogenesis and therefore develops through a process of resegmentation.

33.8 BALDWIN FERGUS, JL; Smithsonian National Museum of Natural History; *baldwin−fergusj@si.edu*

Color vision in a deep sea crustacean, the hyperiid amphipod Paraphronima gracilis

The mesopelagic realm, oceanic depths of 200 to 1000 meters, is often described as the twilight zone. Here, the struggle to perceive dim down−welling light and bioluminescent point sources and the need to remain unseen have generated a suite of optical adaptations, including a broad variation in eye design. Hyperiid amphipods are abundant members of the mesopelagic fauna worldwide. These small crustaceans are known for their widely varying and fascinating visual adaptations. The two species of the genus *Paraphronima* are no exception. In these, the eyes dominate the head and body of these small creatures, taking up about 30% of the body size, and featuring a large clear zone with paired retinas near the ventral surface. To better understand visual function in these little known crustaceans, the spectral sensitivity of *Paraphronima gracilis* (collected from Monterey Bay Canyon) was examined using microspectrophotometry. The primary visual pigment present in the eye has a λ_{max} of 497 nm (N=118). A short wavelength photopigment with a λ_{max} between 360 and 380 nm was only found in two of the animals sampled (N=15). The results suggest sensitivity to both short and medium wavelength light and imply the possibility of color vision. Results will be discussed in regard to habitat and lifestyle.

S2.1−2 BALENGER, Susan L.*; ZUK, Marlene; University of Minnesota, Twin Cities; *sbalenge@umn.edu*

Testing the Hamilton−Zuk hypothesis with 21st century genetic tools

Hamilton and Zuk proposed a good genes model of sexual selection in which genetic variation (and, thus, selection) can be maintained when females prefer ornaments that indicate parasite resistance. When trait expression depends on a male's resistance, the coadaptive cycles between host resistance and parasite virulence provide a mechanism in which genetic variation for fitness is continually renewed. Predictions of this model included expectations at both the intra− and interspecific levels. In the three decades since its publication, these predictions have been examined in models of varying complexity and tested across dozens of vertebrate and invertebrate taxa. Despite such prolonged interest, however, it has turned out to be much more difficult to empirically demonstrate the process described, in part because we have not been able to test the underlying mechanisms that would unequivocally identify how parasites act as mediators of sexual selection. Here we discuss how high throughput sequencing datasets might improve our ability to ultimately test this model. We expect that important contributions will come through the ability to identify and quantify the suite of parasites that are likely to be concurrently influencing host resistance evolution, improved phylogenetic reconstruction of both host and parasite taxa, and, perhaps most exciting, the ability to identify generational cycles of heritable variants in populations of hosts and parasites. Integrative approaches, building on current models of antagonistic coevolution and on the genomics of systems undergoing parasite−mediated natural selection, will be particularly useful in moving us towards true tests of this hypothesis. We finish by more generally summarizing how these tools might be of broader interest to the field of behavioral ecology.

P2.117 BALES, TB*; STRAND, CR; Cal Poly State University, San Luis Obispo; *cstrand@calpoly.edu*

Proliferation, migration, and survival of cells in the adult telencephalon of the ball python, Python regius

Reptiles exhibit neurogenesis throughout the brain during adulthood. However, very few studies have quantified telencephalon−wide neurogenesis in adulthood, and no studies have performed these investigations in snakes. Quantifying neurogenesis in the adult snake is essential to understanding class−wide adult neurogenesis and providing insight into the evolution of this trait. To quantify cell proliferation, migration, and survival in the ball python (*Python regius*) we subcutaneously injected 100mg/kg BrdU into 15 adult male *P. regius* at 3 different time points (2 days, 2 weeks, 2 months) prior to sacrifice to quantify proliferation, migration, and survival of cells in several telencephalic subregions. After sectioning and immunohistochemical staining, we found proliferation to be highest in the anterior olfactory bulb (AoB), retrobulbar regions, dorsal ventricular ridge (DVR), posterior DVR (pDVR), septum (S) and posterior nucleus sphericus (pNS). Of the proliferating cells, the proportions of cells that migrated after 2 weeks were highest in the ventral lateral region (VL), anterior medial and lateral cortices (aMC, aLC), and anterior NS (aNS). After 2 months, the highest proportional survival was in the AoB, aLC, aMC, aNS, DVR, and ventral medial regions (VM). Regions involved in long−term functions like spatial memory may require less proliferation and longer survival, while regions involved in short−term functions undergo more proliferation with higher attrition.

91.2 BALIGA, V.B.*; MEHTA, R.S.; Univ. of California, Santa Cruz; *vbaliga@ucsc.edu*

Ontogenetic transitions from cleaning behavior are associated with shifts in cranial morphology in Thalassoma wrasses

In fishes, cleaning is a mutualistic behavior wherein a species will remove and consume ectoparasites or damaged tissues from other organisms. While over 120 species of teleost fishes exhibit cleaning behavior, more than two thirds of these species display it predominately as juveniles, and are referred to as "facultative juvenile cleaners". Whether allometric changes in morphological traits are correlated with ontogenetic shifts from cleaning in the adult stage is unknown. Here, we tested the hypothesis that the transition from cleaning is associated with key allometric shifts in the feeding apparatus of facultative juvenile cleaners. We measured traits such as vertical gape distance, adductor mandibulae mass, and maxillary KT for ontogenetic series of specimens in a variety of *Thalassoma* wrasses (Labridae). As these fishes predominately capture prey via biting, we used MandibLever (v3.3) to create an ontogenetic trajectory of bite force for each species. Results indicate that facultative juvenile cleaners, when compared to closely−related non−cleaners, are relatively weak biters with small gapes, but shift to being stronger biters as adults. Shifts in maxillary KT towards an increase in forceful jaw movement also characterize these facultative species. Our results indicate that the functional basis for cleaning behavior in *Thalassoma* wrasses lies in slower−moving, relatively weaker−biting jaws in the juvenile condition. These traits ostensibly put these species at a competitive disadvantage with sympatric, non−cleaning congeners as juveniles, perhaps indicating cleaning behavior in *Thalassoma* wrasses is a result of competitive displacement. Through ontogeny, these facultative cleaner fishes develop the ability to compete with such congeners through an allometric increase in bite force, which possibly obviates the need to continue cleaning.

102.7 BARNES, BM*; TOIEN, O; Univ of Alaska Fairbanks; *bmbarnes@alaska.edu*

Thermoregulation and energetics in hibernating black bears: The mystery of multi−day body temperature cycles.

Black bears overwintering in outdoor hibernacula in Fairbanks, Alaska don't move much, reduce whole body metabolism to as low as 25% of basal rates, and decrease core body temperature (T_b) from summer levels of 37−38 °C to a hibernation season average of 33 °C. T_b is not stable during hibernation, however, but instead displays cycles of 2−7 days in length and amplitudes reaching 6 °C. The cause of and reason for these unusual T_b cycles are not known, although we do not believe they are homologous to spontaneous arousals in small mammalian hibernators. To investigate the dependency of T_b cycles on thermoregulatory conditions, we kept 12 hibernating bears with body mass from 35.5−116.5 kg in undisturbed outdoor enclosures and manipulated den temperature (T_{den}) while recording bear T_b, metabolic rate, shivering, and movement. Bears shivered to produce heat preventing T_b from decreasing below 30 °C. T_b cycles shortened as T_{den} decreased (mean R^2 = 0.70), suggesting that cooling rate determines period length, however large bears with lower thermal conductance had the same or shorter T_b cycle length than small bears. Metabolic rate averaged over complete T_b cycles was negatively correlated to T_{den} below lower critical temperatures, which varied among bears from 1.4°C to 10.4°C. We conclude that the patterns of T_b cycling in hibernating black bears is related to the demand for thermoregulatory heat production by shivering, but we can only speculate as to their functional significance.

P1.43 BASHEVKIN, S*; WESSEL, G; GEORGE, S.B.; Tufts University, Medford, Massachusetts, Brown University, Providence, Rhode Island, Georgia Southern University, Statesboro, Georgia; *georges@georgiasouthern.edu*

The effects of fluctuating salinity on protein profiles in echinoderm larvae of Dendraster excentricus and Pisaster ochraceus

Salinity fluctuations are common in the Salish Sea of the Pacific Northwest and are expected to become more common as global warming continues to increase the rate of glacial melting. Increased freshwater into the Salish Sea via rivers can cause the salinity to drop to 20 ppt from the normal level of 30. This occurs during the summer months when many marine invertebrates are reproducing. Echinoderms are especially affected since they cannot osmo− or ion−regulate. In this study we investigated the effects of fluctuating salinity on protein expression in larvae of 2 ecologically important echinoderms: the sand dollar *Dendraster excentricus* and the seastar *Pisaster ochraceus*. Larvae were reared in 2 treatments: control (constant salinity of 29−30 ppt) and fluctuating salinity (salinity dropped to 21 ppt for 2 days every ~7 days). Larvae were sampled periodically, analyzed for protein content by the Bradford Assay, and proteins separated by SDS−PAGE. *Pisaster* larvae exposed to fluctuating salinity expressed more large molecular weight proteins (301−310 and 240 kDa) than those in the controls. *Dendraster* larvae exposed to fluctuating salinity expressed more small molecular weight proteins (48, 74, 34, and 15 kDa) while those in the controls expressed more of a 97 kDa protein. Several proteins remained unchanged regardless of treatment, including 180, 98, and 81−82 kDa proteins in *P. ochraceus* and a 46−47 kDa protein in *D. excentricus* larvae. This is the first study to report the effects of low salinity on protein expression in echinoderm larvae. Future studies will identify these proteins and determine whether they function in metabolism, skeletogenesis, ion−transport or muscle development.

99.5 BASTIN, B.R.*; CHOU, H.; PRUITT, M.M.; SCHNEIDER, S.Q.; Iowa State University; *brbastin@iastate.edu*

Temporal and spatial expression of the Frizzled gene family in a spiral−cleaving embryo

Wnt signal transduction pathways are highly conserved in most metazoans and involved in many developmental processes from cell fate specification to axis formation. Proteins with Frizzled cysteine rich domains play key roles within these pathways: Frizzleds as Wnt ligand receptors transmitting signaling events and Secreted Frizzled Related Proteins (SFRPs) as Wnt signal modulators. Comparative genomic analysis revealed that four distinct frizzled receptor genes and two SFRP genes were present in the last common bilaterian ancestor. Currently, little is known about the complement and roles of the Frizzled gene family in spiralians, a large group of animal phyla including mollusks and annelids. We made use of embryos of the marine annelid *Platynereis dumerilii* whose cell lineage has been described, and where canonical wnt/beta−catenin signaling was previously implicated to distinguish between sister cell fates throughout early development. We found that the genome of *P. dumerilii* retained copies of the four Frizzled and two SFRP ancestral genes as well as an additional Frizzled−related gene. Here we utilize stage specific RNA−seq and *in situ* hybridization to define the temporal and spatial expression of each of these genes during early development. Those expressed early exhibit either a polarized expression along the animal−vegetal axis or cell lineage specific expression. As has also been found in cnidarians and echinoderms, Frizzled1/2/7 transcripts are most prominent and maternally provided. This is the first comprehensive analysis of Frizzled and Frizzled related genes in a spiral−cleaving embryo, and a first glimpse at how these potent developmental regulators may influence patterning in spiralians.

P3.110 BATEMAN, T.F.K.*; MCLELLAN, W.; PISCITELLI, M.; HARMS, C.; BARCO, S.; THAYER, V; CLARK, K; POTTER, C; PABST, D.; UNC Wilmington, Univ. Bristish Columbia, NC State Univ., VA Aquarium, NC Div. Marine Fisheries, Wildlife Resources Comm., Smithsonian Institution; *tfk9187@uncw.edu*

Crassicauda infections in kogiid whales

Nemathelminthes of the genus *Crassicauda* are known to infect a variety of cetacean species. In delphinids and mysticete whales, *Crassicauda* infects the urogenital system and cranial pterygoid sinuses, and contributes to morbidity and mortality. *Crassicauda* was first described in kogiid whales by Johnson and Mawson (1939) and later by Dollfus (1966) as infecting the neck musculature, an uncommon habitat for this parasite. Despite their known pathogenic effects on other cetaceans, no systematic review has been conducted on *Crassicauda* in either the pygmy (*Kogia breviceps*) or dwarf (*Kogia sima*) sperm whales. We conducted a retrospective investigation of stranded kogiids to determine the prevalence of *Crassicauda* in both species, and to describe its location within its host. Individual kogiid stranding records for North Carolina and Virginia from 1998−2013 were examined (n=125). Of those, 64 *K. breviceps* and 40 *K. sima* records contained sufficient data to assess *Crassicauda* prevalence. Our results reveal that *Crassicauda* only infects *K. breviceps* (prevalence of 42%). This species−specific infection pattern may serve to elucidate ecological differences between the closely related kogiids. *Crassicauda* was found exclusively in the cervico−thoracic region, in vascular beds that feed the central nervous system, and throughout thoracic organs. There was also a marked association with the "gill slit" gland, an exocrine gland in the ventral neck. The distribution of *Crassicauda* suggests that it may contribute to morbidity and mortality in the pygmy sperm whale, and that more thorough gross and histological investigations are warranted.

38.5 BATTELLE, B−A.*; KEMPLER, K.E.; PAYNE, R.; Whitney Lab. Univ. of Florida, Univ. of Maryland, College Park; *battelle@whitney.ufl.edu*

Photoreceptors with dual sensitivity to UV and visible light are in the larval eyes of the basal arthropod Limulus polyphemus

Limulus is a classic model for studies of vision. It has three types of eyes: lateral compound eyes (LE), median ocelli (ME) and lateral, median and ventral larval eyes. Larval eyes probably provide phototic information to embryos and newly hatched larvae: they contain both giant (150 µm long) and smaller (45 µm long) photoreceptors. Classic electrophysiological studies suggested all three eye types contain photoreceptors sensitive to visible light and only MEs contain photoreceptors sensitive to UV light. However, we showed that a UVopsin (LpUVops) is expressed in each eye type: in most ME photoreceptors; in LE eccentric cells, a cell type classically considered a second order neuron; and in small photoreceptors of the ventral larval eye (VE). Small VE photoreceptors also express LpOps5, a visible light sensitive opsin, suggesting they respond to both UV and visible (VIS) light. By contrast, giant VE photoreceptors only express visible light sensitive opsins. Intracellular recordings have now confirmed two spectral types of VE photoreceptors. One has spectral properties characteristic of giant VE photoreceptors with a major peak of sensitivity at 520nm and a minor peak at 360nm. The second type also has a peak at 520nm but an even larger peak at 360nm. This spectrum probably originates from small VE photoreceptors and indicates that both LpOps5 and LpUVops drive phototransduction in these cells, and that they are UV−VIS cells. In UV−VIS cells, maximum sensitivity at 520nm varies considerably relative to that at 360nm. This is consistent with immunocytochemical results showing that the rhabdomeral level of LpOps5 varies in a light−dependent manner while that of LpUVops does not. Thus the spectral tuning of the UV−VIS cells may change day to night.

P1.21 BATTLE, K.E.*; FOLTZ, S.; MOORE, I.T.; Virginia Tech, Blacksburg; *keb8392@vt.edu*

Corticosterone Levels and Urbanization Effects on Flight Initiation in Song Sparrows (Melospiza melodia) and Northern Cardinals (Cardinalis cardinalis)

Urbanization can impact fauna by altering their behavioral responses to human presence and activity. Certain traits such as boldness or habituation to humans may be favored to enable their coping with urban challenges. Such traits are components of and characterize an individual's "behavioral syndrome," which likely has physiological control mechanisms. We sought to understand how the urban environment may affect or select for boldness and habituation traits in male Song Sparrows (*Melospiza melodia*) and Northern Cardinals (*Cardinalis cardinalis*). For sparrows, we measured flight initiation distance (FID; distance at which birds initiated flight when approached by a single observer) as well as corticosterone levels and territorial aggression. For cardinals, we measured only FID. For both species, urban birds allowed a closer approach than did rural birds. Within both urban and rural habitats, sparrows allowed a closer approach than did cardinals. Results not only reinforce previous findings that urban birds are more habituated to humans but also demonstrate significant differences in behavioral syndromes across species. Comparing these results with endogenous corticosterone levels and aggression scores will further our understanding of the mechanisms underlying urban adaptations in fauna.

S4.1−3 BAUCOM, RS*; CHANEY, L; University of Michigan; *rsbaucom@umich.edu*

The prevalence of fitness costs of tolerance across organisms

Tolerance, or the ability to maintain fitness in the face of damage, has been studied in plant evolutionary ecology for more than twenty years and is now of great interest to workers in ecological immunology. Most plant systems that have assessed tolerance find the presence of genetic variation underlying this trait, which implies that it is not at a maximum level in nature. Fitness trade−offs and other ecological constraints may maintain intermediate levels of tolerance, and in fact, in plants, fitness costs of tolerance to herbivory appear to be the rule rather than the exception. However, it is unknown if tolerance to other agents of damage in plants, as well as tolerance in other organisms, confers a fitness cost. Here, we perform literature searches and a meta−analysis to determine the ubiquity of fitness costs associated with tolerance across many agents of damage, and report on the general trends uncovered across organisms.

22.4 BAUER, C.M.*; EBENSPERGER, L.A.; HAYES, L.D.; ROMERO, L.M.; Tufts University, Medford, MA, Pontificia Universidad Católica de Chile, University of Tennessee at Chattanooga; *carolyn.bauer@tufts.edu*

Maternal effects of stress in a plural−breeding rodent

The quality of parental care has significant impacts on offspring fitness. In laboratory rodents, chronically stressed mothers have shorter nest bouts and spend less time licking and grooming pups, resulting in pups with hyperactive stress responses. These hyperactive stress responses are characterized by high cortisol (CORT) levels in response to stressors plus poor negative feedback, which can ultimately lead to decreased reproductive output and survival. In degus (*Octodon degus*) and other plural−breeding rodents that practice communal care, however, maternal care from multiple females may increase the fitness of pups born to less parental mothers. We used wild degus to test the hypothesis that plural breeding with communal care buffers post−natal stress. We used radiotelemetry to determine social group membership, and directly after parturition assigned each social group to one of three treatments: CORT, Mixed, or Control. In CORT groups, all females were implanted with cortisol pellets, while 50% and 0% of females were implanted in Mixed and Control groups, respectively. When pups emerged from burrows at four weeks of age, we sampled them for baseline and stress−induced CORT, and in addition assessed their negative feedback efficacy via a dexamethasone suppression test. CORT and Mixed pups were older at emergence and had weaker negative feedback compared to Control pups. Contrary to expectations, stress−induced CORT did not differ between treatment groups and CORT pups had lower baseline CORT compared to Control and Mixed pups. These data suggest that maternal stress impacts some aspects of the pup stress response, but that unstressed mothers may be able to mitigate some of these effects.

114.1 BAUGH, A.T.*; VAN OERS, K.; DINGEMANSE, N.; HAU, M.; Swarthmore College, Netherlands Institute for Ecology, Max Planck Institute for Ornithology, Max Planck Institute for Ornithology; *abaugh1@swarthmore.edu*

The variance within: stress hormone levels vary and co−vary within but not among individual wild great tits Parus major

Circulating steroid hormones, such as glucocorticoids, can have diverse and enduring effects on the phenotype and might serve as a basis for individual differences in hormone−mediated traits. To understand the extent and basis of variation in the circulating concentrations of hormones themselves it is important to accurately decompose within− and among−individual variance components. Previous research in songbirds suggests that concentrations of glucocorticoids exhibit individual consistency, but the variance and covariance of plasma hormones in free−living animals remains poorly understood. In the present study, we repeatedly captured individual great tits *Parus major* from a wild population and measured their initial and stress−induced plasma corticosterone (CORT) levels. We evaluated variances and covariances in these concentrations using a mixed−modeling (character−state) approach. First, we examined within− and among−individual variances in initial (CORT0) and stress−induced levels (CORT30) and found little evidence of repeatability in either measure. Next, we examined the covariance between CORT0 and CORT30. As predicted, given the lack of repeatability, we found no among−individual covariance in these two measures i.e. average initial levels did not correlate with average stress−induced levels. We did find, however, strong within−individual correlations suggesting that an underlying environmental factor(s) simultaneously modulates changes in initial and stress−induced levels within the same individual. Together, these results suggest that plasma glucocorticoid concentrations are determined principally by acute environmental or state−dependent factors.

12.4 BAY, L. K.; DAVIES, S. W.; MATZ, M .V.*; Australian Institute of Marine Science, University of Texas at Austin; *matz@utexas.edu*

All set for adaptation: high heritability of heat tolerance and associated gene expression in a reef−building coral

Reefs along the length of the Great Barrier Reef (GBR) differ widely in mean temperature and temperature variability, yet maintain high genetic connectivity of broadcast−spawning corals. This creates the potential for rapid evolutionary rescue of coral populations from ocean warming, but only if there is pronounced heritable variation in heat tolerance among locations. To investigate this issue, we crossed two parental colonies of Acropora millepora from Orpheus Island (middle GBR, cool location) with two colonies from Princess Charlotte Bay (northern GBR, warm location) in a diallel crossing design and quantified mortality of the larval families under heat stress. Parental effects were responsible for >80% of the variation in mortality, with narrow sense heritability on the order of 0.5 (0.95 credible interval: 0.26−0.95). To identify genes associated with larval heat tolerance, we correlated larval mortality rates with gene expression measured prior to stress exposure. We also measured gene expression in the parental colonies under both benign and heat−stress conditions. Comparing gene co−expression networks between larvae and their parents and with previous data on larval gene expression under heat stress, we find that (i) gene expression variation is strongly heritable and is predominantly additive, and (ii) higher larval heat tolerance and associated gene expression are strongly correlated with the parental origin from the warmer GBR location. Notably, the majority of genes associated with heat tolerance are not involved in the heat stress response itself. We conclude that heat tolerance in the A. millepora larvae has strong genetic basis and is highly variable among coral populations along the GBR, which should favor evolutionary rescue as climate change progresses.

87.2 BøRVE, A.; RYAN, J.F.; HEJNOL, A.*; Sars International Centre for Marine Molecular Biology, Univ. of Bergen; *andreas.hejnol@sars.uib.no*

A convergent dorsal nervous system condensation in the Acoelomorpha driven by the BMP−synexpression group

Nervous system condensations such as the ventral or dorsal nerve cord or anterior condensations such as the brain are an important character of animals. How often such condensations have been evolved is still a hotly debated topic in zoology. Careful investigations of the developmental processes underlying such condensations can contribute to the understanding of the evolutionary origins of such condensation−events. We have focused our investigations of the group Acoelomorpha that comprises Acoela, Nemertodermatida and Xenoturbellida. All species share a basiepidermal nerve−net−like nervous system but Acoela can have additional 3−4 pairs of nerve cords along the body and an anterior brain. Nemertodermatids in contrast only possess two cords composed out of axon−tracts on the dorsal side. We investigated the molecular patterning of the nervous system in two species the nemertodermatid *Meara stichopi* and the acoel *Isodiametra pulchra*. Our results show that the anterior−posterior and dorso−ventral patterning systems in nemertodermatids are acting similar to what is found in other bilaterians. Surprisingly, the two thickenings in the dorsal side however, are located next to the expression of the BMP−synexpression group. In addition, the nerve cords of acoels show an co−opotion of neural genes that are expressed in the region where the cords are located, e.g. *NK2.1* in the ventral cord. Our results indicate an independent condensation of nerve cords in the Acoela for which epidermal patterning genes have been co−opted. Our results illustrate that homologizations of nerve cords that are based on similar arrangement of gene expression have to be performed on the background of a phylogenetic framework.

126.3 BEATUS, T.*; RISTROPH, L.G.; IAMS, S.M.; HENCEY, B.M.; GUCKENHEIMER, J.M.; COHEN, I.; Cornell University, New York University; *tb343@cornell.edu*

What fruit−flies care about − A hierarchy of rotational control in free flight

Flying insects manage to maintain aerodynamic stability despite the inherent instability of flapping flight and the mechanical perturbations they are constantly subject to. How flies quickly correct for flight disturbances within only a few wing beats remains an outstanding problem in insect flight research, especially since each wing beat is controlled by a single neural pulse. Our experiment implements reproducible, controlled mechanical perturbations to free−flying fruit−flies and simultaneously measures their full wing and body kinematics. We glue a small magnet to the back of each fly and apply a short magnetic pulse that rotates the insect in mid−air along its body roll angle, which is the most unstable degree−of−freedom in flapping flight. Here we show that fruit−flies manage to fully recover from roll perturbation as large as 100^{o} within ~9 wing beats, comparable to their visual response time. To generate corrective torques, the flies apply a stroke−amplitude asymmetry that is well−described by a linear PI controller, the same controller type used by engineers for attitude control of airplanes and spacecrafts. Finally, we provide the first experimental evidence for a *hierarchy* among the rotational degrees−of−freedom flies care about. Roll is the most important, next is pitch and then yaw, suggesting that the overall flight controller is cascaded. These results pose roll correction in fruit flies as a model system for extremely fast bio−locomotion control.

3.3 BEBUS, SE*; JONES, BC; SCHOECH, SJ; Univ. of Memphis; *sebebus@memphis.edu*

Stress−response, experience, and neophobia in free−living Florida scrub−jays (Aphelocoma coerulescens)

Stress−responsiveness and degree of *neophobia* is related in Florida scrub−jays (FSJ: *Aphelocoma coerulescens*), in that stress−induced corticosterone (CORT) levels predict' approach behavior to a novel object (i.e., CORT levels are negatively related to boldness). However, previous experience may also play a role in the degree of neophobia an individual exhibits. Although consistent individual differences in behavior exist in a number of taxa, we also know that organisms learn from experience. Few studies have examined the interaction between stress−response and experience on behavior in free−living species. We conducted novel object tests using a 60 cm ring with a food reward to measure the degree of neophobia displayed by 3 month−old FSJs. On a subsequent day, individuals were captured in a Potter trap and a series of blood samples were collected to determine stress−induced CORT levels. Both the ring and the trap were novel objects to the young birds. For another group of FSJs, we trapped the birds first, then conducted the novel object test the following day. We made the following predictions: 1) Individuals that experience a negative event (trapping/handling) associated with a novel object (trap) will exhibit more timid behavior during future novel object encounters, when compared to controls; 2) Individuals that were trapped prior to the ring test will behave differently based on their stress−response, with high CORT−response birds exhibiting a higher degree of timid behavior than individuals with low CORT−responses. Scrub−jays trapped first displayed longer latencies to approach the novel ring, with a large range in the approach latency for both groups of FSJs. Blood plasma samples will be assayed to determine CORT−responsiveness of individuals.

27.1 BECKER, W. R.*; WEBSTER, M. R.; SOCHA, J. J.; DE VITA, R.; Virginia Tech; *wbecker@vt.edu*

Variation in tensile properties of tracheal tubes in the American cockroach

Insects use an extensive network of tracheal tubes to transport oxygen directly to cells throughout the body. These tubes are made of an outer layer of epithelial cells and an inner layer of spirally− or circumferentially−wound folds called taenidia. The taenidia, which are composed of chitin fibers embedded in a protein−rich matrix, provide structural integrity to the tracheae. Despite this structural support, localized compression of tracheae is known to occur during respiratory ventilation in multiple species of insects. Interestingly, only some portions of tracheal tubes appear to deform during a compression event. These localized deformations, which displace volume and therefore contribute to the transport of gasses within the body, may result from variation in the structural and mechanical properties of the tracheae. To better understand the role of tracheal properties on respiratory compression, we conducted mechanical tests on ring sections of tracheal tubes extracted from American cockroaches (*Periplaneta americana*). We successfully tested a total of 33 specimens from 14 thoracic tracheal tubes using a custom−built tensile testing system. The ultimate tensile strength (22.6±13.3 MPa), ultimate strain (1.57±0.68 %), elastic modulus (1740±840 MPa), and toughness (0.175±0.156 MJ/m^3) were measured. The large variation in mechanical properties was examined statistically using bootstrap methods, demonstrating that ring sections excised from the same tracheal tube exhibit comparable mechanical properties. Our results will form the basis for future studies aimed at determining the structure−function relationship of insect tracheae, ultimately improving our understanding of respiratory transport mechanisms in insects. Supported by NSF 0938047.

68.1 BEDORE, CN*; KAJIURA, SM; JOHNSEN, SJ; Duke University, Florida Atlantic University; *christine.bedore@duke.edu*
Bioelectric crypsis in cephalopods reduces detection by shark predators
The ability of cephalopods to camouflage themselves is well documented as a defense against predation. However, visual camouflage is only effective against primarily visual predators. For example, bioelectric cues that arise from the rhythmic exposure of mucous membranes, such as gills, may make certain animals vulnerable to detection by electroreceptive predators, such as elasmobranchs and some teleosts. Thus, modulation of an organism's own bioelectric field in response to predator stimuli may decrease the risk of predation, which has been suggested for egg−encapsulated elasmobranchs that suspend their ventilatory movements in the presence of predator−simulating electric fields. We used behavioral and physiological assays to assess the freeze response in the cuttlefish, *Sepia officinalis*, and its effect on detection by sharks. *Sepia officinalis* ceased ventilation for a period of 2−37s in response to a video simulation of a looming fish predator. The freeze response resulted in a 45±17% decrease in voltage at the mantle opening relative to the surrounding seawater (N=15, P=0.015). Escape by jetting was also observed, and resulted in a 420±240% increase in voltage relative to seawater. Dipole electric fields that simulated *S. officinalis* resting, freezing, and jetting DC fields were produced with underwater electrodes in a behavioral assay to quantify the detectability by shark predators. Blacktip sharks, *Carcharhinus limbatus*, and bonnethead sharks, *Sphyrna tiburo*, responded to freeze stimuli less frequently than resting and jetting and they responded to jetting stimuli most often (N=534 responses; P<0.001). These results suggest the freeze response facilitates predator avoidance via reduction of sensory stimuli, including bioelectric fields, and future work should examine the extent to which other cues are modulated during this behavior.

S9.2−1 BEHMER, S. T.; Texas A&M University; *s−behmer@tamu.edu*
The Physiological Ecology of Nutrition: A Framework for Linking the Lab to the Field
Feeding is a daily activity for most animals, and is fundamentally a nutrient collection exercise. Many animals display a strong ability to regulate their intake of key nutrients, but under some conditions the ability to self−select may be constrained. In this talk I present an experimental framework for exploring how food protein−carbohydrate content impacts animals, including consideration of the costs associated with both under−eating and over−eating nutrients. I then provide examples, mostly from grasshoppers, that show how this approach can inform foraging strategies, and physiological responses, under different nutritional and environmental conditions.

71.6 BELANGER, R.M.*; SABHAPATHY, G.S.; KHAN, S.; University of Detroit Mercy; *belangra@udmercy.edu*
Atrazine and metolachlor exposure affects the chemosensory responses of male crayfish (Orconectes rusticus) to female odors
The presence of environmental pollutants is known to have an effect on olfactory−mediated behaviors in aquatic animals. Exposure to the herbicides atrazine and metolachlor has been shown to affect important chemosensory behaviors in crayfish. Male crayfish rely on the presence of chemical signals, released from reproductively active females, in order to locate those females for mating purposes. In this study, we exposed form I (reproductive) male crayfish to ecologically relevant, sublethal levels of atrazine (80 ppb), metolachlor (80 ppb), an atrazine and metolachlor mixture (80 ppb of each) and water only (control) for 96 hours. We analyzed the behavioral reactions of herbicide−treated and control male crayfish to two different odor sources: reproductive female−conditioned water or water (control) delivered from one end of a test arena. We measured odor localization and locomotory behaviors of male crayfish in response to female odors and water (control) from all treatments. Crayfish that were not exposed to the herbicides spent more time closer to a reproductive female odor source, whereas crayfish in all herbicide exposure treatments showed no preference for the female odor. Further, control crayfish had an increased walking speed (cm/s) when female odor was present in the test arena. Male crayfish treated with atrazine and metolachlor demonstrated lower walking speeds when female odor was delivered. We conclude that sublethal concentrations of atrazine and metolachlor interfere with the ability of crayfish to receive or respond to reproductive signals which may negatively affect population growth in the ecosystems they occupy.

P2.113 BELANGER, JH*; PARIKSHAK, H; West Virginia University; *jim.belanger@mail.wvu.edu*
Analog versus digitial signalling in motor control systems
There is considerable interest in using biological systems to explore the relative capabilities of analog versus digital signaling, particularly the differences between the two modes in terms of information transfer capability and energy efficiency under different conditions. Much research has focused on these issues using sensory systems as the focus, but there has been little to no exploration of these issues in motor systems. This is somewhat surprising, particularly given that vertebrate and arthropod motor systems operate quite differently when examined in this context. In mammalian systems, motor information is passed on in a primarily digital form (frequency coding by action potentials) from the level of the motor neurons forward. Each element in the path (neuromuscular junction, muscle membrane, calcium release from the sarcoplasmic reticulum, contractile proteins) is functioning primarily as a "dumb" follower element, doing little in the way of integration. In contrast, motor commands in arthropod systems are passed in a much more analog form, with integration taking place at several steps along the way. The parsimonious explanation for these differences seems to be that arthropods use analog coding and peripheral modulation to achieve the flexibility and dynamic range for which vertebrates use motor unit recruitment. In order to explore this issue, we are examining the control properties of the two systems, using data from both physiological and simulation experiments. Clearly, there are many places where we can look for useful differences between the two systems. As a start, we have begun using tools from control theory (Bode plots, information transfer rates) to analyze the relative capabilities (and limitations) of the two systems.

P3.60 BELANICH, JR*; SECOR, SM; U. of Alabama, U. of Alabama; *jrbelanich@crimson.ua.edu*

Tarantulas vs. Scorpions: Digestive energetics and efficiencies of drinking versus eating

The processing of any meal comes with a cost; a cost that impacts the net energy gained and therefore is incorporated into the efficiency by which energy is acquired. Animals differ in their mode of food handling and ingestion and thus will experiences differences in the tradeoff between energy intake and expenditure. Within the class Arachnida, tarantulas are liquid feeders using oral mastication and enzymes to produce an ingestible liquid sludge, whereas scorpions masticate and ingest small pieces of their prey. To a common meal, crickets, and body temperature, 30°C, we examined how these two arachnid groups differ in the cost of meal digestion and net energy efficiency.For three species of tarantulas (G. rosea, A. chalcodes, A. avicularia) and five species of scorpions (P. imperator, H. arizonensis, H. longimanus, H. trilineatus, C. sculpturatus), we measured their postprandial metabolic response and quantified from the metabolic profiles their SDA, which represents the accumulative energy expended on meal ingestion and assimilation. Both groups experienced a rapid postprandial increase in metabolic rate that peaked within 6−12 hours after feeding and returned to prefeeding values within two days. Tarantula and scorpion SDA averaged 20.8 kJ kg−1 and 42.2 kJ kg−1, respectively, and for each was highly dependent on meal size. Due to the variation in relative meal size (4.6−19.5% of body mass), we standardized SDA to meal energy. We found that when controlling for meal energy that scorpions expend 80% more energy on digestion and assimilation compared to tarantulas, however the differences in this SDA efficiency was not significant. We suspect that the lower SDA for tarantulas reflects their more liquid−like diet and less post−ingestion effort. Alternatively, the cost of meal digestion may be more similar between the two when including the cost for tarantulas of mastication and enzyme production.

P1.173 BELL, K.L.*; NICE, C.C.; HULSEY, C.D.; Texas State University, University of Tennessee; *kbell@txstate.edu*

Population Genomics of a Trophically Polymorphic Cuatro Ciéngeas Cichlid, Hericthys minckleyi

Resource polymorphism in vertebrates has the potential to be a diversifying force leading to population divergence and speciation. In several diverse taxa, discrete intraspecific morphs show differential resource use and varying degrees of reproductive isolation. Alternatively, resource polymorphism may phenotypically characterize hybridizing lineages that are in the process of collapsing into one species. We used high through−put sequencing to investigate the evolutionary factors involved in the maintenance of alternate morphotypes in a highly variable species of cichlid. *Hericthys minckleyi* is a species of cichlid endemic to a small valley, Cuatro Ciénegas, in the center of Mexico's Chihuahuan desert. Pharyngeal tooth size divides *H. minckleyi* into two discrete phenotypes, with associated feeding differences. We found evidence of genetic differentiation between allopatric populations of *H. minckleyi* in the Cuatro Ciénegas valley. We also detected genetic differentiation between the sympatric alternate morphotypes. Our results found little evidence of nuclear introgression between *H. cyanoguttatus*, a closely related species, and *H. minckleyi* and thus did not find support for the hypothesis that alternate morphotypes may represent collapsing hybridizing lineages. Further work is required to delineate the complex evolutionary relationships and the factors involved in the maintenance of alternate morphotypes in this system.

35.6 BELLON, AM*; SPAULDING, J; LEE, H; COHEN, S; Swarthmore College, Romberg Tiburon Center, San Francisco State Univ.; *abellon1@swarthmore.edu*

Two species of botryllid colonial ascidians show different responses to flow at early juvenile stages

Viscosity of water poses an important challenge for small juvenile suspension feeders that may be particularly severe for internal filter−feeders, such as ascidians. Here, we take a comparative approach using colonial ascidians with similar filtration units, but early differences in size, to test the effect of flow differences on growth in field and flume environments. *Botrylloides violaceus* and *Botryllus schlosseri* were grown from settlement in a flume with flows of 0, 8, and 13 cm/s. *B. violaceus* was grown in the field at 0 and 5cm/s. In the flume measurements of colony area, number of buds and siphon diameter were taken every 3−4 days for up to 17 days. Siphon diameters were additionally measured from flume colonies grown at 0 and 13 cm/s. In the flume, *B. violaceus* showed significantly less growth at high compared to medium flow rates, while *B. schlosseri* showed no significant differences at any flow. However, growth rates of *B. violaceus* were not affected by flow rates in the field. Patterns of early development appear to differ between species. The larger propagule species, *B. violaceus* increased the number of zooids with little developmental change to the ozooid including a consistent siphon size. This strategy may be less flexible across habitats, as *B. violaceus* colonies showed lower success at the higher flow rates in lab. The smaller propagule species, *B. schlosseri*, showed variation in ozooid development including varying siphon sizes; growth rate decreased during addition of a new zooid and siphon growth slowed before budding and before the addition of a new zooid. *B. schlosseri* appears to have a flexible growth strategy showing allocation tradeoffs between siphon size and budding.

S3.3−1 BELY, A. E.*; ZATTARA, E. E.; LI, A.; University of Maryland, College Park; *abely@umd.edu*

Using live imaging to probe the cellular basis of annelid regeneration

Regeneration, the ability to replace lost body parts, is widespread among animals yet its cellular and molecular basis is poorly understood in all but a few species. Such knowledge gaps severely limit our understanding of the evolution of regeneration. A fundamental challenge to studying the cellular basis of regeneration is that the process typically takes place in moving adult organisms, over long periods of time (days to weeks), and in dense tissues, making it difficult to discern even basic morphogenetic and cellular processes in many groups. We are studying regeneration in annelids (segmented worms), focusing in particular on identifying the cells that are activated following injury and participate in regeneration. Toward this end, we have developed a method for long−duration time−lapse imaging of regeneration, using a selective neurotoxin to immobilize specimens. Using this technique, we can continuously image the entire regeneration process in several species of naidid annelids, a group of small, largely transparent worms. Our ongoing studies indicate that injury triggers a major cell migration response, with large numbers of cells with different morphologies and migration speeds moving both toward and away from the wound site. One type of migratory cell corresponds to a cell type (the neoblast) that has long been suspected of being involved in initiating regeneration and/or providing source cells for regenerated structures in annelids. Ongoing studies are aimed at comparing the cell migration response in regenerative and non−regenerative contexts to identify features of cell migration characteristic of successful regeneration. Ultimately, comparisons of the cellular basis of regeneration in a range of animals will be key to understanding how regeneration has evolved, how it has diversified, and why it fails.

103.3 BENDIK, NF*; DAVIS, DR; ZABIEREK, K; GABOR, CR; City of Austin, University of South Dakota, Texas State University, Texas State University; *nathan.bendik@austintexas.gov*

The effects of urbanization on physiological stress of Jollyville Plateau salamanders, Eurycea tonkawae

Jollyville Plateau salamanders (*Eurycea tonkawae*) are aquatic neotenes endemic to two highly populated counties in central Texas. Much of the species' range has been negatively impacted by anthropogenic disturbance, exhibiting low population densities and declining trends in heavily urbanized watersheds. Gross changes in water chemistry have occurred in these areas due to the release of pollutants from a wide variety of sources associated with urbanization. At the same time, increases in flash flooding and sedimentation have altered the physical environment. Assessing stress levels in field−caught animals may provide important insights into population health. Using a recently developed technique to evaluate water−borne stress hormone levels, we compared corticosterone (CORT) levels of salamanders across populations in two urbanized and two non−urbanized sites. We found that salamanders from urbanized sites had significantly higher CORT levels than salamanders from non−urbanized habitats. Our results indicate that anthropogenic disturbance may be contributing to elevated CORT levels in populations of *E. tonkawae*. Further evaluation of stress hormone levels in *E. tonkawae* may help elucidate the mechanistic link between the urban stream syndrome' and population declines in this federally threatened species.

P2.56 BENFIELD, CR*; PODOLSKY, RD; Cornell University, College of Charleston; *crb235@cornell.edu*

Interactive effects of temperature, pCO$_2$, and sperm age on fertilization success in northern and southern populations of the sea urchin Arbacia punctulata.

Decreases in oceanic pH can have negative consequences for various biological processes. In addition to more extensively studied effects on calcification, reduced pH can also negatively affect reproduction, in part by suppressing the activity of sperm that are held quiescent in testes under low pH conditions. Our lab showed previously that sea urchin sperm swimming and motility are reduced by changes in pH expected under predicted near−future atmospheric *p*CO_2. However, little is known about population variation in this response, particularly across a latitudinal gradient of temperature and carbonate saturation. We investigated the effects of *p*CO_2 and temperature on the fertilization success of sea urchins (*Arbacia punctulata*) collected from northern and southern populations. We assayed fertilization success in a factorial design under different *p*CO_2s (1x, 2.5x and 4x current atmospheric levels) and temperatures (14°C and 24°C, corresponding to collection temperatures for the two populations). We also varied the amount of time sperm were exposed to these conditions before fertilization to test the hypothesis that sperm longevity could benefit from metabolic suppression at low pH. Animals from the northern population showed higher fertilization success under all conditions. Animals from the southern population showed the expected decline in fertilization as a function of *p*CO_2; northern animals, however, showed no evidence of a decline. Although sperm age had a negative effect on fertilization success, it showed no interaction with *p*CO_2. Our results suggest that populations may face different levels of risk in response to near−future ocean acidification, with southern populations being especially vulnerable.

66.7 BENNETT, MM*; COOK, K; OWINGS, AA; YOCUM, G; RINEHART, J; GREENLEE, KJ; North Dakota State Univ., Stevenson Univ., USDA, NDSU; *meghan.bennett@my.ndsu.edu*

Low temperature stress during development and its effects on adult performance in alfalfa leafcutting bees

Megachile rotundata develop in brood cells constructed in cavities by adult females. Pre−pupal bees diapause over winter and resume development as temperatures (T_a) increase in spring. While many insects are tolerant of suboptimal T_a in their overwintering stages, insects that initiate active development early in the spring due to an increase in the diurnal T_a range may be vulnerable to sudden cold spells, and global climate change is predicted to increase T_a variability, including the risk of spring frost. We tested the hypothesis that pupal bees may be less resistant to low T_a stress and that this stress may result in altered adult phenotypes. Developing pupae were given one of three treatments: 1) normal T_a at 29°C, 2) interrupted with a low T_a stress (6 °C for 1 week; STR), or 3) interrupted with low T_a stress plus fluctuating T_a (daily, 1h pulse of 20°C for 1 week; FTR). As an index of adult phenotype, we assessed flight performance and measured flight metabolic rate (MR). Male STR−treated bees had lower flight MR, and 50% of all bees were unable to fly. To determine if the lower MR was due to decreased energy availability, we assessed feeding behavior. STR−treated animals had the lowest feeding activity. To determine if the flight defects were due to structural defects, we measured wing length. STR−treated animals had 3−6% shorter wings, which could impact wing loading. While it is clear that low T_a stress during pupal development negatively affects adult flight performance, resulting in structural and behavioral changes, the underlying mechanism remains unknown. Effects of T_a stress during development may have serious consequences for pollinators that rely on flight for reproduction and feeding.

P3.35 BENTZ, AB*; SIRMAN, A; WADA, H; HOOD, WR; Auburn University; *abb0023@auburn.edu*

Effects of maternal hormones on epigenetic state of steroid receptors in Eastern bluebird offspring

The breeding environment females experience elicits varying hormonal responses and prenatal exposure to these maternal hormones alters the developmental trajectory of offspring, creating potentially adaptive phenotypes for the prevailing environment. In avian species, maternal breeding density influences the number of competitive interactions females experience and, thus, the amount of steroid hormones they produce. Females breeding in higher densities, experiencing more competition for resources, typically allocate more testosterone to their egg yolks. Offspring exposed to higher concentrations of testosterone prenatally tend to be more aggressive throughout life. To date, few studies have examined how maternal steroid hormones exert this long−term influence on offspring phenotype. One possibility is that maternal hormones alter the epigenetic state of pertinent genes in offspring during development causing changes in gene expression and, ultimately, expressed phenotype. In particular, expression levels of the androgen and estrogen receptor in the avian brain have been linked with differences in aggressive phenotypes. Indeed, offspring are exposed to maternal hormones during the period of greatest developmental plasticity when methylation patterns are being established, making this a potential mechanism. Here, we examine the allocation of yolk testosterone in wild Eastern bluebirds (*Sialia sialis*) breeding in varying densities and compare the methylation status of steroid receptor genes in offspring brain tissue.

P3.106 BERGEON BURNS, C.M.*; WOLTMANN, S.; STOUFFER, P.C.; TAYLOR, S.S.; Louisiana State University and Agricultural Center, Baton Rouge, Austin Peay State University, Clarksville, TN; *cbburns@agcenter.lsu.edu*

Physiological responses of Seaside Sparrows to the Deepwater Horizon oil spill

Oil pollution is known to have immediate and often lethal effects on resident organisms. However, a full understanding of the effects oil exposure on wildlife also requires assessment of sublethal effects over longer timescales. Contaminants including polycyclic aromatic hydrocarbons (PAHs) contained in crude oil can persist in the environment for many years, where they have pronounced effects on the physiology of organisms residing in affected ecosystems. We examined responses of Seaside Sparrows (*Ammodramus maritimus*) residing in coastal Louisiana salt marshes to the Deepwater Horizon oil spill, which occurred in the Gulf of Mexico in spring of 2010. Seaside Sparrows are abundant passerine birds that have narrow habitat requirements, and so may be a valuable indicator of the impact of environmental disturbance in coastal marshes. In 2012 and 2013, we collected adult birds breeding in areas that varied in the degree of contamination from the oil spill, and we asked whether those exposed to oiled habitats showed increased expression of CYP1A, a gene commonly used as a biomarker for PAH exposure. Further, we sought to link oil exposure with biological impacts and fitness measures by comparing stress hormone (corticosterone) levels, population density, and outcomes of nesting attempts of free−living birds across heavily and lightly oiled areas. Preliminary data indicate a negative impact of oil exposure on reproductive outcome.

13.4 BERGEON BURNS, C.M.*; ROSVALL, K.A.; HAHN, T.P.; DEMAS, G.E.; KETTERSON, E.D.; Louisiana State University and Agricultural Center, Baton Rouge, Indiana University, Bloomington, University of California, Davis; *cbburns@agcenter.lsu.edu*

Identifying sources of variation in HPG axis reactivity among males of two dark−eyed junco populations

While much is known about the function of sex steroid hormones, relatively less is known about sources of variation along the endocrine axis that affect levels of circulating hormones and thus might be expected to respond to environmental change. We studied males of two closely related populations of the dark−eyed junco (*Junco hyemalis*) in a controlled captive environment, examining potential sources of variation along the hypothalamo−pituitary−gonadal (HPG) axis that may contribute to known population differences in testosterone (T)−related phenotype. We compared the populations for circulating levels of T, as well for luteinizing hormone (LH), relative abundance of mRNA for LH receptor in gonad, and relative abundance of mRNA for androgen receptor (AR) and aromatase in rostral hypothalamus. We found that the populations were similar in circulating LH and T in response to exogenous GnRH, as well as in T in response to exogenous LH. Within populations, individual T titres were highly repeatable whether males were challenged with GnRH or with LH. However, LH in response to GnRH did not covary with T in response to LH. These findings implicate the gonad but not the pituitary as an important source of variation in T production. Testis mass, but not LHR transcript abundance, predicted individual T responses. Interestingly, the smaller, less ornamented population had greater abundance of mRNA for LHR in the testes and for AR in the anterior hypothalamus, despite similar LH and T responses. We conclude that circulating hormone levels may be less prone to evolutionary change than the responsiveness of individual hormone targets.

119.2 BERGMANN, P.J.*; HARE−DRUBKA, M.; Clark University; *pbergmann@clarku.edu*

Hindlimb muscle lever systems differ among joints and stride phases in basilisk lizards

Vertebrate limbs act as lever systems, and the lengths of limb bones and muscle insertion locations define the architecture of the lever systems, determining their functional properties. The gear ratio (GR) is out−lever length divided by in−lever length, and characterizes whether a lever system's architecture is designed for high velocity movements or high force movements. The physiological cross−sectional area (PCSA) of a muscle further determines how much force a muscle can generate. We use detailed dissection and measurements of the hindlimbs of six juvenile and nine adult basilisk lizards (*Basiliscus vittatus*) to quantify GR and PCSA for 20 muscles, involved during stance and swing phases, and moving the hip, knee, and ankle. The hindlimb muscle architecture did not differ between juveniles and adults. However, we found that GR was highest for the knee, followed by the ankle and finally the hip. The GR was comparable between stance and swing, although it was higher for swing than stance phase muscles that move the ankle. We found that PCSA was higher in stance phase than swing phase muscles, with stance phase muscles of the knee having the highest PCSA. This is expected because the stance is the part of the stride during which propulsive force is generated. We also found that muscle fiber length decreased in more distal joints for stance phase muscles, suggesting that muscles powering proximal joints may have higher shortening velocities. For swing phase muscles, those serving the knee had the highest fiber lengths, mirroring our GR results, and indicating selection of these muscles for high velocity joint movements. Our findings illustrate the value of myological dissection for studying locomotion when physiological and in vivo studies are not practical.

P1.128 BERK, SA*; ROMERO, LM; PARKER, C; ARDIA, DR; WINKLER, DW; ROSS, C; GILL, CJ; University of Montana, Tufts University, Franklin & Marshall College, Cornell University, Hampshire College; *sara.berk@umconnect.umt.edu*

Feather CORT predicts subsequent year's lay date in female Tree Swallows

Feather growth takes place over a relatively short time period, but has numerous consequences for future reproduction. Birds with lower quality feathers may face costs during the non−breeding season through decreased flight efficiency or thermoregulation. Furthermore, feathers function as a social signal and have been demonstrated to impact territory quality and mate choice. Prior laboratory work has found that elevated corticosterone (CORT) during feather growth decreases feather quality, which may affect both migratory efficiency and reproductive success over the subsequent year. I used a new methanol extraction technique to investigate the relationships between CORT deposited in feathers (molted at the end of the prior breeding season) and current reproductive effort using a population of Tree Swallows *() Tachycineta bicolor ()* breeding at Beaverhill Lake, Alberta. I found that females with higher feather CORT had later clutch initiation dates. This relationship could reflect 1. delayed spring migration due to low feather quality, 2. delayed lay due to greater challenge in the prior year, or 3. simply that lower quality individuals have higher CORT and lay later in the season. Measurement of CORT in feathers is relatively recent in the literature, and is used to estimate general CORT levels over the entire growth of the feather. Feather CORT also allows examination of CORT levels experienced by the animal many months prior, without the need for recapturing individuals at separate time points. This data indicates the utility of such an approach for understanding long−term implications of CORT elevation on birds.

P3.117 BERKE, SK*; NEEDHAM, CN; SALERNO, CR; Siena College; *skberke@gmail.com*

A regime shift in progress? New effects of an invasive alga in Virginia's coastal bays

Successful invasive species have the potential to drive regime shifts in invaded ecosystems. In the coastal bays of Virginia, the invasive red alga *Gracilaria vermiculophylla* may now be driving such a shift. *G. vermiculophylla*has represented 90% or more of all macroalgal biomass in these habitats since at least 2003. More recently, however, *G. vermiculophylla*has come to form thick, continuous mats in habitats that have historically lacked algal mats. These habitats were previously dominated by the onuphid polychaete *Diopatra cuprea*, which has facilitated the *G. vermiculophylla*invasion by attaching the algae to its tubes. Within the *G. vermiculophylla*mat, *D. cuprea* is now experiencing extraordinarily high mortality rates, evidenced by reduced abundance and by the presence of unusually large numbers of decaying tubes. The *G. vermiculophylla*mat is also associated with "hummocks", mounds of sediment bound together by *G. vermiculophylla*and *D. cuprea* tubes. Hummocks have significantly shallower oxic layers compared to nearby sediment, and are associated with high concentrations of dead *D. cuprea* tubes. Understanding (i) how widespread *G. vermiculophylla*mats are becoming, (ii) how they influence infaunal communities and sediment biogeochemical processes, and (iii) the causal link (if any) between *G. vermiculophylla*and the *D. cuprea* die−off are important questions for future work.

118.1 BERNAL , MA*; MATZ , MV; ROCHA, LA; Univ of Texas at Austin Marine Science Institute, Univ of Texas at Austin , California Academy of Science; *bernal.moises@gmail.com*

Unraveling the transcriptome of three sympatric species of coral reef fishes (genus: Haemulon)

The genus *Haemulon* is comprised of 19 nominal species of reef fishes, distributed in the Tropical Western Atlantic and Eastern Pacific. The distribution of species on both ocean basins lead to suggest the radiation of the group was due to the formation of the Isthmus of Panama. Recent molecular phylogenies, however, indicate most of the sister species have completely overlapping ranges. Interestingly, grunts in general exhibit no genetic partitions over their broad distribution, showing only signatures of isolation by distance. Further, recent studies have shown reefs accelerate the rate of morphological evolution of haemulids. These traits make the group well suited for the study of sympatric speciation in coral reef fishes. In the present project, we aim to elucidate the main causes of divergence between three sympatric species of the Western Atlantic: *Haemulon macrostomum, H. carbonarium* and *H. flavolineatum*. For this goal we sequenced, assembled and annotated the transcriptome of the three closely related species. The expressed genome will allow us to detect signatures of positive and balancing selection, as well as the genes that may be responsible for the divergence of the group.

P2.70 BERNARD, M*; CURRY ROGERS, K; Macalester College; *rogersk@macalester.edu*

Testing the Accuracy of Skeletochronological Indicators in Age Determination for the Tegu Lizard, Tupinambis merianae

Growth marks in vertebrate bone tissue indicate periodicity of bone deposition. Lines of arrested growth (LAGs) occur in all major vertebrate groups, and are highly mineralized concentric rings that occur within compact bone and indicate complete cessation of growth. LAGs are thought to represent endogenous responses to particular environmental cues, regardless of metabolic rate. LAGs have been researched most thoroughly in extant amphibians and reptiles, and several studies have corroborated the hypothesis that LAGs represent annual cycles of bone growth that can serve as a proxy for estimating the age of an organism. However, intraskeletal variation in LAG deposition remains poorly understood. Do all skeletal elements from a single animal document the same age as recorded by LAGs? We analyzed a single zoo specimen of *Tupinambis merianae* that was euthanized at 5 years of age. We sampled six appendicular elements − left humerus, radius, ulna, femur, tibia and fibula. The general histology of slow−growing lamellar−zonal bone with sparse vasculature and endosteal remodeling is characteristic of all elements. However, the number of LAGs varied between the limb bones. Only the fibula accurately records the known age of our sampled skeleton. All other sampled elements record an age of only three years. Our results highlight intraskeletal variation in LAGs that should be considered, particularly in studies of fossil vertebrates, where researchers may only have access to a single element from which to garner skeletochronological data.

1.2 BERNARDO, J.; Texas &M University; *jbernardo@tamu.edu*

Spatial, phylogenetic, and functional ecological perspectives on aquatic insect thermal tolerance

Aquatic insects are key ecological players in freshwater food webs. Accordingly, an understanding of their physiological tolerances to warming waters illuminates the potential responses of aquatic systems, especially streams, to climate change. I review literature data for 100+ global species to quantitatively describe patterns of thermal tolerance and to describe latitudinal, phylogenetic, or functional−ecological patterns in tolerance that may have bearing on understanding the resistance, resilience, or vulnerability of these species and their ecosystems to warming. I also report new data for 10 tropical species. There is tremendous interspecific variation in thermal tolerance within and between phylogenetic lineages (orders), and within and among functional groups. Nonetheless, a strong colinearity between functional group and order means that statistically, any effect ascribable to functional group vanishes when phylogeny is considered in the analysis. That said, the implications of the variation for tolerance to warming waters is evaluated, given the distributions of existing species traits. No striking latitudinal patterns were observed such as those that have been documented for terrestrial insects and other terrestrial ectotherms. The dominant result is that aquatic stream insects exhibit thermal tolerances that are far greater than those encountered in their habitats, indicating that it is unlikely the aquatic temperatures per se are likely to be limiting. Rather, thermal tolerance during terrestrial dispersal is most likely the venue during which physiological limitation will arise, and which is the selective mileau venue which has molded the evolution of thermal tolerance in aquatic insects.

106.1 BERRIO, A; OKHOVAT, M; O'CONNELL, L; PHELPS, SM*; University of Texas, University of Texas, Harvard; *sphelps@mail.utexas.edu*

Regulating monogamy: evidence for adaptive evolution of an avpr1a enhancer

Voles are important models for the molecular mechanisms of social behavior. Species differences in mating system are shaped by the expression of vasopressin receptors (V1aR) in reward−related brain regions. We examined the evolution of brain and behavior by sequencing the avpr1a locus and several neutral loci from 8 species of New World Microtus, using Myodes gapperi as an outgroup. Of these, two species are socially monogamous (M. ochrogaster and M. pinetorum), and the remaining taxa are promiscuous. Remarkably, M. ochrogaster and M. pinetorum were found to be sister taxa (post. prob.=0.99), indicating monogamy evolved a single time within this clade. This novel pairing suggests the elevated expression of V1aR both species exhibit in the ventral pallidum, a reward region that governs pairbonding, is homologous rather than convergent. To identify cis−regulatory changes associated with this phenotype, we examined ~7kb of avpr1a non−coding sequence, spanning from ~2.6kb 5' of the translation start site to ~1.5kb 3' of the avpr1a stop codon. We found a total of three microsatellite sequences, none of which were reliably associated with mating system. However, a short region of non−repetitive 5' sequence exhibited evidence of accelerated evolution that coincided with the onset of monogamy (LRT, P<0.01). Furthermore, preliminary ChIP−seq data targeting H3K4me1, a marker of enhancers, suggests the site gained function as an enhancer of expression in the ventral pallidum. Lastly, an HKA test indicates reduced standing variation at this putative enhancer. Together the data demonstrate how changes in cis−regulation can drive adaptive changes in gene expression and social behavior.

25.2 BERTRAM, JEA*; HASANEINI, SJ; Univ. of Calgary, Calgary; *jbertram@ucalgary.ca*

Templates and anchors revisited: Distinguishing the phenomenon' of locomotion from the mechanisms' that produce it

Studies of animal locomotion involve interpreting both the complexities of the observable motions and their functional consequences. With the multi−dimensional dynamics, and the highly redundant activation systems responsible, it has been difficult to organize the hierarchy of neuro−muscular and mechanical influences so that the challenges faced, and strategies utilized, can be found. It has been suggested that low dimension models of targeted behavior' (templates) represent broad categories of locomotion behavior emulated by a wide range of organisms. These template behaviors are achieved by the organism (and validated in research) through specific mechanisms that allow testable verification and are referred to as anchors'. This approach has two serious problems; the first is identifying a non−arbitrary method of linking the measurable mechanism (anchor) to the model. The second, and more fundamental problem, is justifying and identifying a legitimate targeted' behavior (template) − why should organisms target a low dimension conceptual model of their behaviour (where reduced dimensionality is advantageous only for mathematical analysis)? As an alternative, we recommend adjusting this approach to replace templates' with the recognition that, at its essence, terrestrial locomotion is a dynamic interaction between the mass of the organism and the substrate − the irreducibly basic phenomenon' of locomotion is the time varying center of mass trajectory. This vector defines the movement strategy implemented by the organism to accomplish its translation across the substrate (and the alternative strategies that are avoided). The trajectory is mediated and guided by the limbs directly interacting with the substrate, action that links the discrete mechanisms of locomotion with the realistic representation of what is accomplished.

79.6 BIDDULPH, T.A.*; HARRISON, J.F.; Arizona State University; *tbiddulp@asu.edu*

Oxygen Modulates Density Effects on Body Size in Drosophila melanogaster

Larval crowding has been shown to reduce body size in *Drosophila melanogaster* but the mechanisms responsible for this effect remain unclear. While nutritional limitation and larval competition are two factors that likely play an important role in the determination of body size, it may be possible that hypoxia occurs in the media at high densities and this might be a factor in the density effect on body size. To partially test this hypothesis, *Drosophila melanogaster* were reared in 10, 21, or 30 kPa oxygen at three densities from egg to adult. Adults were collected during the first two days after eclosion began in each treatment and were starved for one day with agar gel to prevent desiccation before their masses were recorded. There was a significant interaction between oxygen and density on adult body mass (two−factor ANOVA, N=146, p > 0.0000001). At low densities, as seen in prior studies, hypoxia suppressed body size while hyperoxia had no effect, but at high densities hyperoxia increased body size and hypoxia had no effect. These results demonstrate that oxygen needs to be considered as a potential major factor in causing the reduction of body size in *Drosophila melanogaster* at high densities, and suggest that larval crowding causes hypoxia in the media. This study was funded by the SOLUR Program at ASU as well as NSF IOS 1122157 and NSF 0938047.

S5.1−2 BIEWENER, Andrew*; WAKELING, James; LEE, Sabrina; ARNOLD−RIFE, Allison; HOLT, Natalie; Harvard University; *abiewener@oeb.harvard.edu*

Validation of Hill−type muscle models in relation to neuromuscular recruitment and force−velocity properties: predicting muscle force patterns.

Muscle models are frequently used in musculoskeletal simulations of muscle function. However, such models are rarely validated against direct measures of muscle performance. Comparison of novel 2−element and standard 1−element Hill−type models with *in situ* and *in vivo* measures of goat gastrocnemius force and strain shows that 2−element models that allow independent recruitment of slow and fast units result in improved prediction of temporal force patterns. Recruitment patterns based on wavelet and principal component analysis were generally associated with *in vivo* fascicle strain rates, EMG intensity and muscle−tendon force, with faster units linked to greater strain rates and more rapid forces. To investigate the effect of motor unit recruitment on force−velocity properties of whole muscles, differential stimulation of rat plantaris muscles *in situ* were carried out under isotonic conditions. Unexpectedly, recruitment of subpopulations of fast or slow motor units resulted in slower force rise times, lower shortening velocities and less steeply curved F−V relationships. These results suggest significant inertial, viscous and elastic effects on muscle F&V when a subfraction of the muscle is recruited. Future muscle models need to take such effects into account to improve predictions of time−varying muscle force and work output (NIH AR055648).

13.1 BIGA, PR*; FROEHLICH, JM; SEILIEZ, I; University of Alabama at Birmingham, INRA, St. Pee−sur−Neville, France; *pegbiga@uab.edu*

Opposing muscle growth paradigms: a model for understanding the balance between atrpophy and hypertrophy.

Piscine growth is unique in that many species exhibit patterns of muscle growth opposite that of mammalian species. Many teleosts exhibit hyperplastic muscle growth throughout their lives, while most mammals only exhibit hyperplasia during fetal growth or following trauma. Recently, we have characterized closely related fish species that exhibit different growth types: zebrafish (determinate−like) and giant danio (indeterminate). The zebrafish (Danio rerio) has been used extensively as a model system for developmental studies but, unlike most teleost fish, it grows more determinately. A close relative, the giant danio (Devario cf. aequipinnatus), grows indeterminately, displaying both hyperplasia and hypertrophy in muscle as an adult. Muscle satellite cells in the determinate growth model express myogenic biomarkers consistent with mammals, while indeterminate growing danionins express high levels of Pax3 and little Myf5. Additionally, indeterminate satellite cells exhibit a higher proliferative capacity, suggesting a more stem−like phenotype. Hormonal sensitivity and responsiveness vary between the growth paradigms, suggesting that the balance between atrophy and hypertrophy in adults is due to mechanisms regulating cell phenotype. Closely related species exhibiting opposing growth paradigms offer a unique platform to test various questions related to epigenetic regulation of growth potential.

S8.3−1 BILBO, S.D.*; WILLIAMSON, L.L.; PARKER, W.; Duke University; *staci.bilbo@duke.edu*

Early−Life Programming of Neuroendocrine Function by the Immune System: Plasticity or Autoimmunity due to Biome Depletion?

Immune molecules have a powerful impact on neuroendocrine function during health as well as sickness. Microglia are the primary immunocompetent cells of the brain, and rapidly respond to any infection, injury or perturbation of homeostasis via a dynamic process of activation. These functional shifts are thought to be evolved, adaptive responses that organize changes in behavior and mobilize immune resources, but can also lead to pathology or exacerbate disease if prolonged or exaggerated. The developing brain in particular is exquisitely sensitive to both endogenous and exogenous signals, and increasing evidence suggests the immune system has a critical role in brain development and associated behavioral outcomes for the life of the individual. We have demonstrated that a single bacterial infection early in life can program neuroendocrine function and impair cognition throughout the remainder of the lifespan in rodents, and that these changes are causally linked to enduring changes in microglial function. However, it is unclear whether these changes represent developmental plasticity, as many aspects of the sensitized phenotype of the microglia suggest autoimmunity. A wide range of diseases associated with a hyperactive immune system are now pandemic in post−industrial society. Increasing evidence points to a profound depletion in the human biome, particularly those organisms living in a symbiotic relationship with all humans prior to the industrial revolution, as the underlying cause that leaves many individuals susceptible to these pandemics of immune−related disease. This talk will consider the evidence that "developmental programming" of microglial function by early−life infection may be a pathological consequence of biome depletion, rather than plasticity in the face of early−life immune exposures.

51.4 BIRD, NC*; WEBB, JF; University of Rhode Island; *nathan_bird@mail.uri.edu*

Modularity and Heterochrony in the Adaptive Evolution of the Lateral Line System of Fishes

The ability of different modules to evolve independently is a fundamental concept in organismal evolution. Module independence is critical for local evolutionary changes in developmental rate or timing, *i.e.*, heterochrony. This study examined the role of heterochrony in the evolution of the cranial lateral line (LL) canals and how it reveals modularity. Among the four LL canal phenotypes found in teleosts, simple heterochronic shifts may explain the evolution of branched and reduced canals from a narrow canal phenotype, but widened canals cannot be explained as simply. Rather, it was hypothesized that dissociated heterochrony, or a mix of paedomorphic and peramorphic changes, may explain the evolution of widened canals. This hypothesis was tested by comparing ontogenetic trends in canal and neuromast growth in two closely related Lake Malawi cichlids with divergent adult LL canal morphologies, *Tramitichromis* sp. (narrow canals) and *Aulonocara stuartgranti* (widened canals). Neuromast patterning and the pattern of canal morphogenesis was the same, but *Aulonocara* tended to show delayed canal enclosure and ossification, indicating a paedomorphic shift. ANCOVA revealed that the increase in LL canal diameter was 1.8−3.6X faster and neuromast growth (width) was 1.6−2.1X faster in *Aulonocara* than in *Tramitichromis*. Johnson−Neyman tests showed that canals are already wider and neuromasts are already larger in *Aulonocara* larvae and juveniles of 7.8−12.2 mm SL, indicating a developmental acceleration. Such peramorphic shifts in both canals and neuromasts suggest tight integration among these genetic modules. The mix of paedomorphic and peramorphic trends in the lateral line system supports the hypothesis of evolution by dissociated heterochrony. Supported by NSF grant IOS−0843307 to JFW.

S10.2−1 BIRD, J.C.; Boston University; *jbird@bu.edu*

From bouncing drops to draining bubbles: the influence of biological features on capillary flow

Drops and bubbles are ubiquitous in the environment, as evidenced by falling rain or the white caps produced when bubbles are entrained by breaking waves. The physical forces of the flow can influence the surrounding ecology, and likewise, the surrounding ecology can influence the flow − sometimes in counter−intuitive ways. This talk focuses on two surface−tension phenomena: 1) the impact of water droplets on superhydrophobic biological surfaces, such as a lotus leaf, and 2) the draining of air bubbles in liquids with particulates, such as yeast. For example, it is well−known that the microtexture of lotus leaves cause impacting water drops to completely bounce off the surface in a matter of milliseconds. In this talk, it is demonstrated that when larger−scale textures are present, such as those found on butterfly wings, the flow is modified and the water droplets impact with shorter residence times than previously thought possible.

118.7 BIRD, C E*; FURINESS, S; HOGAN, J D ; HOBI LAB, ; Texas A&M Univ. − Corpus Christi; *chris.bird@tamucc.edu*

RADseq: Minimizing the cost of population genomics

Restriction site associated DNA sequencing (RADseq) have enabled population genomic research on non−model species, but the original protocols from the University of Oregon are quite expensive to perform. In order to address high costs, strategies were developed that involve using restriction enzymes to create fragments of a particular size or range of sizes. These size selection strategies, while effective for high quality, high molecular weight DNA, are not suited to degraded DNA where fragment size is not indicative of identity. Consequently, it is extremely difficult to achieve substantial coverage of targeted loci with most intermediate quality DNA samples that were isolated for mtDNA and microsatellite analysis. Here, we present modifications to the Oregon RADseq protocol that dramatically reduce costs to the same level as digest−size select−sequence methods, while maintaining its superiority in processing degraded samples. Our method, termed RADseq, requires only small amounts (10−100 ng) of partially degraded DNA in order to produce libraries for Illumina sequencing. RADseq facilitates the population genomic analysis of a wide range of samples at the minimal cost.

S5.3−4 BIRN−JEFFERY, AV*; HIGHAM, TE; University of California Riverside; *aleks.birnjeffery@ucr.edu*

What goes up must come down: how sloped surfaces impact the mechanics of locomotion

Terrestrial animals move over highly variable surfaces that include inclines and declines. Although the mechanical demands of inclined and declined locomotion differ greatly, and are both important for the animal, uphill locomotion is most commonly studied. An animal must overcome gravitational pull during uphill locomotion, requiring significant amounts of positive work. In contrast, downhill movement involves aspects of stability and resistance to gravity. However, both impart a toppling moment on the centre of mass (CoM) − be it backwards or forwards. On inclines animals tend to pull towards the ground with their forelimbs, but push away from the ground with their hindlimbs, indicating differential leg function. This reduces the pitching moment and also brings their CoM closer to the surface. Arboreal and rock−dwelling animals regularly go up and down inclines, making them well suited for studies of incline and decline locomotion. Geckos often occupy arboreal or rocky habitats, and those that do often possess an adhesive system that enhances movement on sloped surfaces. Using a generalist gecko, we examine how 3D forelimb and hindlimb kinematics, as well as the use of the adhesive system, differ between uphill and downhill locomotion. Comparable to previous studies, they moved significantly slower on inclines and exhibited a reduced shoulder height. Hindlimb stance and swing times were shorter on the decline condition, suggestive of a smaller contribution to propelling the CoM forwards. Understanding the mechanical demands of moving on a variety of slopes is critical given that animals that go up an incline will also need to come back down. Given the functional differences, there is likely a trade−off in functional demands between inclined and declined locomotion. Supported by NSF IOS−1147043.

P2.154 BJORNSON, K.L.*; DAVIS, J.E.; Radford University; *kbjornson@radford.edu*

Exogenous Corticosterone Administration vs. an Environmental Stressor: Approach Behaviors in Passer domesticus

Stress responses to an immediate threat are generally considered to be beneficial to survival. The stress hormone corticosterone (CORT) is known to regulate energy management; however, the behavioral effects of CORT are not fully understood. Previous studies have observed behavioral effects with repeated acute CORT administration over relatively long durations. Additionally, few studies have compared whether exogenous CORT administration alone produces the same behavioral responses as an actual stressor. In the study presented here we exposed female house sparrows to a mildly aversive stimulus immediately after a single acute tropical administration of CORT and contrasted to birds subjected to a 30 minute restraint in order to explore whether CORT−treated birds displayed more hesitant and anxious behaviors than those without CORT treatment or birds that were actually stressed. The results from this study will further our knowledge of how corticosterone influences the stress response.

P2.168 BLATZHEIM, L*; BOWER, C; POLK, T; IKIZO LU, D; KARAHN, A; LEVINSON, B; GUNE^, N; ÇAKMAK, I; WELLS, H; HRANITZ, J.M.; Southwester Oklahoma State University, Bloomsburg University of Pennsylvania, Southern Nazarene University, Uluda University, Bursa, TURKEY, University of California, San Diego, University of Tulsa; *blatzheiml@student.swosu.edu*

The neonicotinoid pesticide thiamethoxam affects motor responses and foraging behavior of honey bees.

Neonicotinoid compounds are the next generation of nicotine−like substances (e.g., thiamethoxam) that are currently widely used in agriculture. Neonicotinoids have been implicated as causal agents in honey bee colony collapse disorder (CCD), since the onset CCD coincided with the widespread use of neonicotinoids. The doses that bees encounter in agriculture are well below the LD50 and considered "safe" but sublethal effects may be important. Our goal was to study the sublethal effects of thiamethoxam on the motor coordination of captive bees and foraging behavior of free−flying bees. We tested doses at 1/5 to 1/500 of the LD50 for motor responses after 4 h of administration for harnessed bees and 60−150 minutes after administration in free flying bees. At 4 h post−administration, motor coordination was assessed for antennal movement, proboscis extension reflex, leg, and abdomen movement. Motor coordination of bees treated with 1/5 LD50 was lower than motor coordination of control bees. We assessed the visitation rate and foraging abilities of free−flying bees on an artificial flower patch. The return rate was significantly lower for pesticide−treated bees at doses as small as 1/10 LD50 and the ability of foragers to distinguish between high and low sucrose nectar was impaired at doses higher than 1/50 LD50. Our results show significant sublethal effects of thiamethoxam, impairing basic motor coordination and foraging performance of honey bees at doses substantially lower than the LD50.

123.9 BLEVINS, C.E.*; GE, J.; SUTHERS, R.A.; HOMBERGER, D.G.; Louisiana State University, Baton Rouge, Indiana University, Bloomington; *zodhomb@lsu.edu*

Modeling a Complex Skeleto−Muscular System in 3D: The Vocalizing Behavior of a Songbird, the Northern Cardinal (Cardinalis cardinalis)

The vocal apparatus of birds is superimposed on the respiratory and feeding apparatus and comprises the semi−independently moving shoulders, neck, skull, upper jaw apparatus, mandible, hyoid apparatus, trachea, and laryngeal apparatus. The interplay of these skeleto−muscular systems was analyzed in a songbird, the Northern Cardinal, by taking advantage of recent developments in x−ray CT scanning, 3D reconstruction, imaging, animation, and microanatomy. The CT data were reconstructed and visualized with the software Avizo® and the skeletal elements were segmented (i.e., individually marked). This 3D model was imported into the software Maya® to be subjected to the computer animation technique called "character rigging", which applies kinematic constraints based on a prior functional−morphological analysis, to match the movements of a living bird. The 3D model was animated by pose−matching each frame of the image sequence of an x−ray video of a singing bird in lateral view and synchronized with a regular video in dorsal view to show any sideways movements. The correct positions of the skeletal elements in the created video of the 3D model were checked by comparing them with a separate x−ray video in frontal view. The sound−track of the x−ray video allowed the matching of the exact anatomical configuration of the 3D model to each syllable of the song. This method allows the modeling of any movements of a subject and requires only one x−ray camera. Supported by NIH grant NINDS R01 NS029467 to RAS

S5.1−1 BLOB, R.W.*; ESPINOZA, N.R.; BUTCHER, M.T.; LEE, A.H.; D'AMICO, A.R.; BAIG, F.M.; SHEFFIELD, K.M.; Clemson Univ., Youngstown St. Univ., Midwestern Univ.; *rblob@clemson.edu*

Diversity of Limb Bone Safety Factors for Locomotion in Terrestrial Vertebrates: Evolution and Mixed Chains

During locomotion over land, vertebrate limb bones are exposed to loads. Like most biological structures, limb bones have a capacity to withstand greater loads than they usually experience, termed a safety factor (SF). How diverse are limb bone SFs, and what factors correlate with such variation? We have examined these questions from two perspectives. First, we used bone strain and force platform recordings to evaluate locomotor SF for the femur of diverse lineages, including salamanders, frogs, turtles, lizards, crocodilians, and marsupials (opossums). Comparisons with values for hind limb elements in running birds and eutherian mammals indicate phylogenetic diversity in limb bone SF. A high SF (>5) is primitive for tetrapods, but low load magnitudes and elevated bone strength contribute to different degrees across lineages. Birds and eutherians appear to have evolved lower SFs independently, a conclusion strengthened by finding SFs in opossums intermediate between those of eutherians and non−avian reptiles. Second, we tested the hypothesis that SFs would be similar across limb bones within a taxon by comparing the femur and humerus of alligators. In both bending and torsion, we found a higher SF for the humerus than the femur. Such a "mixed chain" of different SFs across elements has been predicted if bones have differing load variabilities, different costs to maintain, or high SF values. Though load variability is similar for the humerus and femur, a high SF may be less costly for the humerus because it is smaller than the femur. Moreover, the generally high SFs of alligators might promote SF differences among their limb bones.

70.8 BODENSTEINER, BL; MITCHELL, TS*; STRICKLAND, JT; JANZEN, FJ; Iowa State University, USFWS; *timmitch@iastate.edu*

Do hydric conditions during embryonic development in the field influence phenotypes of neonatal painted turtles?

Many reptiles produce eggshells that are permeable to water, and hydric conditions experienced by these embryos can have substantial influence on phenotypes and survival. Most research on the influence of hydric conditions on eggs and phenotypes has occurred in the laboratory, yet little is known about how hydric conditions influence phenotypes in the wild. In this experiment, we manipulated the hydric conditions of painted turtle (*Chrysemys picta*) nests in the field over two years. We divided the eggs from natural nests into two artificial nests adjacent to the maternal nest; one nest served as a control and the other nest was watered regularly to mimic a year with heavy precipitation. We assessed the effects of supplemental water on the hydric and thermal environment of nests and observe the consequences of this treatment on embryonic development and offspring phenotypic variation. Results from our experiment accord with prior laboratory research and offer new insights into the influence of water in natural nests. Hatchlings from watered nests were slightly but significantly larger and converted more yolk into tissue than those from control nests. As size is related to survival, this phenotypic variation likely influences fitness. Current climate models predict substantial changes in precipitation patterns which may consequently influence relevant environmental conditions within reptile nests.

29.6 BODUCH, C*; LIU, H; FIDELMA, O; St. Edward's University, Austin; *cboduch@stedwards.edu*

Isolating the Impact on Voluntary Motor Control of Individual PD Pathologies and Potential Treatments in the Model Organism C. elegans

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by the loss of dopaminergic neurons, diminished voluntary motor control, and aggregation of ±−synuclein (AS) protein into Lewy bodies (Lundblad, 2002). The transgenic PD strains of *C. elegans*, NL5901 and CB1112, are useful models to examine progressive degeneration of locomotion over the organisms' lifespan. NL5901 expresses human ±−synuclein (AS); CB1112 is deficient in tyrosine hydroxylase, a biosynthetic enzyme in dopamine synthesis, thus mimicking the individual human PD pathologies. Additionally, RNAi knockdowns (KD) of HSP−90, confirmed to increase aggregations, were used to test the impact of AS aggregations on locomotive control. Both PD strains and KD were treated with dopamine agonist and dopamine reuptake inhibitor in order to strengthen dopaminergic signaling. Voluntary motor control for each group was examined daily for 9 days using a locomotive control index (LCI). The LCI data suggests the expression of AS alone significantly diminished locomotive control in *C. elegans* compared to N2 wt (t−test, $p<0.001$). The resulting increased AS aggregation in KD further decreased LCI compared to N2 (t−test, $p<0.001$). The data also shows a significant reduction of the LCI in CB1112 (dopamine−deficient) strain compared to N2 (t−test, $p<0.001$). Furthermore across all strains, motor deficits progressed with age; possibly due to a continuous increase in AS load, or to progressive degeneration of elements in the dopaminergic circuit. When strains were treated from birth to enhance dopaminergic signaling, the LCI rose for all strains. This suggests that strengthening the dopaminergic pathway was enough to partially restore locomotive control. Isolation of each of the pathologies of PD has provided insight into their individual impact on locomotive control in *C. elegans*.

36.4 BOETTGER, S.A.; West Chester University;
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Environmental Impact on hemic neoplasia, growth and reproductive output in the softshell clam (Mya arenaria).
Hemic neoplasia a disease in bivalve mollusks characterized by highly mitotic hemocytes is one of the six most destructive molluscan diseases. Efforts to link the onset of this fatal disease to environmental or physiological factors have depended on data collected from natural populations, generally following a catastrophic event. Studies documenting chronic neoplasia development are needed due to changes in the marine environment and differences between individual locations. In this study we examine the development of neoplasia in the soft shell clam, *Mya arenaria*, at 3 sites of know environmental, contaminant and sediment qualities in Maine and Massachusetts. Deployment of healthy, hatchery raised *Mya arenaria* for 12 months allowed us to document the highest frequency of neoplasia development, establish physiological factors such as decrease of phagocytic ability (immune response), growth and reproductive output and compare them to environmental factors such as temperatures, sediment characteristics and contaminant levels. Sediment levels of heavy metals have previously been linked to neoplasia development and indicate vulnerability of juvenile clams to environmental stress induced by heavy metal contamination, which decreases their immune defenses. (NOAA Saltonstall/Kennedy NA08NMF4270215)

S9.1−2 BOGGS, C.L.*; NIITEPOLD, K.; Univ. of South Carolina;
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Stress, nutrient allocation and multivariate life history: from lab to field
Both life history responses to nutritional stress and the mechanisms underlying those responses have been subject to intense study in recent years, in the context of global change and of ageing. Most studies have been done under controlled laboratory conditions, providing only limited understanding of how nutritional stress affects nutrient allocation, life history and population dynamics in the wild. Here we use a lepidopteran study system, *Speyeria mormonia*, to test the relationship between lab results and what happens under nutritional stress in the field. We first summarize results from work testing different commonly used laboratory adult diets, with different micronutrients. We then review the effects of adult nutritional stress on life history traits in the lab, yielding predictions for effects in the field. We show that several of these predictions are indeed upheld under nectar stress in the wild. This synthesis demonstrates that laboratory studies can indeed provide useful insight into life history and population dynamics in the field.

90.3 BOLLFRASS, K.T.*; GREEN, C.C.; Louisiana State Univ. Agricultural Center; *kbollf1@lsu.edu*
Oxidative stress in red swap crayfish Procanmbarus clarkii exposed to acute hyperosmotic conditions
The red swamp crayfish *Procambarus clarkii* are commercially important in the gulf coast region of the United States of America and China, and are ecologically important elsewhere as an invasive species. Southern Louisiana is experiencing coastal land loss at a rapid rate, causing saltwater intrusion and threatening commercial production in some areas. Red swamp crayfish are tolerant of moderate salinity but maintaining homeostasis under environmental stress increases basal metabolism and oxidative stress. Currently little is understood about antioxidant defense and oxidative stress in crayfish related to increased salinity. In this study, red swamp crayfish were acutely transferred from salinities of 0 psu to 5, 10, or 20 psu water. Tissues and hemolymph were sampled (n=6) at 0, 12, 24, 72, and 120 h after transfer. Biochemical assays were performed to quantify antioxidant enzymes, lipid peroxidation, and hemolymph chloride ions. Sodium and potassium ions were quantified with flame spectrophotometry. Real time qPCR was used to quantify the expression of prophenoloxidase and superoxide dismutase genes. Total osmolarity, sodium, potassium, and chloride significantly increased in crayfish hemolymph 24 h after exposure to hyperosmotic conditions. Lipid peroxidation was significantly higher in crayfish heptaopancreas tissue 72 h after exposure. Superoxide dismutase was significantly lower in crayfish gills 72 h after exposure. These findings explore the biocemical and molecular underpinnings of oxidative stress from acute hyperosmotic stress.

P2.136 BOLLINGER, RJ*; BUJAK, JK; MADSEN, SS; TIPSMARK, CK; Univ. of Arkansas, Fayetteville, Univ. of Southern Denmark, Odense; *rxb031@email.uark.edu*
Vivo−Morpholino Induced Knock−Down of Gill Na,K−ATPase Impairs Seawater Acclimation in Rainbow Trout
The gill epithelium of euryhaline fishes undergoes comprehensive molecular and cellular remodelling in response to salinity changes. This leads to a reversal of the direction of gill ion transport. Correlative mRNA and protein expression data strongly suggests that a switch in the dominating gill Na,K−ATPase alpha−subunit isoform, from alpha−1a in freshwater (FW) to alpha−1b in seawater (SW) is among critical factors during salinity acclimation of rainbow trout (Oncorhynchus mykiss). Accordingly it is currently hypothesized that the alpha−1b is essential for ion secretion whereas alpha−1a is the isoform driving ion uptake. However, direct functional evidence is lacking. This study sought to provide direct evidence for the functional role of alpha−1b in SW. We designed a translational vivo−morpholino to knock−down alpha−1b in the gill of rainbow trout. In an initial experiment, we injected alpha−1b vivo−morpholinos intraperitoneally in FW trout (n=4−6) followed by a 3 day SW−challenge. Vivo−morpholino injection induced a ~5% drop in muscle water content after SW−transfer, when compared with sham−injected SW−fish that were fully recovered. Knock−down reduced the SW−induced increase in gill Na,K−ATPase protein and enzyme abundance by 52 and 38 %, respectively. In the alpha−1b morpholino fish alpha−1a mRNA was increased 30−fold compared to SW−sham, suggesting compensatory stimulation of the isoform. This preliminary experiment suggests that vivo−morpholino knock−down in salmonids may be an important genetic method to determine direct functional roles of specific proteins. Further in vivo knock−down studies of gill Na,K−ATPase subunits is currently underway to substantiate and elaborate our understanding of the gill enzyme.

P1.164 BOND, S.R.*; BAXEVANIS, A.D.; Genome Technology Branch, Division of Intramural Research, National Human Genome Research Institute, National Institutes of Health; *steve.bond@nih.gov*

Reconstructing the evolution of ancestral gap junction proteins

Gap junctions (GJs) are a nearly ubiquitous feature of metazoan life, coupling the cytoplasm of adjacent cells into a partially selective syncytium. The range of physiological and pathophysiological processes that GJs partake in is extensive − a feature that is mirrored by an equally extensive diversity in the primary sequence of GJ−forming proteins. A particular curiosity is the presence of two distinct families of GJ proteins within the animal kingdom. In chordates, connexins (Cxs) are responsible for coupling adjoining cells, while the "invertebrate analogs of connexins", namely innexins (Inxs), perform the function across most of the remaining phyla. While the three−dimensional structures of Inxs and Cxs are thought to be quite similar, they share very little identity at the sequence level, making it difficult to infer homology with any level of statistical rigor. In the current study, we explore the evolutionary relationship between Inxs and Cxs, making use of newly released whole−genome sequence data to include GJ proteins from all major metazoan phyla. Structural features of these proteins are used to guide multiple sequence alignments, and ancestral states are reconstructed as position−specific scoring matrices (PSSMs) from groups of closely related sequences using partial−order sequence graphs, Bayesian inference, and maximum likelihood approaches. Sequential profile−profile alignments then allow us to progressively step down through deeper phylogenetic nodes to the inferred base (i.e., the last common ancestor) of both the Inx and Cx families. It is from these basal PSSMs that we finally calculate the probability of Inx and Cx homology.

130.5 BONETT, R M*; STEFFEN, M A; LAMBERT, S M; ROBISON, G A; WIENS, J J; CHIPPINDALE, P T; University of Tulsa, University of Arizona, University of Arizona, University of Texas Arlington; *ron−bonett@utulsa.edu*

Evolution of paedomorphosis in plethodontid salamanders: ecological correlates, reversals, and heterochrony

Life history modes can profoundly impact the biology of a species, and a classic example is the dichotomy between metamorphic (bi−phasic) and paedomorphic (permanently aquatic) life−history strategies in salamanders. However, despite centuries of research on this system, several basic questions about the evolution of paedomorphosis in salamanders have not been addressed. Here, we use a newly developed, comprehensive, time−calibrated phylogeny of spelerpine plethodontids to reconstruct the evolution of paedomorphosis and to test if paedomorphosis is (1) reversible, (2) associated with living in caves, (3) associated with relatively dry climatic conditions on the surface, and (4) correlated with limited range size and geographic dispersal. We find that paedomorphosis arose multiple times in spelerpines. We also find evidence for re−evolution of metamorphosis after several million years of paedomorphosis, in a lineage of Eurycea from the Edwards Plateau region of Texas. We also show for the first time using phylogenetic comparative methods that paedomorphosis is highly correlated with cave−dwelling, arid surface environments, and small geographic range sizes, providing insights into both the causes and consequences of paedomorphosis. Finally, we use the new phylogeny to test hypotheses regarding patterns of heterochrony in spelerpines that gave rise to developmental variation and paedomorphosis.

30.5 BONIER, F*; MARTIN, PR; Queen's University; *bonierf@queensu.ca*

How does selection act on endocrine traits? And how can we measure it?

Behavioral endocrinologists are becoming increasingly interested in the evolutionary context of the endocrine traits that we study. Yet, we lack a robust approach for detecting natural selection on these exquisitely plastic traits, perhaps in large part because of their plasticity, and also because of the complex ways in which selection might act. For example, selection may favor hormone levels that closely match dynamic environmental challenges in nature, and thus optimal phenotypes cannot be understood without accounting for the current and prior challenges facing individuals. I will explore some of the unique challenges for understanding the evolution of endocrine traits, illustrating these challenges using corticosterone levels and life history data from free−ranging birds. Within individual birds, we see fluctuations in relative corticosterone levels depending on diverse challenges   individuals with the highest fitness may have both the highest and lowest levels of corticosterone in the population, depending on the environmental challenges that they face. Overall, standard fitness−trait curves can be misleading, obscuring our understanding of how selection acts on endocrine traits. Reaction norms and adaptive plasticity, however, could provide more useful frameworks for moving forward.

P3.85 BORATYNSKI, J.S.*; JEFIMOW, M.; WOJCIECHOWSKI, M.S.; Nicolaus Copernicus Univ., Torun, Poland; *jan.boratynski@gmail.com*

Seasonal heterothermy correlates with lower phenotypic flexibility of energetics

Heterothermy and phenotypic flexibility enable animals to survive in seasonally changing environments, either by "escaping" from excessive energy expenditure or by adjusting mechanisms of heat production and dissipation. We hypothesized that the capacity for seasonal heterothermy negatively correlates with the scope of this phenotypic flexibility and tested the prediction that adjustments of basal metabolic rate (BMR) in response to short−term changes in ambient temperature (T_a) are greater in summer−acclimated than in winter−acclimated animals that have a broader heterothermic scope. We measured BMR by indirect calorimetry of 40 male Siberian hamsters (*Phodopus sungorus*) acclimated to winter−like or summer−like conditions for 3 months. After each acclimation period, hamsters were exposed twice for 21 d to different T_as (10, 20 or 28 °C). We used the difference in BMR measured after the two exposures as an estimate of phenotypic flexibility. Body temperature (T_b) was recorded continuously with implanted data−loggers and body mass (m_b) was measured weekly. Variability of T_b was used as a measure of heterothermy. We found that m_b in winter−acclimated hamsters was ~22% less than in summer−acclimated ones and, after adjusting for m_b, BMR did not differ seasonally (p=0.6). Also, T_b was more variable in winter−acclimated hamsters than summer−acclimated ones (p<0.001). In support of our prediction, we found that BMR in winter−acclimated animals was indeed less flexible than in summer−acclimated hamsters (p=0.02), which suggests that seasonal heterothermy may offer an alternative to extensive adjustments of heat production in heterothermic rodents.

113.3 BORATYNSKI, J.S.; WILLIS, C.K.R.; JEFIMOW, M.; WOJCIECHOWSKI, M.S.*; Nicolaus Copernicus Univ., Torun, Poland, Univ. of Winnipeg; *mwojc@umk.pl*

Huddling reduces evaporative water loss but not metabolic rate in torpid bats

Huddling is thought to reduce thermoregulatory energy expenditure in normothermic mammals and birds. Theoretical predictions suggest that during hibernation huddling also may reduce evaporative water loss (EWL) by reducing the surface area of huddled animals, which is exposed to air. However, to our knowledge it has not been tested empirically. We hypothesized that huddling affects not only energy expenditure but also water balance in torpid animals. We predicted that huddled individuals would have lower EWL than solitary ones and that this difference would be greater in dry than in humid air. We also predicted that huddling would reduce individual energy expenditure during torpor. We tested these predictions by measuring EWL and torpid metabolic rate (*t*MR) of insectivorous bats, *Myotis nattereri*, housed as solitary individuals or huddling in groups of five or six. Bats were measured for 24h at an ambient temperature (T_a) of ~6.5 °C, consistent with their natural hibernation. As predicted, after adjusting for *t*MR and body mass (m_b), bats in huddles had ~27% lower EWL per individual than solitary animals ($p < 0.05$). However, surprisingly, after adjusting for T_a and m_b, *t*MR per individual was ~45% higher for huddled bats compared to individuals ($p < 0.01$). These results provide the first experimental evidence that a primary benefit of huddling by hibernating bats is reduced EWL. Our calculations indicate that huddling bats would have to hibernate at T_a of ~3.5 °C to be able to reduce *t*MR to the level we recorded for solitary bats. That could bring about even greater reduction of EWL during hibernation.

20.7 BORCHERT, JB*; ANGILLETTA, MJ; Arizona State University, Tempe; *jdborche@asu.edu*

The games that flies play: laying eggs based on temperature and competition

We used game theory to predict how fruit flies, *Drosophila melanogaster*, should compete for oviposition sites. Although flies prefer to lay their eggs within a particular range of temperatures, the potential for competition among offspring should cause females to accept warmer or cooler sites when preferred sites become crowded. To look at this problem, we observed where flies chose to lay eggs under various densities of competing females. In each trial, 4 or 15 flies were placed within a thermal arena containing a choice of two oviposition sites, one at a preferred temperature (25°C) and another at a lower temperature (20°C). In a concurrent trial, 100 eggs were added to the site with the optimal temperature and then 4 flies were added to see if behavior depended on the presence of other females or eggs. After 4 hours, we counted the eggs laid in each portion of the gradient and analyzed how the distribution of eggs was affected by the density of females. Flies at low density laid eggs almost exclusively at 25°C, but those at high density laid a significantly greater proportion of eggs at 20°C than did flies at low density. Surprisingly, flies did not avoid laying at 25°C when eggs were present, suggesting that flies responded to the presence of competing females rather than cues associated with eggs. By drawing on game theory to make quantitative predictions, this research builds on previous empirical studies of competition between thermoregulating animals.

P2.75 BORCHERT, JB*; ANGILLETTA, MJ; Arizona State University, Tempe; *jdborche@asu.edu*

The games that flies play: effects of temperature and density during development on the fitness of Drosophila melanogaster

Both temperature and competition can affect the fitness of an organism. We examined how temperature and competition covary to affect the fitness of *Drosophila melanogaster*. We transferred either 1, 5, 15, or 30 eggs to a petri dish and maintained them in an incubator kept at either 16°, 21°, 25°, or 30°C. We then measured developmental time, survival to adulthood, wing size, and fecundity to approximate the fitness of drosophila under each treatment. These data were used to parameterize a game theoretical model that predicts where flies should lay eggs when microhabitats vary in temperature and density.

34.4 BORONOW, K.E.*; MUNOZ, M.M.; SHIELDS, I.H.; LOSOS, J.B.; Harvard University, Cambridge, MA; *kboronow@fas.harvard.edu*

Behavioral divergence along an altitudinal gradient in a clade of tropical lizards

Entry into novel macrohabitats often requires physiological, morphological, or behavioral changes. However, the role of behavior in facilitating divergence into novel macrohabitats is virtually unknown. The Caribbean radiation of *Anolis* lizards is a well−studied example of adaptive radiation that occupies a diverse range of habitat types. Here we utilized the replicated evolution of a high−altitude specialist from a low−altitude generalist in a clade of *Anolis* lizards to test the hypothesis that a suite of behavioral traits accompanies divergence into a climatically distinct macrohabitat. The montane specialists *A. armouri* and *A. shrevei* each independently evolved from the lowland dwelling *A. cybotes* in two widely−separated mountain chains on the island of Hispaniola. We found evidence for convergent behavioral adaptation to the high−altitude macrohabitat: *A. armouri* and *A. shrevei* spend more time basking, utilize more open environments, and are more wary than *A. cybotes*. We also found divergence in display behavior in *A. shrevei*, but not *A. armouri*, perhaps due to differing trends in predation pressure with elevation in each mountain chain. The breadth of variation in behavior observed in this study of a single clade recapitulates that generated by the entire Caribbean *Anolis* radiation, suggesting that macrohabitat is an understudied axis of diversification in these lizards.

P3.36 BORUTA, M*; KILVITIS, H.J; KELP, S; EVERETT, B; MARTIN, L.B; Univ. of South Florida, Tampa, Univ.of South Florida, Tampa; *mboruta@mail.usf.edu*

Effect of Early−life Stressors on Honest Signaling of Zebra Finches (Poephila guttata)

Honest signals of male quality are costly and therefore preferred. Many sexually selected traits are sensitive to stressors in adulthood and early development, and may infer a mate's recent and past condition. Males with no previous parasite exposure may be preferred; but, if exposed, females should choose males that overcome infections, especially if they better resist a second encounter. Parasite avoidance may be rare: do females prefer males never exposed to parasites or those generating robust defenses and capable of future survival to exposures? When environmental factors are considered, are mechanisms providing protection against subsequent infections more likely to be compromised? We compared various developmental stressors on zebra finch sexually selected traits; some birds experienced a lipopolysaccharide (LPS) simulated infection, an avian stress steroid, corticosterone (CORT), both challenges (CORT/LPS), or some were controls. We predicted CORT/LPS individuals would grow slowest and express the least developed sexual characteristics (i.e., bill and cheek patch coloration). We also predicted increased growth in CORT−only and LPS−only birds compared to birds challenged with both substances. We expected LPS−only birds to have more developed sexual characteristics than CORT−only birds because they survived a simulated infection thus favorable to choosy females. However, LPS−only birds grew faster than all other groups, which grew at similar rates. There was no difference in bill coloration among manipulated treatments, but there was a tendency for CORT males to have brighter cheek patches than LPS males. Additional analyses are ongoing, but we interpret these data as physiological mechanisms may be impacted differently, altering female choice in adulthood.

81.2 BOSCH, I*; SNYDER, S.M.; GALAC, M.R.; JANIES, D.A; State University of New York, Geneseo, University of South Florida, St. Petersburg, University of North Carolina, Charlotte, University of North Carolina, Charlotte; *bosch@geneseo.edu*

Oceanic Sea Star Larvae Host Microbial Community Dominated by Cyanobacteria of the Genus Synechococcus

Sea star planktotrophic larvae provisionally identified as *Oreaster* sp. are abundant in the Gulf Stream and other oligotrophic regions of the Western North Atlantic. The larvae are unusual in two ways: They have the capacity to clone themselves, and they harbor large populations of sub−cuticular bacteria. We studied the diversity of the symbiont microbial community using traditional Sanger and 454 technology to sequence the V1−V3 region of the microbial 16S rDNA. Larvae were collected in the Gulf Stream, 13−15 km south of Long Key, Florida over a three−year period. Sanger sequences of cloned 16S rDNA from six groups of larvae indicated that the microbial communities were dominated by cyanobacteria of the genus *Synechococcus*. Less abundant microbial groups genetically matched the cyanobacterial genera *Prochlorococcus* and *Cyanobium*, and two types of heterotrophic *Alphaproteobacteria*. The 454 sequencing analysis of 15 individual larvae collected in May 2012 also showed dominance of the microbial flora by *Synechococcus*, while the second most abundant bacterial type was an *Alphaproteobacteria* of the order Kiloniellales. Alpha rarefaction analysis indicated that we sampled all of the bacteria present in the individual clonal larvae and beta diversity analysis showed a very high affinity between their bacterial communities. We conclude that these clonal larvae host a specialized bacterial community dominated by photosynthetic bacteria that may provide nourishment for growth and clonal reproduction in the oligotrophic open ocean.

P3.180 BOSTWICK, C*; YANG, Q; FODOR, A; MOROZ, T; KOHN, A; HAWKINS, RD; MOROZ, LL; Univ. of Florida, Columbia Univ.; *cbostwick87@gmail.com*

Single−neuron transcriptome profiling of the memory−forming circuit in the sea slug Aplysia californica

Aplysia californica is a well−established model for learning and memory. It possesses a simple memory circuit, the gill and siphon withdrawal reflex. Here, the monosynaptic connections between the sensory and motor neurons are fundamental sites of neuroplasticity underlying associative and non−associative forms of learning such as sensitization, habituation, and classical conditioning. The diversity of molecular components that comprise this sensory−motor synapse is largely unknown. For the first time transcriptomes of single sensory, motor and interneurons were sequenced. We developed a novel protocol to identify and quantify >99% of all RNAs from individual neurons. These RNA−seq data were assembled, then annotated using the gene models from the recently sequenced Aplysia genome, GenBank's non−redundant protein database, Uniprot's Swiss−Prot, Gene Ontology (GO), PFAM, and KEGG pathways. When the annotated transcripts from each cell type were compared to the combined CNS/neuronal Aplysia transcriptome, we discovered a multitude of transcripts were differentially expressed. This supports the hypothesis that each of these neuron types has a unique molecular signature. In the sensory neurons, one of the most abundant transcripts is sensorin, which is even more highly expressed than beta−tubulin. Some of the differentially expressed transcripts include: several neuropeptides, two−pore potassium/cationic channels, Slack potassium channel, HCN channels, taurine transporter, NCAM, NMDAR, iGluRs, and non−coding RNAs. These expression data are integral to deciphering the genomic bases of neuronal identity, synaptic transmission, and plasticity within this memory−forming circuit

43.1 BOUILLIART, M.*; TOMKIEWICZ, J.; LAUESEN, P.; ADRIAENS, D.; Ghent University, Belgium, Technical University of Denmark, Charlottenlund , Billund Aquaculture, Denmark; *mathias.bouilliart@ugent.be*

Leptocephalus larvae: Mysterious, Curious and Armed with teeth

The leptocephalus larva is the unique larval stage of Elopomorph fishes. Unfortunately, many aspects of this larva's anatomy, physiology and behavior are, at present, still overshadowed by mystery. Being the proud owners of long, needle−like and forwards−pointing teeth, these larvae nonetheless possess a peculiar characteristic that is as astonishing as it is brain teasing. As teeth do not belong to the standard equipment of fish larvae, a variety of questions come to mind in observing them. What is the function of these teeth? Do they play a role in feeding? Do these teeth change during ontogeny? And if so, will this change influence the feeding performance? To get an insight into these questions, an ontogenetic series of leptocephalus larvae from hatching till glass eel transformation is put together from two artificially bred Anguilliformes. Using a graphical three−dimensional reconstruction of the musculoskeletal system of European (*Anguilla anguilla*) and Japanese eel (*Anguilla japonica*) larvae, present modifications at the level of the teeth and the jaws are visualized throughout the series. Subsequently, 3D data of joints, levers and muscle insertions, as well as muscle data, are derived from these reconstruction and used to estimate theoretical bite forces. Although the expected increase in bite force is observed with progressing age of the larvae, the obtained forces remain rather small. Keeping these forces, as well as a more up−close investigation of the tooth morphology, in mind, actively biting prey items with its teeth ultimately seems an unlikely feeding hypothesis for this developing larva.

S10.1−1 BOUROUIBA, Lydia; Massachusetts Institute of Technology; *lbouro@mit.edu*

Disease transmission through the lens of fluid fragmentation

The transmission mechanisms of most infectious diseases in fauna and flora share common features, in particular they involve multiphase flows. Pathogens are suspended in a liquid phase taking the form of films, drops, or bubbles, and can, in turn, become suspended in a gas phase. The common physical features of such processes ensure that understanding one biological system via the lens of fluid dynamics can yield insights into another. Here, the interplay between fluid fragmentation processes and pathogens will be discussed to highlight common aspects of indoor disease transmission. Fragmentation as arises in sneezes, burst of bubbles from contaminated pools, and nosocomial disease transmission will be discussed.

42.2 BOUZID, N/M*; ROVITO, S/M; VáSQUEZ ALMAZáN, C/R; WAKE, D/B; MVZ, UC Berkeley, Universidad de San Carlos de Guatemala, Guatemala City, Guatemala; *simab0418@gmail.com*

Molecules, mountaintops, and webbed feet: systematics of the bolitoglossine subgenus Mayamandra

The Neotropics are a hotspot of plethodontid salamander diversity, with new species being described each year. The largest genus of neotropical salamanders, *Bolitoglossa*, has been partitioned into seven subgenera by previous studies on the basis of mitochondrial sequence data and morphology. Many recent taxonomic revisions also rely primarily on mitochondrial sequence data to delineate species. In this study we have obtained sequence data from two mitochondrial and four nuclear loci for species in the subgenus *Mayamandra*, the subgenus with the most restricted geographic range, which ranges from Chiapas, Mexico, to northwestern Guatemala. We elucidate geographic species boundaries and test both the recently proposed taxonomic hypotheses and the monophyly of *Mayamandra* in relation to its sister subgenus, *Nanotriton*. We use morphological data to compare both described species and genetically distinct populations. Phylogeographic results show a complex spatial distribution of named species with large mtDNA divergences between different lineages over short geographic distances. The most striking example is a single population restricted to Cerro Tzontehuitz, the highest peak in central Chiapas, that displays a level of divergence comparable to that of other described species within the subgenus. Our results suggest that unrecognized species diversity may remain a factor in Central America and that comprehensive, multi−locus studies of other taxa that include morphological data would provide a more accurate estimate of salamander biodiversity in the tropics. We acknowledge support from the National Science Foundation, award number 1026393.

S8.2−1 BOWDEN, RM*; PAITZ, RT; Illinois State University, University of Illinois; *rmbowde@ilstu.edu*

The importance of fluctuating temperatures for offspring phenotype in turtles with temperature−dependent sex determination

In species with temperature−dependent sex determination (TSD), the temperatures experienced during incubation are correlated with the resultant sex of the offspring. It has also been shown that incubation temperature can influence other phenotypic characteristics of the offspring beyond sex in species with TSD, indicating that temperature can have broad influence over the resulting phenotype. Unfortunately, much of the empirical work demonstrating the relationship between temperature and offspring phenotype has been conducted under constant incubation conditions, conditions that are quite different than those embryos would likely encounter in nature. We have conducted a series of fluctuating temperature studies using the painted turtle (*Chrysemys picta*) and the red−eared slider (*Trachemys scripta*), in both laboratory and field settings. From these studies, we found that traits including body size and coloration are affected by temperature fluctuations, as are measures of immune function under some circumstances. We also found that offspring sex is impacted by temperature fluctuations, with fluctuations producing a greater proportion of females in both species. While constant temperature studies have provided us with a wealth of information on the potential effects of temperature on phenotype, if we are to begin to understand the complex relationship between incubation temperature and offspring phenotype, it is imperative that we utilize more naturalistic incubation conditions. This becomes even more pressing as we contemplate the potential effects of global climate change on both mean temperatures and temperature fluctuations.

P1.53 BOWER, C.D.*; ABRAMSON, C.I.; GUNE^, N.; ÇAKMAK, I.; HRANITZ, J.M.; Bloomsburg University of Pennsylvania, Uluda University, Bursa, TURKEY; *cdb84667@huskies.bloomu.edu*

Extending a hormetic stress model for ethanol to other chemical stresses affecting honey bees.

Stress proteins are molecular chaperones, assisting nascent protein folding during cellular stress. These proteins are highly conserved among all organisms and allow for organisms to survive environmental stresses. Previous research shows that ethanol ingestion affects bee physiology and behavior in ways similar to humans. Increased alcohol dose raises blood alcohol content, reduces locomotor activity and coordination, disrupts memory and learning, increases aggression, and impairs communication among worker bees. Honey bees also exhibit dose−dependent responses to ethanol; low doses stimulate compensatory stress responses and high doses yield lethal stress responses. We used honey bee microarrays to investigate gene expression in the brain at 0 hr and 4 hr post−feeding of an ethanol dose that stimulates a maximum compensatory stress response. Microarray analysis detected 603 reporters that differed between treatment and control bees. Ethanol−induced stress altered expression of gene networks for cellular processes and pathways that regulate cell signaling and stress tolerance, promote oxidoreduction balance, maintain chemical homeostasis, regulate locomotion, and foster communication. In parallel studies, we observed sublethal dose responses for several pesticides used to control mite infestations (acaracides). If similar to our ethanol studies, sublethal doses of acaracides may alter gene expression with unforeseen consequences for honey bee performance. Candidate gene networks are useful to integrate genetic mechanisms of ethanol− or pesticide−induced impairment with specific biological processes, including locomotion, communication, memory, and learning in honey bees.

18.1 BOWLIN, MS*; ENSTROM, DA; MURPHY, BJ; JURICH, P; PURDY, C; PLAZA, E; COCHRAN, WW; COCHRAN, J; University of Michigan−Dearborn, Illinois Natural History Survey, JDJC Corp; *mbowlin@umd.umich.edu*

Between−individual variation in the flight altitudes of Swainson's Thrushes

Radar can track individual migratory birds at night for tens of minutes and in some cases even longer, but in most cases little if anything is known about the individual being studied. Here, we present continuous flight altitude data from 12 Swainson's Thrushes (*Catharus ustulatus*) making full (6−8 h) migratory flights over the midwestern United States. We used new ~1g altitude radiotransmitters and a radiotracking vehicle to collect our data. To our surprise, the thrushes did not select a consistent altitude for the majority of their flight; instead, most repeatedly gained and lost over 60% of their maximum altitude throughout the flights. We will present our data and discuss some potential explanations for this seemingly maladaptive behavior.

108.3 BOYLES, J.G.*; JOOSTE, E.; RUTHERFORD, R.W.; MCCRACKEN, G.F.; Southern Illinois University, Slana, AK, University of Tennesee; *jgboyles@siu.edu*

Energetic costs of pregnancy for small bats at high latitudes

Small endotherms at high latitudes may experience unique bioenergetic constraints during the reproductive season because of cool temperatures and short summers. Insectivorous bats may be under even more severe constraints than other endotherms because of their unique life history traits, including nocturnality. We estimated an energy budget for pregnant little brown bats (*Myotis lucifugus*) in an anthropogenic roost in eastern Alaska (~63°N) using temperature−sensitive radio−transmitters in the field, metabolic rate measurements in the lab, dietary analysis of fecal samples, and energetic content estimates of likely prey items. Body temperature patterns varied widely with some individuals maintaining homeothermy while other individuals commonly entered torpor, a pattern that is thought to be relatively rare among pregnant insectivorous bats. Our estimate of average daily energy expenditure (DEE) for bats that remained euthermic was identical to previous DEE estimates for little brown bats in New Hampshire, where energetic constraints are presumably less severe. However, as expected, torpor resulted in considerable energy savings, which may help some individuals at high latitudes weather the high cost of pregnancy, even with relatively short foraging periods associated with the lack of true darkness. Bats in this study almost completely avoided eating the ubiquitous mosquitoes, which we found to have very little energetic value. Instead, they consumed large numbers of spiders and moths, both of which are relatively energy rich. Thus it seems that relatively minor physiological (e.g., increased torpor usage) and behavioral (e.g., slight dietary shifts) adjustments are sufficient for bats to survive and reproduce at high latitudes.

111.1 BOYKO, CB*; RHODES, A; PETRUNINA, A; KOLBASOV, GA; Dowling College, Texas A&M University−Corpus Christi, Moscow State University, Moscow State University; *cboyko@amnh.org*

A New Species of Tantulocarida (Crustacea) in the Gulf of Mexico: The First Tantulocarid Parasite from the Western Atlantic

The parasitic crustacean taxon Tantulocarida contains 36 species in 23 genera known from eastern Atlantic, Indo−West Pacific and Antarctic waters. To date, none have been reported from the western Atlantic Ocean. We report here on a new species of tantulocarid, apparently a species of *Microdajus* based on light microscopy observations, collected at 684 m on a new species of Typhlotanaidae (Crustacea: Tanaidacea) in the Gulf of Mexico. 75% (6/8) of these tanaid host specimens in a single core were infested. The unique and complex life cycle of tantulocarids is reviewed and additional evidence provided based on this new material. The biogeographic and bathymetic implications of the new species discovery are discussed: Tantulocarida is postulated to have a global distribution where suitable tanaid hosts (all currently known to belong to Paratanaoidea) are present and a wide depth range from 20 to nearly 3000 m. Tantulocarids are often found on locations on hosts (antennae, chelipeds) where the likelihood of mechanical removal is high, suggesting that the host behavior is modified to prevent parasite removal.

P1.65 BRACE, AJ*; SHEIKALI, S; MARTIN, LB; University of South Florida; *abrace@mail.usf.edu*

Dose and context dependency of the costs of immunity in an introduced ectotherm

When exposed to parasites, a vertebrate's first mechanism of resistance is activation of the innate immune system. However, differences in environmental (e.g., temperature), host (e.g., infection history, reproductive status), and parasite (e.g., virulence) characteristics drive defense strategies (e.g., resistance or tolerance) to vary among or within populations. The main reason for this diversity may be that no single defense strategy is optimal in all contexts as immunity in various forms is costly and tradeoffs among physiological processes must occur to support it. Host investments in defenses should differ contingent on exposure level to a pathogen. Additionally, environmental conditions can alter efficacy of the immune response, especially in ectotherms, whose immune defenses are impacted greatly by temperature. Here, we compared the effect of ambient temperature and multiple doses of a simulated pathogen (LPS), which incurs a protein−intensive response, on allocation of a critical amino acid (leucine) to the liver and gonads of brown anoles (*Anolis sagrei*), an introduced species in Florida. We hypothesized that leucine allocation to the liver would increase with LPS dose, although the shape of the function for the cost of defense was unpredictable. We expected that low temperature might reduce the slope of the dose−allocation function, change the dose at which resource costs are incurred, or slow overall assimilation rates. We also expected that gonad effects would be opposite the patterns in the liver due to tradeoffs between the immune and reproductive system. Our results will provide a better understanding of the shape of defense cost functions, which will inform when and why resistance, tolerance and subsequently virulence, should evolve in this and related ectotherms.

P3.121 BRADLEY, P. W.*; BLAUSTEIN, A. R.; Oregon State University; *paul.bradley@science.oregonstate.edu*
Differences in susceptibility to the amphibian pathogen Batrachochytrium dendrobatidis across host age
Metamorphosis can be a stressful period for amphibians with the transition from an aquatic and herbivorous lifestyle to that of a more terrestrial and carnivorous lifestyle. The amphibian immune system is believed to be down−regulated during and through this period of transition leaving recently−post−metamorphic frogs in an immunosuppressed state. One ecologically important disease of amphibians is chytridiomycosis, which is caused by the fungal pathogen *Batrachochytrium dendrobatidis*. Negative effects of infection are believed to be stronger in the post−metamorphic life stage, and there is some evidence to suggest that recently−post−metamorphic frogs are at the most risk to the negative effects of the disease. Our experiment was designed to test the hypothesis that susceptibility to infection, and survival after infection, vary as recently−post−metamorphic frogs age. We raised two species of amphibians (*Pseudacris regilla* and *Rana aurora*) to metamorphosis and subsampled a portion of these individuals at various time points following metamorphosis: approximately 1, 2, and 3 weeks post−metamorphosis and 1, 3, 5, 7, and 9 months post−metamorphosis. At each time point, we exposed individuals to the pathogen and monitored survival and infection load. We exposed individuals to one of two concentrations of the pathogen: a fixed number of infectious particles across all ages, or a mass−specific concentration based upon the average mass of the individuals at that time point. Counter to our initial predictions, in both species survival was highest at the earliest time points and only at the later time points did we observe the expected levels of mortality. Additionally, this trend of increased pathogen−induced mortality with age was consistent across both pathogen−exposure concentrations.

17.3 BRANDT, E.E.*; CHAN, N.S.; MILDER, M.J.; ELIAS, D.O.; Univ. of California, Berkeley; *eebrandt@berkeley.edu*
Kinematic and Behavioral Differences between Targeted and Untargeted Jumps in a Jumping Spider
Jumping has convergently evolved in many animal taxa. Although well−studied in insects such as grasshoppers, little attention has been paid to other arthropod groups such as spiders. Jumping spiders (Aranae, Salticidae) do not spin webs for prey capture, and instead use jumping as a primary means of locomotion (both escape from predators and prey capture). Previous work has shown that spiders have distinctive muscular morphology, incorporating hydraulic pressure into a unique jumping mechanism. However, jumping in jumping spiders has been understudied. In this study, we used *Habronattus conjunctus*, a desert−dwelling jumping spider, to investigate how jumping mechanisms differ between behavioral contexts. In particular we examined escape and targeted jumps. We found that spiders spent more time preparing for targeted jumps and attain relatively lower velocities. We also noted imprecise, often unpredictable aerial paths, and clumsy landings in escape jumps. We suggest that the increases in velocity and unpredictability are important to predator evasion and that a high degree of physical robustness has evolved in these spiders to allow them to withstand unwieldy landings. Finally, we found that spiders were unable to attain distances during escape untargeted jumps that they could easily attain in untargeted jump. We explore accuracy at different distances and speculate as to why distances on targeted jumps are so much shorter.

62.5 BRAZEAL, K.R.*; HAHN, T.P.; Univ. of California, Davis; *krbrazeal@ucdavis.edu*
Carotenoid coloration and the breeding molt trade−off in Cardueline finches
Carotenoid coloration in birds has long been studied for its role in sexual selection because it signals male quality and correlates with mating success. However its relationship with molt timing is less well understood. This link is important because carotenoids are deposited into feathers during molt. Testosterone may be an important mediator of the relationship between carotenoids and molt since it has been shown to play a role in carotenoid signaling as well as in timing of the breeding−molt transition. We examined the relationship between carotenoid coloration and molt timing in T−treated and non−T−treated captive male house finches and pine siskins. More brightly colored individuals (i.e. redder house finches and larger yellow wing patches in pine siskins) tended to molt later in non−T−treated groups of both species. Further, in house finches, redder birds had greater molt delay and less breeding−molt overlap in response to T−treatment. Therefore, enhanced carotenoid coloration seems to have a negative association with molt. From a sexual selection perspective, this may be because birds with greater carotenoid coloration are more likely to attract mates late in the breeding season and would therefore benefit more from delaying molt and investing in current reproduction. The proximate relationship between carotenoids and molt timing is unclear. Carotenoids in the blood could directly influence molt, or alternatively, factors related to male quality (e.g. body condition) could affect both coloration and molt timing. Either way, testosterone is likely to be a mediating factor since individuals differ in their responses to T−treatment.

30.2 BREUNER, C.W.*; HAHN, T.P.; The University of Montana, Univ. Of California, Davis; *creagh.breuner@umontana.edu*
The migration−breeding transition: integrating behavior, stress physiology and experience from a long term data set
The transition from migration to breeding requires major changes in morphology, physiology and behavior. Many long−distance migrants need to be highly flexible during this transition, given the disconnect between conditions on the wintering grounds and at the breeding site. Arrival at the breeding site may be followed by immediate initiation of nesting (in mild years), or an extended wait for nest sites to become available (in more extreme years). The mountain white−crowned sparrow is such a species. Nest initiation date can vary interannually by as much as 6 weeks depending on local snow pack and weather. We have studied the arrival biology of the mountain white−crowned sparrow for 15 years, evaluating the role of stress physiology in behavioral transitions from migration into nesting. In this presentation I will discuss data demonstrating that glucocorticoids extend flexibility during this migration/breeding transition: as winter−like conditions persist on the breeding site, glucocorticoids temper the increasing focus on the nesting site; higher glucocorticoids are associated with earlier territorial abandonment during spring storms; and, exogenous glucocorticoids induce movement away from the breeding site down to lower elevation staging areas. Taken together, this glucocorticoid−induced increase in flexibility may enhance survival in years with more inclement weather.

9.7 BRISCOE, N.J.*; HANDASYDE, K.A.; KROCKENBERGER, A.; PORTER, W.P.; KEARNEY, M.R.; Univ. of Melbourne, James Cook Univ., Cairns, Univ. of Wisconsin, Madison; *nbriscoe@unimelb.edu.au*

Lizard thermoregulation indices applied to the koala provide evidence for behavioural thermoregulation

Both ectotherms and endotherms can select microclimates or adopt postures or orientations that aid with the regulation of body temperature. The thermoregulatory behavior of ectotherms is often quantified using indices that compare body temperatures experienced by animals in the field to that of a non−regulating control moving randomly through the environment. These indices provide information about the thermal quality of the habitat and allow comparisons to be made between sites, seasons or different species. We adapt this approach for endotherms so that thermal quality of habitat (d_e) and effectiveness of thermoregulatory behaviour (E) are evaluated with respect to an animal's thermal−neutral zone, rather than preferred body temperatures. We then use these indices to evaluate patterns of thermoregulatory behaviour in an arboreal marsupial, the koala *Phascolarctos cinereus*. We collected behavioural, microclimate, and habitat data from a southern (temperate) and northern (tropical) site, and used a biophysical model to predict energy and water costs of koalas as well as to model energy and water costs of a randomly behaving control. There was no evidence that koalas used behaviour to reduce energetic costs of thermoregulation. However they used both postural adjustment and microclimate selection to reduce heat loss requirements, remaining closer to their thermal−neutral zone than expected from the null model. Koala investment in thermoregulatory behaviour increased as the thermal quality of the habitat decreased in summer, but not in winter.

31.7 BROKAW, J. M.*; HUDDLESTON, J. R.; ZAK, J. C.; JETER, R. M.; Abilene Christian University, Texas Tech University, Texas Tech University; *jmb97t@acu.edu*

The evolution of natural transformation as a mechanism of horizontal gene transfer among environmental Aeromonas species

Aeromonas species are common inhabitants of aquatic environments and relevant as human pathogens. Their potential as pathogens may be related in part to lateral transfer of genes associated with toxin production, biofilm formation, antibiotic resistance, and other virulence determinants. Natural transformation has not been characterized in aeromonads. DNA from wild−type, prototrophic strains that had been isolated from environmental sources was used as donor DNA in transformation assays with auxotrophs as the recipients. Competence was induced in 20% nutrient broth during the stationary phase of growth. Optimal transformation assay conditions for one chosen isolate were in Tris buffer with magnesium or calcium, pH 5−8, and a saturating concentration of 0.5 ¼g of DNA per assay (3.3 ng of DNA ¼l) at 30 °C. Sodium was also required and could not be replaced with ammonium, potassium, or lithium. The maximal transformation frequency observed was 1.95 × 10 transformants (recipient cell) . A survey of environmental *Aeromonas* auxotrophic recipients (n = 37), assayed with donor DNA from other wild−type environmental aeromonads under optimal assay conditions, demonstrated that 73% were able to act as recipients, and 100% were able to act as donors to at least some other aeromonads. Three different transformation groups were identified based on each isolates' ability to transform other strains with its DNA. The transformation groups roughly corresponded to phylogenetic groups. These results demonstrate that natural transformation is a general property of *Aeromonas* environmental isolates. However, a surprising result was that close relatives were far more likely to exchange DNA through transformation in a pattern reminiscent of the biological species concept in eukaryote evolution.

9.4 BROTHERS, C.J.*; MCCLINTOCK, J.B.; Univ. of Alabama, Birmingham; *brotce@uab.edu*

The effect of climate−induced elevated seawater temperature on covering behavior in the echinoid Lytechinus variegatus.

Most species of regular echinoids lift materials such as stones, seagrass, or shells on to their aboral surface using their tube feet and spines. The functional significance of this "covering behavior" may include protection from UV radiation, preventing dislodgement from surge, and/or avoiding predation. Although studies have indicated that non−covering neuromuscular behaviors in invertebrates are sensitive to thermal stress, no studies to date have examined the potential impact that climate−induced elevated seawater temperatures may have on echinoid covering behavior. Individuals of *L. variegatus* were collected in Port Saint Joseph, FL and slowly adjusted over a period of one week to either 28°C (current summer seawater temperature) or 32°C (near−future climate−induced summer seawater temperature). A preliminary experimental trial was conducted to establish protocols for further experiments. Echinoids (n=4 per treatment) were each presented with fifteen identical covering items (1 cm diameter glass spherical beads) and then observed every four hr over a two day 48 hr period (12 hr light:12 hr dark cycle). Echinoid covering behavior (up to six beads per individual) was observed regardless of temperature treatment. There was no obvious difference between the number of beads held during light or dark periods. However, sea urchins exposed to 32°C required twice as long (8 hr) to initially cover than did urchins held at 28°C (4 hr). Based on these preliminary data additional experiments conducted at various time lengths and with larger numbers of individuals will be conducted to provide a rigorous assessment of potential impacts of future temperature rise on covering behavior in *L. variegatus*.
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48.7 BROTHERS, JR*; LOHMANN, KJ; University of North Carolina, Chapel Hill; *brotherj@live.unc.edu*

Baby come back: Geographic shifts in sea turtle nesting provide evidence for geomagnetic imprinting

Some migratory animals return to reproduce in the same geographic region where they began life, a behavior known as natal homing. Loggerhead sea turtles from the southeastern US provide an iconic example. These turtles circumnavigate the North Atlantic before returning, as adults, to lay eggs on the same area of coastline that they left as hatchlings. The mechanism for natal homing is unknown, but the geomagnetic imprinting hypothesis proposes that young turtles imprint on the magnetic field of their natal beach and use this information to return years later. This strategy appears plausible because the earth's magnetic field varies spatially and most nesting beaches have unique magnetic signatures. Furthermore, loggerheads can detect the magnetic signatures that exist in different geographic regions. The geomagnetic field is not stable and the field at a given location drifts slightly over time. Along the Florida peninsula the field has moved in such a way that at some times and places magnetic signatures converge along the coast, while at others they drift farther apart. In principle, if the geomagnetic imprinting hypothesis is correct, then these changes in the field should cause detectable shifts in nesting distributions. An analysis of Florida nesting data revealed that areas of magnetic convergence are characterized by an increase in nest density, while areas of divergence are associated with a decrease. This finding is consistent with the magnetic imprinting hypothesis and implies that sea turtles use magnetic cues to target nesting beaches.

P3.53 BROWN, J.B.*; TURNER, S.E.; RAMIREZ , J.N.; CORY, W.C.; WELCH, A.M.; College of Charleston; *jbbrown@g.cofc.edu*
Individual and combined effects of ibuprofen and its photodegradants on southern toad tadpoles
Many pharmaceuticals are not completely broken down within the body and may not be adequately removed during wastewater treatment. Once released into the environment, these pharmaceuticals can be converted into related compounds, which may be more toxic than the original molecule. In addition, pharmaceuticals and their degradants are expected to co−occur during the degradation process, yet little to no information exists about the effects of such compounds in combination. Ibuprofen is one of the most commonly used pharmaceuticals and exists in appreciable concentrations in the environment. In the presence of sunlight, ibuprofen degrades into 4−isobutylacetophenone. This photodegradant is less polar than the parent molecule and is therefore predicted to be more toxic. Using tadpoles of the southern toad (*Anaxyrus terrestris*) as a representative freshwater vertebrate, we tested the relative toxicity of ibuprofen and its photodegradant as well as their toxicity in combination. Tests of acute toxicity (measured as median lethal concentration at 96 hours) showed that the photodegradant was more toxic than ibuprofen, as predicted by their relative polarities. In addition, the mixture of ibuprofen and its photodegradant was more toxic than predicted based on the effects of either compound alone, showing a moderately synergistic effect. Thus, photodegradation of ibuprofen in the environment is predicted to result in increased risk for freshwater organisms. More generally, understanding the biological effects of pharmaceuticals and their degradants, alone and in combination, is important for assessing the environmental impact of pharmaceutical pollution in freshwater ecosystems.

59.6 BROWNE, AM*; MOORE, PA; Bowling Green State University; *amandmb@bgsu.edu*
Effects of sublethal levels of the herbicide 2,4−D on foraging behaviors in the crayfish, Orconectes rusticus
The widespread use of herbicides across the globe has significantly increased the probability of synthetic chemicals entering freshwater habitats. Upon entering aquatic habitats, these chemicals target and disrupt both physiological and behavioral functioning in many different aquatic organisms. In particular, herbicides, such as 2,4−dichlorophenoxyacetic acid (2,4−D), can have negative impacts on the olfactory system because these receptor cells are in direct contact with water−soluble chemicals and stimuli in the environment. Studies focusing on LD50 concentrations can understate the impact of herbicides within aquatic habitats because damage to the olfactory receptors can result in modified behaviors or lack of appropriate responses to environmental or social cues. The purpose of this experiment was to determine whether exposure to sublethal levels of 2,4−D alters the foraging behaviors of crayfish, *Orconectes rusticus*. We hypothesized that crayfish exposed to greater concentrations of 2,4−D would be less successful in locating food, or would consume smaller amounts of food, possibly due to the inability to process the food odors in the contaminated waters. Crayfish were starved for a week to provide motivation to find food and were exposed to three sublethal levels of 2,4−D for 96 h. Animals were placed into a Y−maze system with a fish gelatin food source placed randomly in the right or left arm. Average walking speed, average time spent in the correct arm, and percent consumption were analyzed . Crayfish were impaired in their ability to forage effectively. These inabilities to locate and consume adequate amounts of food could further result in lower body weights and decreased fitness in the populations of crayfish exposed to sublethal levels of 2,4−D in natural habitats.

56.6 BROWNE, K*; CLARKE, J; University of Texas, Austin; *katie.pyon@gmail.com*
Orbit and Scleral Ring Measurements as Predictors of Diving Ecology
Many birds navigate two optically different media, air and water. A few species, such as penguins (Sphenisciformes) dive to depths approaching the aphotic zone of the ocean and must accommodate their vision to both the change in media and significant light attenuation. Optical properties of the eye e.g., pupil aperture and focal length, are reflected in the eye's gross morphology and have been shown to have a strong positive correlation with osteological proxies from the orbit and scleral ring. This study combines measurements of osteological features of the eye utilized in previous studies to create a larger feature space for classification of ecology based on eye shape. A total of 170 species were evaluated for distinct classes of eye shape, 97 of which were newly measured species of Charadriiformes, Procellariformes, and Pelecaniformes. Logistic regression and neural networks recovered diving birds as most similar to mesopic terrestrial taxa but did not recover classes by dive depth or activity pattern. Logistic regression recovers different styles of prey capture (i.e., plunge, pursuit, skimming, or wading) based on orbit and scleral ring measurements. Misclassification of dive type is most common in birds that exhibit multiple modes of prey capture. Aquatic birds are active in a wide range of conditions. Foraging both day and night and at varying water depths based on the time of year and available prey. Diverse waterbird ecology probably contributes to the lack of distinct ecological classes based on dive depth and dirunal/nocturnal activity. However, prey capture method has a sufficiently strong influence to allow classification of eye shape with minimal error.

P2.6 BROZEK, J.B.*; SCHNEIDER, J.E.; Lehigh University; *jmb408@lehigh.edu*
Interindividual variation in hamster hoarding behavior likely due to maternal effects, not additive genetic variation
Acquisition of nutrients from the environment is critical to survival and reproduction. Associated behaviors like appetite may represent plastic responses to internal and external cues. Consistent differences among species and populations in behaviors like food hoarding suggest an underlying genetic component, and that selection can act on variation in hoarding in wild populations. We use Syrian hamsters *Mesocricetus auratus* as a model system to understand neuro−endocrine mechanisms associated with the switch between food and sex behavior. We observe consistent variation in hoarding among individuals acquired from breeding colonies, and within stocks produced in our lab. Within individuals, hoarding behavior is repeatable. We test the hypothesis that inter−individual variation is due to additive genetic variance using a pedigreed population of hamsters representing a mix of three ancestral stock populations. We established a heterogeneous stock as a 3−way cross, and tested hoarding behavior over 4 days, ending on postnatal day (PND) 90. Tested animals were randomly mated, avoiding sibling pairs. We use parent offspring regression and ANOVA to estimate heritability and additive genetic variance. An animal model was used to evaluate the contribution of several factors to observed variance. We found little evidence for additive genetic variance contributing to hoarding behavior in laboratory bred hamsters. We suggest that maternal effects, possibly through gestational programming, likely contribute significantly to variation in appetitive ingestive behaviors in laboratory derived hamsters. Accounting for this variance may play a role in the interpretation of data from neuro−endocrine studies attempting to understand the underlying mechanisms associated with food hoarding.

109.7 BRUGLER, M.R.*; RODRIGUEZ, E.; SIDDALL, M.E.; AMATO, G.; Sackler Institute for Comparative Genomics (SICG), American Museum of Natural History (AMNH), Central Park West at 79th Street, New York, NY 10024 USA, Division of Invertebrate Zoology, AMNH, SICG, AMNH, SICG, AMNH; *mbrugler@amnh.org*

Next−generation sequencing of legacy collections at the American Museum of Natural History

The American Museum of Natural History is one of the world's largest repositories of preserved specimens in the world. To take advantage of these legacy collections, the AMNH's Sackler Institute for Comparative Genomics recently acquired a 454 Next−Gen Sequencer and initiated a collaboration with the New York Genome Center. We are utilizing transcriptomics to elucidate the evolution of venom genes (model system: sea anemones), anticoagulant genes (terrestrial and aquatic leeches), wing development genes (damselflies), gene expression levels in metamorphosing flatfish larvae and marker development for phylogenetic analysis of *Eleodes* darkling beetles and deep−sea anemones (the latter will serve as a case study). Whole genome shotgun sequencing (WGSS) is being used to characterize the luciferase gene(s) of deep−sea myctophids (lanternfish), map polydnaviridae sequence in a parasitic wasp genome, and to determine whether the rate of molecular evolution is correlated with mitochondrial gene rearrangements in the order Actiniaria (sea anemones). Lastly, amplicon sequencing is being used to elucidate the biodiversity and ecology of microbiomes in the Amazon River. We have also undertaken an innovative approach of combining amplicons and WGSS into a single 454 run to analyze the crop blood meals of haemadipsid leeches as well as crop−resident bacteria and trypanosomatid flagellates. Whole genome and transcriptome sequencing projects that are being completed in collaboration with the Weill Cornell Medical College will also be discussed.

90.4 BUCHWALTER, D*; CAMP, A; KIM, K; FUNK, D; PATHMASIRI, W; RAYMER, J; SUMNER, S; North Carolina State University, Stroud Water Research Center, Research Triangle Institute ; *david_buchwalter@ncsu.edu*

Does temperature affect aquatic insects via oxygen limitation?

Oxygen limitation has been proposed as the fundamental mechanism responsible for establishing thermal limits in ectotherms. This paradigm is based on data from several species that indicate that the metabolic demands associated with thermal challenge are not met with commensurate uptake and delivery of oxygen to tissues. To test whether this paradigm can be applied to aquatic insects, we combined respirometry, gene expression (qPCR) and metabolic profiling studies in an emerging mayfly laboratory model − *Centroptilum triangulifer* (Ephemeroptera: Baetidae). Thermal ramping studies were conducted at an environmentally relevant ramping rate of 1°C/hour from a base culture temperature of 22 °C to 34°C. Intermittent−flow respirometry studies revealed the expected logarithmic increase in oxygen consumption with no evidence of leveling off or plateauing a higher temperatures. qPCR studies in larvae sampled at 4°C intervals showed strong thermal responses in heat shock protein genes, with no evidence of genes associated with hypoxia inducible factor (HIF) signaling. At 34°C (beyond the thermal tolerance of this species in life cycle rearing tests), we observed a very modest increase in lactate dehydrogenase (LDH) gene expression relative to its expression levels in hypoxia−treated positive controls, suggesting that obviously heat stressed C. triangulifer were not experiencing oxygen limitation. Metabolic profiling studies indicate that purine metabolism, urea cycle, and fatty acid metabolism are affected by thermal challenge.

108.8 BUJAK, JK*; BOLLINGER, RJ; MADSEN, SS; TIPSMARK, CK; Univ. of Arkansas, Fayetteville, Univ. of Southern Denmark, Odense; *jkbujak@uark.edu*

Effects of Salinity and Hormone Treatment on Gill Claudin Expression and Localization in Rainbow Trout (Oncorhynchus Mykiss)

In the branchial epithelium of euryhaline fish, permeability changes are critical during acclimation to changes in salinity. Claudin proteins are integral components of tight junctions and control paracellular resistance and cation selectivity. From previous studies in our laboratory it is clear that claudin−10e, −28a and −30 have the highest expression in gill tissue of rainbow trout. In the present studies we examined the localization of these three proteins in the gill tissue to develop our knowledge about their physiological role. Specific antibodies were developed and validated for Western blot. Localization of claudin−10e, −28a and −30 were then examined in freshwater and seawater acclimated rainbow trout. Immunofluorescence microscopy showed localization of claudin−10e exclusively in Na,K−ATPase rich cells in the filament of SW fish. This is in accordance with our previous observations that seawater (SW) transfer strongly stimulates claudin−10e expression. Furthermore localization in SW ionocytes is consistent with in silico analysis suggesting that this isoform forms cation pores and thus may be instrumental in creating the leaky pathway for sodium. Claudin−30 was found deeper in the gill filament and was absent from Na,K−ATPase rich cells while Claudin− 28a was detected in both pavement cells and ionocytes. The effect of osmoregulatory hormones on claudin−10e, −28a and −30 is currently under investigation and will be presented.

15.1 BULA, PA; ZANI, PA*; University of Wisconsin−Stevens Point; *pzani@uwsp.edu*

The effects of predatory lizards on limb−morphology evolution in side−blotched lizards, Uta stansburiana

Since Arnold (1983) introduced the ecomorphological paradigm numerous studies have demonstrated clear morphology−performance links. However, less clear are the ecological patterns stemming from morphotype−performance−fitness links. To elucidate such patterns we tested the hypothesis that limb dimensions of a prey species vary among populations that differ in predation pressure. To test this hypothesis we studied 22 populations of side−blotched lizards, *Uta stansburiana stansburiana*, in the northern portion of the species' range where site differences in types and abundance of predators were evident. Using external markers from standardized photos we measured limb elements in 774 male lizards. As predicted, lizards from sites with lower predator densities had shorter size−relative limbs and limb elements (pes and 4th toe were significantly longer; femur and tibia were marginally longer). However, of the major classes of predators (birds, snakes, predatory lizards), only the densities of predatory lizards explained limb morphology in side−blotched lizards. Moreover, using the number of species of predatory lizards at a site was sufficient to explain limb dimensions. It is presumed that after the last glacial maximum, side−blotched lizards dispersed into the northern portions of the Great Basin and became parapatric to predatory lizards. We postulate that this parapatry reduced the need for the longer limbs associated with greater locomotor performance, thereby selectively favoring the opposing advantages of shorter limbs. We suggest that the strong morphotype−performance link has led to rapid fitness−enhancing morphotypic changes among quasi−continuously distributed populations of side−blotched lizards.

93.1 BURDEN, SA*; SASTRY, SS; FULL, RJ; Univ. of California, Berkeley; *samaburden@gmail.com*

Optimization for models of legged locomotion: parameter estimation, gait synthesis, and experiment design

Optimization theory provides a powerful framework for the study of organismal biomechanics that enables: estimation of uncertain model parameters or exogenous inputs using empirical data; synthesis of gaits and dynamic maneuvers that extremize a given performance criteria; and design of experiments to maximally distinguish predictions of competing models or sets of hypotheses. Such techniques are well−studied for continuous models that are specified by a single ordinary differential equation, but less well−developed for the piecewise−defined or discontinuous models that naturally describe terrestrial locomotion. Computationally−tractable algorithms for parameter estimation near a periodic gait undergoing a prespecified sequence of isolated foot touchdown events exist, but still impose stringent assumptions on the sequence of discrete events or the region of the state or parameter space that may be explored. We propose a scalable algorithm for optimization of piecewise−defined models for terrestrial locomotion that generalizes previous efforts by defining and numerically computing the first−order variation of model trajectories. We apply nonlinear programming to solve optimization problems while imposing minimal restrictions on model structure or event sequences. In particular, our method can optimize footfall sequence and timing for aperiodic gaits. More broadly, this foundational technique for parameter estimation, gait synthesis, and experiment design provides a link between model−based investigations and data−driven experimental study of legged locomotion.

S1.1−1 BURGGREN, W. W.; University of North Texas; *burggren@unt.edu*

Epigenetics and Organismal Biology

Epigenetics as a focus for biological studies has increasing exponentially over the decades since the introduction of this concept by Conrad H. Waddington in 1942. Yet, the broad incorporation of epigenetic theory and practice into experimental paradigms for studies in organismal biology has been slow in developing. Indeed, a lack of recognition of the subtle yet powerful influences of epigenetics has doubtlessly contributed to the "intrinsic" variation that is recognized but unexplained in comparative biological data sets. Organismal biologists are increasingly familiar with epigenetic phenomena and their mechanisms, but may still not fully appreciate that delineating epigenetic effects is a complex process, often requiring elaborate experimental designs affected across multiple generations. Adding to the complexity of a sometimes confusing epigenetic landscape is the fact that, while the original definition of "epigenetics" incorporated non−genetic transgenerational transfer of phenotypic characters, biomedical research of late has co−opted this term to also refer to within−generational phenomena related to disease states (e.g. "the epigenetic origins of cancer"). The purpose of this symposium is to 1) use a broad array of examples (invertebrates, vertebrates, plants) to increase awareness and understanding of epigenetics and the epigenome among comparative physiologists, morphologists, developmental biologists and numerous other disciplinary practitioners whose experiments may be unknowingly influenced by epigenetic effects, 2) to discuss the latest research on the molecular mechanisms underlying epigenetic phenomena, and 3) review recent investigations of epigenetic phenomena and their implications to both organismal biology and health−related research.

35.3 BURNETT, N.P.; Univ. of California, Berkeley; *burnettnp@berkeley.edu*

Effects of floats on how seaweeds move in unidirectional and wave−driven flow

Seaweeds are an important group of organisms in marine ecosystems, serving as major primary producers, providing habitat for smaller organisms, and competing for space with other sessile organisms. Each of these important ecological roles is influenced by the movement of the seaweed in ambient water flow: moving higher in the water column increases light exposure for photosynthesis, fluttering induces mixing and gas exchange, and large sweeping motions can dislodge or damage neighboring organisms. I used physical models of strap−like algal blades to identify how the movement of the blade is impacted by buoyant floats (pneumatocysts), a common feature of intertidal kelp, such as *Egregia menziesii*. The buoyancies and arrangements of the model pneumatocysts were manipulated and the height, flapping amplitude, and speed of the models were measured in both unidirectional and wave−driven flow conditions in laboratory flumes. In both unidirectional and wave−driven flow, positively buoyant pneumatocysts along the length of a blade increased the height and the amplitude of blade motion. However, manipulating the drag and buoyancy of pneumatocysts at the base or middle of blades had different effects in waves than in unidirectional currents. For example, in wave−driven flow, blades maintained a higher position in the water column after basal and middle pneumatocysts were removed or made neutrally buoyant, whereas this generally had the opposite effect in unidirectional flows. This model−based study suggests that the position, buoyancy, and drag of pneumatocysts can influence seaweed motion differently in waves versus unidirectional currents, thereby impacting how those seaweeds interact with the surrounding community.

95.2 BURNETTE, M.F.*; ASHLEY−ROSS, M.A.; Wake Forest University; *burnmf0@wfu.edu*

Foraging archer fish aggressively drive conspecific competitors away from reliable food sources

Archer fishes (Toxotes spp.) are skillful hunters of terrestrial insects; firing streams of water from their mouths, they are capable of dislodging a prey item from overhanging perches positioned several body lengths away. Archer fishes are social, and bystanders will attempt to steal prey knocked down by shooters. Previously published research has found that even in small groups (3 individuals) thieves are highly successful when prey are spatially and temporally unpredictable. We asked what tactics are used by shooters and bystanders when prey are (1) spatially and temporally predictable and (2) when prey are spatially but not temporally predictable. Fish were housed in pairs, giving us the smallest possible group size so that interactions between animals could be better understood. We found that when prey are spatially and temporally predictable, one animal aggressively guarded the area under which the terrestrial prey would appear, and chased other individuals away. This led to high capture success rates by the aggressor when it shot down the prey item. Under the spatially predictable (but temporally unpredictable) prey presentation regime, aggressive individuals guarded the area under which prey would appear, and prey capture rates were also high. We found that, when prey are spatially predictable (regardless of temporal predictability), aggressive individuals were more likely to shoot down prey and have high rates of capture success, while bystanders rarely shot down prey and were less successful at stealing prey. Bystanders were always non−aggressive and were unable to secure a spot for an extended period of time underneath where prey would appear. Future work will quantify circulating hormones in archer fish and seek a physiological understanding of why shooters are aggressive and bystanders are not.

42.1 BURROUGHS, R. W. ; The University of Texas at Austin, Jackson School of Geosciences; *RBurroughs@utexas.edu*

Evaluating the impact of anatomical partitions on morphology−based phylogenetic reconstructions

The nature of biology is such that the total amount of potential phylogenetic data cannot be used to construct phylogenetic hypotheses. This is particularly true for the fossil record, which most often is limited to morphological data for phylogenetic inference. In systematic analyses that include fossils this often results in an implicit assumption that individual anatomical regions each provide complimentary phylogenetic signal and hypotheses. I chose to explicitly evaluate this assumption, by testing whether or not two separate character sets each provide congruent and complimentary phylogenetic hypotheses. I used a dataset of extant turtles from the Emydidae and partitioned it into two anatomical regions, head and shell. My results indicate that these anatomical regions did not independently yield complimentary or congruent phylogenetic hypotheses. The results of a partition−homogeneity test and comparison of consistency index scores were inconclusive as to whether the two partitions could be combined. Results from Bayesian partition analyses indicated that the best models of evolution for my data are ones that allow independence among the partitions in the form of unlinked branch length priors. My results support the idea that head and shell characters for emydid turtles can be combined, but need to be modeled with some degree of independence. These results also indicate that it is not appropriate to assume that anatomical regions provide complimentary phylogenetic signal and hypotheses without testing this assumption. My work provides a framework by which others may investigate their own morphological datasets to evaluate similar problems.

P1.28 BURROWS, S.J.*; PASCUAL, C.J.; GONZALEZ , V.H; CAKMAK, I.; Utah State University, University of Maryland, College Park, Southwestern Oklahoma State University, Uluda University; *skyler.burrows@aggiemail.usu.edu*

Mid−summer urban bee community diversity on a campus in the Marmara Region of western Turkey

Urban expansion affects the nesting materials and substrates available to bee communities as well as floral hosts that would normally occur in an area. We investigated the bee communities in several distinct habitats on the campus of Uluda University, located in the southern Marmara region of western Turkey, in Bursa. Our goal was to compare the bee communities in open field, forested and highly disturbed areas of campus. We surveyed bees in transects using a mixture of pantraps and net collections radiating from heavily disturbed unmanaged flower patches near the center of campus to wooded meadows near the outside edge with intermediately disturbed sites between the two. From 20 June to 22 July 2013, we collected over one hundred species of bees from twenty five genera. Mid−summer bee diversity and abundance were highest in disturbed areas and lowest in the less disturbed wooded areas.

40.5 BURT, D.B.*; KWIATKOWSKI, M.A.; GUMM, J.M.; Stephen F. Austin State University; *dbburt@sfasu.edu*

Male color as an indication of quality and reproductive success in painted buntings (Passerina ciris)

Painted buntings, *Passerina ciris*, are elaborately colored passerine birds. The exaggerated display traits of painted buntings likely communicate male quality to conspecifics. Determination of male quality is important during competition among males to establish breeding territories and during female mate choice decisions. High quality males are expected to establish territories in the best habitats and have higher relative fitness. We examine how different plumage regions and variation in male color predict nesting success. We also examine how male quality relates to the relative location and habitat makeup of painted bunting territories.

S10.1−2 BURTON, L.J.*; BUSH, J.W.M.; Massachusetts Institute of Technology; *lisa.j.burton@gmail.com*

Biomimicry and the culinary arts

Avant garde cooking, or modern cooking using knowledge of physical and chemical processes, has gained tremendous popularity in the past 20 years. Focusing on science in cooking has introduced new food preparation techniques, revived old cooking methods, and led to novel dishes that aim to engage all the senses. In this presentation, we demonstrate the incorporation of interfacial biological processes into avant garde cuisine. Inspired by a family of floating flowers and interfacial insects, we have developed two culinary devices that rely on surface tension. The cocktail boat is a drink accessory, a self−propelled edible boat powered by alcohol−induced surface tension gradients, whose propulsion mechanism is analogous to that employed by a class of water−walking insects. The floral pipette is a novel means of serving small volumes of fluid in an elegant fashion, an example of capillary origami modeled after a class of floating flowers. The biological inspiration and mechanics of these two devices, along with the collaborative process that led to their development and deployment, are detailed.

P3.19 BUSH, J. M.*; QUINN, M. M.; JOHNSON, M. A.; BALREIRA, E. C.; Trinity University; *jbush1@trinity.edu*

Mathematical Analysis of Social Dominance in the Green Anole Lizard

Dominance relationships are an important aspect of the social organization of many species, and male dominance often results in successful territory defense and/or access to potential mates. In this study, we identified the behavioral and morphological traits associated with dominance in green anole lizards (*Anolis carolinensis*). We first performed a tournament of arena trials using pairs of 18 male lizards. These arena trials stimulated aggressive interactions, often resulting in a clearly dominant male. We used these data to rank the lizards using a series of algorithms, including original ranking methods developed specifically for this application. Our results showed that behavioral displays and relative head length (but not body size) were the most predictive of rank in the majority of ranking systems. We then sought to validate our results by comparing male rank to territory size, a proposed proxy of social dominance. In two replicate studies with 10 male lizards each, we first used a series of arena trials to determine individuals' ranks. We then placed the 10 males in an enclosure with 10 females and measured the sizes of male territories over one week. Although we hypothesized that higher ranked males would have larger territories, we found no correlation between rank and territory size. Finally, we measured morphological traits, aggressive behavior, and territory size in 24 green anoles in Palmetto State Park, Gonzales, Texas, to determine how these traits were related in a natural population. Results from this study indicated that body size (but not behavior) was an important predictor of territory size. Thus, the traits associated with successful long−term defense of a large territory in green anoles may be independent from those needed to win short−term confrontations.

64.4 BUTLER, L.K.*; HOPE, S.; STABILE, F.; OUELLETTE, M.; The College of New Jersey, Ewing; *lbutler@tcnj.edu*

Warmer spring temperatures predict earlier summer molt in a songbird

The atmosphere has warmed significantly at northern latitudes over the past century, and understanding effects of this climate change on life is a major concern for conservation. Whereas earlier nesting is now well−documented in birds in years with warmer springs, no study has investigated effects of a warmer climate on the life−history stage that follows nesting in most songbirds: the annual molt. We studied climate effects on molt dynamics in a forest population of a common and widespread resident songbird, the Carolina Chickadee (*Poecile carolinensis*). Over four years, average March temperature strongly predicted the timing of the start of molt three months later, with molt starting earlier in warmer years and later in cooler years. Analysis of historical museum specimens collected over the past 118 years revealed the same pattern. These results suggest that spring temperatures influence the timing of summer molt via well−described effects on the timing of nesting. Thus a warming climate may result in earlier molting dates in northern resident songbirds.

P2.19 BUTLER, L.K.*; DE BRUIJN, R.; ROMERO, L.M.; The College of New Jersey, Ewing, Tufts University, Medford, Massachusetts; *lbutler@tcnj.edu*

Physiological response of molting songbirds to a labile perturbation factor: Hurricane Irene

Hurricanes are predicted to increase in frequency over the next century at northern latitudes. For most northern songbirds, hurricane season overlaps the molting season. Juvenile birds may be particularly susceptible to hurricane conditions because the first juvenile plumage is lower quality than later plumages, juveniles are less experienced at foraging and seeking shelter than adults, and juveniles have low social status. We compared several measures of the stress physiology of molting juvenile Carolina Chickadees (*Poecile carolinensis*) before and after a hurricane along the Atlantic Coast of North America. The hurricane appeared to have a physiological cost, because hematocrit (percent packed−cell volume) and fat stores were significantly lower the day after the hurricane compared to before the hurricane. Baseline and stress−induced corticosterone concentrations, and body mass, were similar before and after the hurricane. Birds with a less−complete new plumage were significantly less likely to be caught after the hurricane, suggesting the possibility of a molt−dependent effect of hurricane weather on survival or behavior. Together these results suggest that increased frequency of hurricanes may reduce recruitment of songbirds along the northern Atlantic Coast.

50.5 BUTLER, M.R.*; CHUGHTAI, A.; RILEY, L.A.; WALKER, R.A.; DEAROLF, J.L.; RICHMOND, J.P.; Hendrix College, Conway, AR, Univ. of North Florida, Jacksonville, FL; *butlermr@hendrix.edu*

Effects of prenatal glucocorticoids on the fetal guinea pig scalenus muscle

Glucocorticoids are commonly administered to women considered at risk for premature birth to speed up fetal lung development and reduce infant mortality. Although these steroids aid lung development in preterm infants, their effects on ventilatory muscles are not well documented. Studies in our laboratory have found an increased proportion of type IIA fast−twitch fibers and increased IIA and IIX fiber diameters in rectus thoracis muscles of fetal guinea pigs exposed to prenatal steroids. In addition, we have discovered higher concentrations of NADH in the fibers of the scalenus muscles of steroid−treated fetuses, suggesting these muscles have a higher oxidative capacity. Thus, we hypothesized that fetal scalenus muscles exposed to prenatal steroids will exhibit elevated proportions of IIA fibers, increased fast−twitch fiber diameters, elevated citrate synthase activity, and increased myoglobin expression. To test these hypotheses, pregnant guinea pigs were injected with either betamethasone, a glucocorticoid, or sterile water twice a week, twenty−four hours apart, at 65%, 75%, and 85% gestation. Fetal muscle samples were collected and prepared for immunohistochemistry or biochemical analyses. If increased fiber proportions, larger fiber diameters, higher oxidative enzyme activity levels, and higher levels of myoglobin expression are found in treated individuals, these findings would suggest that treated scalenus muscles will produce greater contractile forces and have greater fatigue resistance, which may be demonstrated through physiological testing. These improved functional abilities would allow treated premature infants to better cope with ventilatory challenges when compared to their untreated counterparts.

P3.146 BYRNES, G*; SPENCE, AJ; MARTINO, B; HILT, M; WILSON, AM; Siena College, Royal Veterinary College; *gbyrnes@siena.edu*

The effects of gap distance and substrate compliance on the biomechanics of jumping in gray squirrels (Sciurus carolinensis)

The structure of arboreal environments poses many challenges to animal locomotion including unsteady, compliant branches and large open spaces between adjacent branches. The ability to move among the terminal branches and cross these gaps by leaping can greatly reduce transit distances within the canopy. Branch compliance potentially enables animals to store elastic strain energy in the environment to increase leaping performance. However, animals must delay leg extension until the branch is ascending back to its resting position to take advantage of stored external energy. We investigated the effects of gap distance and branch compliance on the biomechanics of jumping in the gray squirrel (*Sciurus carolinensis*). Both gap distance and branch compliance had significant effects on the kinematics and kinetics of leaping in squirrels. Squirrels jumped with higher peak forces and larger impulses when crossing larger gaps. In addition, extension of both the proximal and distal limb joints increased with increasing gap distance. Peak forces decreased with increasing branch compliance while both joint extension and the time over which joint extension occurred increased with increased compliance. These preliminary data suggest that squirrels are capable of delaying leg extension to coincide with branch recoil during jumping, potentially recovering some of the strain energy stored in the branch. Squirrels also use behavioral mechanisms to limit the magnitude of branch deflection they experience during leaping.

99.4 BYRUM, CA*; WIKRAMANAYAKE, AH; College of Charleston, Charleston, SC, University of Miami, Miami, FL; *byrumc@cofc.edu*

Selective nuclearization of beta−catenin is sufficient to induce formation of a normal pluteus embryo from ectodermal precursors

In metazoans, canonical Wnt signaling is critical for formation of the primary body axis. Translocation of beta−catenin to the nucleus during Wnt signaling activates the production of posterior structures whereas repression of this pathway allows formation of anterior structures. In the 16−cell stage sea urchin embryo, nuclear accumulation of beta−catenin in the micromeres is known to trigger a signaling cascade that defines the primary body axis and causes subsequent specification of the endomesoderm. At this stage, transplanting micromeres to the animal pole induces formation of ectopic endomesoderm in the mesomeres, cells which normally give rise to ectodermal derivatives, via a cell non−autonomous process. To test whether activation of the canonical Wnt pathway is sufficient to impart organizer−like abilities to blastomeres that do not have overt signaling capacity, we overexpressed a constitutively active form of beta−catenin in a pair of mesomeres and recombined them with an isolated animal half at the 16−cell stage. We found that nuclear beta−catenin was sufficient to convert the injected mesomeres into an organizer−like signaling center. Chimeras exhibited normal patterning of the body plan, and nuclear accumulation of beta−catenin had both cell autonomous and cell non−autonomous effects on the specification of cell fates. Furthermore, these results support the hypothesis that a shift in the location of canonical Wnt signaling during early embryogenesis could have contributed to modifications in polarity of the main body axes during metazoan evolution.

92.2 CAHILL, A.E.; Stony Brook University; *acahill@life.bio.sunysb.edu*

Physical and chemical interactions mediate sex change in the protandrous gastropod, Crepidula fornicata (Calyptraeidae)

Crepidula fornicata (Gastropoda: Calyptraeidae) is a protandrous species that lives in semi−permanent stacks of both males and females. Sex change in males is affected by conspecific interactions. Previous lab and field work has shown that males change sex faster and at a smaller size when in isolation or with other males than when the males are associated with females. Recent work in a conspecific (*C.* cf. *marginalis*) has shown that males change sex faster when physically separated from females but contained in the same water (i.e., in contact with the same waterborne cues) than when in physical and chemical contact with a female. However, this has not been demonstrated in *C. fornicata*. Here, I present results of an experiment that investigates the rate of sex change in *C. fornicata* when males are isolated, in physical and chemical contact with females, and in chemical contact only. Snails were physically isolated by placing them in cups with mesh screening separating males and females. Males in this treatment (only in chemical contact with females) change sex at a similar rate to isolated males, suggesting that sex change is mediated by contact cues in this species. This result is consistent with previous studies of calyptraeid gastropods. An additional treatment of empty, cleaned shell (in both the physical and chemical contact treatments) allows me to further localize and characterize the potential cue in *C. fornicata*.

95.4 CAIN, KE*; COCKBURN, A; LANGMORE, NE; Australian National University; *kristalcain@gmail.com*

The role of ecology in shaping female competitive traits: Resource availability, aggression and nest success in two populations of superb fairy−wren

Weapons, ornaments, and agonistic behaviors are common in both sexes, but until recently most research has focused on the role of sexual selection in shaping male traits. In contrast, we know little about the ecological and evolutionary forces that shape the expression of these traits in females. The limited available data suggests that these traits are used to compete for access to limited reproductive resources. If so, variation in ecology is likely an important factor shaping the evolution of female competitive traits. However, the importance of resource availability in mediating female competition, or altering the consequences of variation in female competitive traits, is currently unresolved. Here we explore the eco/evolutionary forces that influence female competition by contrasting two populations of superb fairy−wren (*Malurus cyaneus*) that differ in habitat quality, and examining the relationships between resource availability, reproductive success, female competition and competitive trait expression. We found that when resources were more limited, females had reduced reproductive success and responded more intensely to simulated competitors. We also found that the relationship between competitive ability and reproductive success differed according to resource availability. We conclude that ecology likely plays an important role for determining the optimal level of competitive trait expression in females.

33.4 CALABRESE, G.M.*; BRADY, P.; GRUEV, V.; CUMMINGS, M.E.; University of Texas at Austin, Washington University in St. Louis; *gina.maria.calabrese@gmail.com*

Dynamic Polarization Signaling in Swordtails Alters Female Mate Preference

Polarization of the light field and visual sensitivity to it is pervasive across aquatic and terrestrial environments. While documentation of invertebrate use of polarized light is widespread, evidence of polarization−mediated signaling in vertebrates is currently lacking. Here we provide evidence that vertebrates use polarized reflectance in communication. Combining videopolarimetry and polarization−manipulated mate choice trials using the northern swordtail, *Xiphophorus nigrensis*, we found sexually dimorphic polarized reflectance, polarization−dependent mate choice behavior, and differential polarization signaling across social contexts. Our videopolarimetry measurements reveal that courting males adjust contrast in polarization patterning in social conditions by increasing within−body contrasts but decreasing body−to−background contrasts relative to asocial conditions. Use of polarization cues in mate choice contexts may provide aquatic vertebrates with enhanced detection of specific display features (e.g., movements or angular information), as well as a dynamic signaling mechanism that may enhance detection by intended viewers while minimizing detection by others.

P1.56 CALHOON, E.A.*; WILLIAMS, J.B.; Ohio State University; *calhoon.18@osu.edu*

Connections between non−mitochondrial phospholipid fatty acid composition and life history in temperate and tropical birds

Temperate birds tend to have a fast pace of life, having short life−spans with high reproductive output and high metabolic rate, whereas tropical birds tend to have a slower pace of life, apparently investing fewer resources in reproduction and having higher adult survival rates with lower metabolic rates. How these differences in life history at the organismal level are rooted in differences at the cellular level is a focus of current research. Increasing the saturation level of fatty acids in the phospholipids of cell membranes has been implicated in decreasing metabolic rate and oxidative stress, but this connection has been challenged and its validity may depend on which organelle the saturated fatty acids are located. Several studies have looked at the fatty acid content of phospholipids in whole cells and in mitochondria, but few, if any, have examined the fatty acid composition of non−mitochondrial membranes. Here, we cultured fibroblasts from phylogenetically−paired tropical and temperate bird species, isolated the mitochondria from the other organelles, and then compared non−mitochondrial membrane lipids between tropical and temperate birds using high−performance liquid chromatography−mass spectrometry. There was not a significant difference in the saturation level of fatty acids in phospholipids of non−mitochondrial membranes, indicating that non−mitochondrial membranes may not be important in the connections among the fatty acid content of cellular phospholipids, metabolism, and oxidative stress.

89.6 CALISI, RM*; DICKENS, MJ; ERNST, DK; BENTLEY, GE; Univ. of California, Berkeley; *beccacalisi@gmail.com*

Different Lab Environments Are Not the Same Animal: Aspects of Zebra Finch Stress Physiology Depend on Captive Housing Environment

John Wingfield revolutionized the field of Environmental and Stress Endocrinology by showing that changes in an animal's natural environment (seasonal, social, stress) can and do affect endocrine physiology in profound ways. As certain fields of science become increasingly laboratory model focused, it is important to remember that differences in captive environment can also yield differences in endocrine physiology. Here, we review such instances and report new data that support this notion. Using a model organism, the zebra finch, we show that environment still matters within the captive, laboratory setting. We paired adult males and females in standard laboratory breeding cages and compared aspects of their stress physiology to those housed in large, social, free−flight aviaries. Specifically, we examined differences in circulating plasma corticosterone as well as brain expression of corticotropin releasing hormone (CRH) and gonadotropin inhibitory hormone (GnIH) in response to restraint stress. Data reveal that not all lab environments are equal, and careful interpretation and discussion of discordant data are important to truly understand cause and effect. By understanding such variation, we increase our understanding of the relationship between organism and environment in general.

82.1 CAMP, A.L.*; ROBERTS, T.J.; BRAINERD, E.L.; Brown University, Providence RI; *ariel_camp@brown.edu*

Comparison of cranial and axial muscle power for suction feeding in largemouth bass

Suction feeding relies on substantial muscle power to expand the mouth cavity so that volume increases, pressure decreases, and water and prey are accelerated inside. The power for suction expansion must be generated by muscles, but we know little about how much power is required and the relative contributions of cranial and axial muscles. All actively shortening muscles generate some power, but the magnitude depends on a muscle's mass, activation, and shortening velocity. Both cranial and axial muscles have the appropriate attachments to generate mouth expansion, but the cranial muscles have been hypothesized to be too small to power this motion. We calculated the total power generated during mouth expansion, and compared it to the power each cranial and axial muscle is capable of producing. To calculate suction expansion power, we measured pressure and volume change of the mouth cavity during suction feeding strikes in largemouth bass (*Micropterus salmoides*). The maximum power output of each axial (epaxial, hypaxial) and cranial (levator operculi, dilator operculi, sternohyoid, levator arcus palatini) muscle was calculated from measurements of mass and in vivo shortening velocity. The cranial muscles together could not produce the power required for suction expansion, even assuming optimal activation and shortening velocity. However, the axial muscles were capable of substantial power production, exceeding that required for suction expansion. This was true even when non−optimal (i.e., *in vivo*) shortening velocities were considered. The relatively small size of the cranial muscles limits their ability to generate power for feeding. Fish appear to use much of their massive body muscles to provide the power required for suction feeding.

1.3 CAMP, A.*; BUCHWALTER, D.; North Carolina State University; *david_buchwalter@ncsu.edu*

A stressful shortness of breath: Oxygen consumption patterns associated with molting and thermal challenge in the mayfly Cloeon cognatum.

In insects, one of the more fascinating and improbable aspects of the molt is the fact that not only does the individual discard its exoskeleton, but that the lining of the respiratory (tracheal) system is also shed and renewed. While conducting respirometry experiments on thermally ramped mayfly (*Cloeon cognatum*) larvae, we discovered radical changes in oxygen consumption patterns associated with the molting process. The signature pattern includes a precipitous drop in oxygen consumption (likely associated with the temporary blockage of the trachea), followed by a surge of oxygen consumption to compensate for the preceding oxygen deficit. The magnitude of this respiratory disruption increases with increasing temperature. To our knowledge, this is the first report of molting causing oxygen deficit in an aquatic insect, and provides a potential explanation for anecdotal observations of increased mortality rates in aquatic insect larvae during the molt. We further compared standard metabolic rates (SMRs) and respiratory Q10s in *C. cognatum* larvae reared at different temperatures. The SMR of 22°C reared larvae was 80% higher than 17°C reared larvae, while the SMR of 27 °C reared larvae was only 39% higher than 22°C reared larvae. Q10s were highest (2.41 ± 0.32) in larvae ramped from an optimal rearing temperature (22°C), somewhat lower (2.13 ± 0.36) at a sub optimally warm rearing temperature (27 °C), and significantly lower (1.82 ± 0.17) in sub optimally cold (17°C) reared individuals. The importance of linking physiological performance to known life history outcomes will be discussed.

31.6 CAMPBELL−STATON, SC*; CHEVIRON, ZA; BARE, AC; LOSOS, JB; EDWARDS, SV; Harvard University, University of Illinois Urbana−Champaign; *scstaton@fas.harvard.edu*

Physiological and genomic underpinnings of cold tolerance variation in the green anole, Anolis carolinensis

Climate can play an important role in the evolutionary history of species. Novel variation in the abiotic environment can limit species distributions and provide a selective pressure leading to adaptive differentiation between populations distributed across a climatically heterogeneous range. The green anole lizard, Anolis carolinensis, is an ideal species to explore the physiological and molecular basis of thermal adaptation. The only anole native to the continental United States, this species has spread throughout the southeast to occupy diverse thermal environments from subtropical peninsular Florida and southern Texas to temperate climate along the east coast, the foothills of the Smoky Mountains and Oklahoma. We measured the upper (CTmax) and lower (CTmin) boundaries of thermal tolerance of 15 populations across the species' range and performed a common garden experiment to test if variation in thermal tolerance may have a genetic component. We then used double digest restriction−site associated digest sequencing (ddRAD−seq) to explore the relative effects of geographic distance and environmental dissimilarity in contributing to molecular variation across the species' range. Finally, we used oxygen consumption and blood physiology data (hemoglobin and lactate concentrations) to explore the physiological mechanisms contributing to variation in cold tolerance. The results of this study will provide valuable information for understanding the evolution of thermal tolerance in terrestrial ectotherms.

P3.18 CAMPOS, SM*; KING, C; MARTINS, EP; Indiana University, Bloomington; *smcampos@indiana.edu*

Resident male lizards are attracted to artificially−presented chemical cues

In many animals, territorial residents have a considerable advantage in aggressive encounters, and in gaining access to mates and other resources. Here we use male *Sceloporus undulatus* lizards to ask whether intruder chemical cues influence a resident male's use of territorial space. Male chemical cues were collected and artificially−presented in different male territories repeatedly over several days. We recorded the presence and absence of lizards in each territory, sex and identity of lizards present, and distances of present lizards from the placed chemical cue. Males and females collectively, males only, and resident males only were analyzed in subsets, and in all cases were present more often in territories with intruder chemical cues than in territories to which a control was introduced. Lizards tended to keep in closer proximity to the chemical cues than to a blank control. This suggests that a resident male is attracted to an area of its territory that has been chemically marked by a male intruder. Our results indicate the chemical modality of communication assists in shaping spatial distributions of territorial individuals, and influences conspecific encroachment on territorial space.

P3.72 CANEPA, JR*; POWERS, DR; WETHINGTON, SM; George Fox Univ., Newberg, OR, Hummingbird Monitoring Network, Patagonia, AZ; *jcanepa11@georgefox.edu*

A Non−Invasive Doubly−Labeled Water Protocol for Use in Comparing Daily Energy Expenditure in Hummingbird Populations

Higher environmental temperatures associated with global climate change in landscapes used by hummingbirds might increase thermoregulatory costs and alter foraging patterns resulting in increased daily energy expenditure (DEE). Because hummingbirds are key pollinators in these landscapes behavioral changes due to higher DEE that change how they interface with the landscape could have profound ecosystem impact. Few DEE measurements have been made on hummingbirds due to their delicate morphology restricting use of many techniques such as doubly−labeled water (DLW). Classic DLW involves isotope injection and blood collection, the latter of which is difficult in hummingbirds. In this study, we evaluated a non−invasive protocol for the DLW method on broad−billed hummingbirds (*Cynanthus latirostris*, ~3.00−3.40 g) in SE Arizona. Because hummingbirds process nearly all water consumed, we enriched birds by feeding them an isotopically labeled (D and ^{18}O) sugar water solution. Dose was determined post feeding by change in mass. Urine samples were collected after a period of equilibration (~30−60 minutes) and again after ~24 hours. CO_2 values ranged ~30−50 mL CO_2/hr (~10−15 mL CO_2 g^{-1} h^{-1}), lower than in similarly sized black−chinned hummingbirds (*Archilochus alexandri*, ~3.67g, ~45−80 mL CO_2/hr, ~13−18 mL CO_2 g^{-1} h^{-1}; Powers & Conley 1987). Higher DEE measured in this earlier study might be influenced by the method of blood collection and cooler environmental temperatures associated with the study site. We believe the noninvasive methods presented here have promise for doing at least population−level comparisons of DEE in hummingbirds.

P1.69 CAPELLARI CARNIO, E*; BRANCO, LGS; SAIA, RS; University of São Paulo; *carnioec@eerp.usp.br*
Cholecystokinin inhibits inducible nitric oxide synthase expression in lipopolysaccharide−stimulated macrophages
Cholecystokinin (CCK) receptors are expressed in macrophages and are up−regulated by inflammatory stimulus. In vitro and in vivo studies have demonstrated the ability of CCK to decrease the production of various pro−inflammatory cytokines. This study investigates the role of CCK on iNOS expression in lipopolysaccharide (LPS)−activated peritoneal macrophages, as well as the intracellular signaling pathways involved in affecting iNOS synthesis. Thioglicollate−elicited macrophages were obtained by peritoneal lavage and cultured in RPMI 1640 medium, 10% fetal bovine serum and antibiotics. Nuclear p65, cAMP and iNOS levels were determined using ELISA kits, CCK receptors and IκB± expression by Western blot and nitrite by Griess method. Data was compared by one−way ANOVA and significant differences obtained using Tukey multiple variances post hoc test. CCK reduced NO production attenuating iNOS mRNA expression (15.49±10.80 vs. 113.16±0.23 AU; p<0.05) and protein formation. Furthermore, CCK inhibited the nuclear factor (NF)−κB pathway reducing IκB± degradation and minor p65−dependent translocation to the nucleus (543.78 ± 84.57% vs. 90.42 ± 9.13%, p<0.05). Moreover, CCK restored the intracellular cAMP content activating the cAMP−protein kinase A (PKA) pathway, which resulted in a negative modulatory role on iNOS expression and nitrite production. In peritoneal macrophages, the CCK−1R expression was predominant and up−regulated by LPS (0.61±0.08 vs. 0.30±0.09 AU; p<0.05). The pharmacological studies confirmed that CCK−1R subtype is the major receptor responsible in the biological effects of CCK. These data suggest an anti−inflammatory role for the peptide CCK in modulating iNOS−derived NO synthesis, possibly controlling the macrophage hyper−activation through NF−κB, cAMP−PKA and CCK−1R pathways.

96.1 CAPPER, RL*; MATZ, MV; University of Texas at Austin; *roxana.capper@gmail.com*
Signals of natural selection and local adaption in the genome of the reef−building coral Acropora millepora
Population genomics seeks to correlate the genetic repertoire of a species with the local environmental gradients encountered along the species' range. Historically, population genetic statistics were calculated using a minimal number of markers to make general statements about population dynamics on a coarse scale. However, recent technological advances such as restriction−site associated DNA sequencing (RAD−seq) have allowed population genetic statistics such as F_{st} to be calculated continuously and in high resolution along each chromosome. Patterns of these statistics can be used to pinpoint regions of the genome that may currently be or previously have been subject to selection or other evolutionary trajectories. Such regions can then be analyzed in depth to potentially reveal the genes or even nucleotides relevant to survival in different environments.

We performed Type II−B RAD−seq for the reef−building coral *Acropora millepora*, a species that is in decline due to climate change and other anthropogenic threats. Our hope is to identify genes that influence survival in warmer waters, which could then inform conservation biology. We sampled 148 individuals from six populations representing much of the species range along the Great Barrier Reef, Australia. We used 30,000 high−quality single nucleotide polymorphisms (SNPs) to scan the genome for loci exhibiting canonical signatures of evolution. Beyond linking loci to environmental conditions, we can examine existing transcriptomic resources to determine if these loci are directly involved in coral stress responses. Our RAD−seq data can be also be used for high−resolution connectivity studies and to infer past population demographics to give an unprecedented, holistic view of coral evolution.

P1.207 CAPPER, RL*; WRIGHT, AM; MIKHEYEV, A; University of Texas at Austin, Okinawa Institute of Science and Technology; *roxana.capper@gmail.com*
Coalescent theory reconstructs the known history of experimentally evolving yeast populations
Coalescent models can estimate relationships among individuals to produce tree topologies, rates of evolution and demographics such as population size fluctuations. However, coalescent theory is rooted largely in statistics and simulations, and no direct experimental tests have previously been performed. To test the performance of coalescent theory on a known phylogeny, we propagated asexual, haploid yeast in the lab for approximately 250 generations. In one experiment, we grew cells for four generations, then split the culture into two populations which were maintained at a constant population size by bottlenecking the culture every 12h. One population was grown in the presence of mutagen to artificially increase the mutation rate, while the other branch was grown normally. In a second experiment, we maintained a culture of yeast at a constant population size for 160 generations, then split it into two populations. One population was kept at the same population size while that of the second branch was reduced by an order of magnitude. These populations were grown for an additional 100 generations. Then, we sequenced the genomes of sampled individuals. We used the single nucleotide polymorphism (SNP) data produced to test commonly applied models of coalescence. Though our experimental design is simplistic, recapitulating the known phylogenies and demographics of our populations has been difficult. The topology estimated in the variable mutation rate experiment is not accurate, but the mutational rate difference between clades is indeed detected. The topology of the second experiment is plausible, but the population size decrease is not detected. These issues may be due to the abundance of mutations acquired through treatment with mutagen, working with a single locus, or small sample sizes.

P1.190 CAPSHAW, G*; HIGGS, D; NIEMILLER, M; SOARES, D; University of Maryland, Windsor University, Yale University, University of Maryand; *daph@umd.edu*
Auditory differences in the lungless salamanders Plethodontidae: from inside caves and out.
Salamanders, being early land vertebrates, have many of the structures of terrestrial animals in simple form. The Plethodontidae, commonly called lungless salamanders, are the largest family of extant salamanders with over 350 species. This group is prominent in the Appalachian Mountains in the eastern United States. Members within this group are adapted to stream, arboreal, terrestrial, and underground habitats. We are interested in the hearing characteristics of species that inhabit caves compared to surface habitats. We recorded Auditory Evoked Potentials (AEPs) in two cave species: the Cave Salamander (Eurycea lucifuga), and the Spring Salamander (Gyrinophilus porphyriticus) and three surface stream species: the Red Salamander (Pseudotriton ruber), the Two−lined Salamander (Eurycea bilineata) and the Spotted Dusky Salamander (Desmognathus conanti). All salamanders had similar thresholds and range when placed on a solid surface directly coupled to the speaker. This result in consistent with a bone conduction mechanism that detects vibrations. However, when animals were physically isolated from vibrations via acoustic foam, salamanders showed an increase in auditory threshold. We also created 3D reconstructions of the otic capsules and connections with the lower jaw.

29.5 CAPUTO, C.R.; St. Edward's University; *ccaputo2@stedwards.edu*

Investigating the Effect of Dopamine Deficiency, its Impact on Octopamine Signaling, as well as Treatments in a C. elegans Model of Parkinson's Disease

Investigating the Effect of Dopamine Deficiency, its Impact on Octopamine Signaling, as well as Treatments in a *C. elegans* Model of Parkinson's Disease. Parkinson's disease (PD) is a progressive neurodegenerative disease which affects roughly 500,000 United States citizens, with 50,000 new cases diagnosed each year. Clinically, PD expresses itself in a variety of neuromuscular and cognitive forms. It is important to better understand the molecular and physiological nature of conventional treatment methods. The purpose of this study was threefold; to determine the effects of a complete loss of dopaminergic (DA) neurotransmitters in *Caenorhabditis elegans*, to evaluate potential disruptions in the octopamine/dopamine synthesis pathways as a result, and to try and mitigate any effects of DA deficiency. The drugs used in this experiment were the DA agonist quinpirole and the dopamine reuptake−inhibitor nomifensine. We used a transgenic strain of *C. elegans* with tyrosine hydroxylase, a DA biosynthetic enzyme, knocked out, wildtype N2, and the DA deficient strain. Worms were exposed to quinpirole−*via* their *E. coli* food source. They were subsequently tested throughout their lives with multiple assays compared to N2. We found that quinpirole does rescue problems stemming from the lack of DA, and it improved the PD strain's thrashing ability by 69% at day 12. It was also found that octopamine levels are raised in DA deficient worms, as a more than 200% increase in movement was found when looking at foraging behaviors comparing N2 to PD strain. The octopamine increase was found to be partially reversed when using quinpirole along with the DA reuptake inhibitor nomifensine. This finding, along with the ability of the DA agonist alone to rescue physiological and behavioral deficits, provides insights into potential treatments.

S2.1−1 CAREAU, V; BUTTEMER, WA; BUCHANAN, KL*; Deakin University; *kate.buchanan@deakin.edu.au*

Effects of developmental stress on a suite of physiological and behavioural traits in the zebra finch.

Developmental pathways are shaped by evolution and may lead to defined suites of metabolic, behavioural, and life−history traits. Recent data suggest that experiencing poor environmental conditions in early life programs a developmental pathway which allows individuals to prioritise short−term fitness benefits and maximise their reproductive output in challenging environments. Such fine−tuning towards a "faster" life−history strategy should be accompanied by concordant changes in metabolism and behaviour. We investigate this by examining how early developmental stress affects a variety of metabolic and behavioural traits in the zebra finch. We predict that: i) individuals subjected to nutritional restriction in the nestling phase will have higher metabolic rates and associated feeding rates and activity levels, ii) nutritional restriction in early life will alter adult stress−induced corticosterone levels, and iii) developmental stress will respectively increase and decrease the amount of among− and within−individual variation in behavioural and physiological traits, hence affecting the repeatability of these traits. Our study has implications for better understanding the degree of developmental plasticity of species−level behavioural and physiological traits in a changing world. We suggest the possibility of an adaptive ontogenetic coupling among developmental plasticities of metabolism and behaviour, such that individuals behave consistently with the life−history trajectory they adopted in response to early−life conditions.

P3.82 CAREY, C.S.*; BOYLES, J.G.; Southern Illinois Univ., Carbondale; *charleve@siu.edu*

Measuring Cutaneous and Pulmonary Gas Exchange and Water Loss of Hibernating Bats

An emerging fungal−borne disease of concern in North America, white−nose syndrome (WNS), is responsible for a catastrophic bat epizootic. The "dehydration hypothesis" postulates the causative fungal agent (*Pseudogymnoascus destructans; Pd*) of WNS damages the wings in such a way as to disrupt water and electrolyte balance, which is a crucial challenge for bats. To test the dehydration hypothesis and further elucidate the pathogenesis of WNS, we must understand physiological processes that occur during hibernation. To this end, we tested various respirometry chambers (some from previous studies on non−hibernating species and some newly designed chambers) to investigate which design best separates cutaneous and pulmonary gas exchange and water loss of hibernating bats. Designs were tested on big brown bats (*Eptesicus fuscus*) in spring 2013 with the most promising design selected for further investigation later in the year. The best design had no significant leaks between the head and body chambers or outside air. Also, bats were able to maintain steady−state torpor for three hours. Now, with this chamber, relative contributions and changes of pulmonary and cutaneous gas exchange and water loss due to WNS−associated wing damage can be estimated. Bats will undergo manipulative tests to address our predictions related to the dehydration hypothesis; a) water loss will increase when outer sebaceous oil on the wings are removed, and b) pulmonary gas exchange will increase when cutaneous gas exchange is restricted. Specifically, we are measuring oxygen, carbon dioxide, and water vapor of hibernating bats. Not only does this study allow us to expand our understanding of the physiological complexities of hibernation, but also the WNS epizootic.

P1.204 CARLEN, E.J.*; RATHBUN, G.B.; DUMBACHER, J.P.; California Academy of Sciences; *ecarlen@calacademy.org*

Reconstructing the molecular phylogeny of giant elephant shrews (genus Rhynchocyon)

Macroscelidea is the order of sengis, also known as elephant shrews. The 18 extant species vary in size and pelage coloration and are restricted to the African continent. Giant sengi (genus *Rhynchocyon*) taxonomy has historically relied on morphological characters, specifically variation in pelage color and pattern. We investigated whether the currently−accepted species (based upon pelage variation) represent distinct species, interbreeding populations with a high degree of variation within a single gene pool, or some other genetic construct. Moreover, previous phylogenetic studies of the Macroscelidea have failed to take into account the phenotypic variation and geographical distribution of *Rhynchocyon*. We analyzed 5,800 nucleotide bases (3.4 kilobases of mitochondrial DNA and 2.4 kilobases of nuclear DNA) representing all described *Rhynchocyon* taxa. These data were used to reconstruct a phylogeny of giant sengis and confirm the taxonomic classifications. Each recognized species formed a monophyletic clade in our analysis. This research hopes to provide a better understanding of the giant sengi species complex, the biogeographical patterns and the historical causes for such patterns.

P2.45 CARLISLE, J.F.; LYDE, E.A.*; MYERS, A.G.; RULE, K.N.; ROARK, A.M.; Furman University; *betsy.lyde@furman.edu*

Effects of symbiont density and feeding rate on sexual and asexual reproduction in Aiptasia pallida anemones

Aiptasia pallida is a subtropical sea anemone that is used as a model organism for research in cnidarian−algal symbioses. Thorough knowledge of *A. pallida* reproduction is vital because of its role as a model organism. *A. pallida* reproduces both asexually via pedal laceration and sexually via broadcast spawning. The purpose of this study was to describe the reproductive cycle and development of *A. pallida* by analyzing lacerate production, gonad histology, and spawning events across different lighting and feeding regimens. Experimental anemones were housed individually and assigned to either a lit or dark protocol. Within each of these treatments, anemones were further assigned to a fed or starved treatment group. Three times per week, anemones were examined and new lacerates were identified. In one week out of every four for a period of six weeks, anemones in the lit groups were induced to spawn by altering photoperiod. Sperm and eggs were collected and quantified each morning during spawning weeks. At the end of six weeks of observation, all parent anemones were anesthetized and their tentacles were sampled to determine algal density. The body column of each anemone was fixed, histologically sectioned, and stained. Differences were observed in algal density and lacerate production between lit and dark experimental groups. This research provides important insights into reproduction in *A. pallida*.

105.3 CARLSON, BE*; LANGKILDE, T; Penn State University; *bec169@psu.edu*

Pervasive effects of size variation in tadpoles on pond communities

While ecologists historically focused on mean trait values in study populations, recent evidence has begun to demonstrate that intraspecific variation in traits may be similarly important for understanding ecological processes. Body size is a particularly variable trait within species and is known to be influenced by well−described factors such as competition. Size also has strong impacts on physiological processes and species interactions, making size variation a potentially very important characteristic of populations. We tested how tadpole size variation is affected by population densities in natural ponds, and used mesocosm experiments to compare the ecological impacts of populations of tadpoles that were either variable or homogeneous in size. We found that tadpole populations of higher density were also more variable in size. We also found that size−variable populations of tadpoles had different effects on periphyton, zooplankton, and newts than homogeneous populations of the same mean size. Size variation also interacted with the presence or absence of predatory newts, indicating that the effects are context−dependent. These findings highlight the importance of accounting for variation in size and other phenotypic traits in ecological studies.

131.4 CARLTON, E.D.*; DEMAS, G.E.; Indiana Univ., Bloomington; *elcarlto@indiana.edu*

Energetic regulation of seasonal sickness responses in Siberian hamsters (Phodopus sungorus)

The acute phase response is one of the first responses to infection and is accompanied by behavioral and physiological manifestations of sickness. Sickness is an adaptive response generated to clear pathogens but carries great energetic costs. Seasonally breeding species exhibit variation in sickness responses. Sickness intensity tracks an animal's energetic state and is attenuated in the season in which an animal has the lowest fat stores. Energetic state may be signaled via leptin, a hormone that provides a signal of fat stores. Siberian hamsters are seasonal breeders that respond to short, winter−like days (SDs) by reducing food intake, fat stores, and leptin levels, relative to those in long, summer−like days (LDs). Sickness is also attenuated in hamsters exposed to SDs as compared to LDs. We hypothesized that leptin provides a physiological signal by which animals modulate sickness responses, such that animals with higher leptin levels show increased sickness intensity. To test this, we provided SD hamsters with a LD−like leptin signal and assessed their responses to lipopolysaccharide (LPS), a sickness−inducing antigen. We compared this response to SD−control, LD−control, and LD−leptin treated hamsters. Surprisingly, hamsters in all groups exhibited a hypothermic response to LPS rather than fever. However, the SD−controls exhibited the greatest hypothermia, and leptin attenuated this response in SD hamsters, making hypothermia more LD−like. Alternatively, SD−leptin treated animals showed the least pronounced LPS−induced anorexia among all groups. These results suggest that leptin signals may mediate some, but not all, aspects of seasonal sickness variation and have prompted research into how other energetic signals may influence seasonal modulation of sickness.

38.1 CARRILLO, A.*; GARCIA, D.A.; MCHENRY, M.J.; Univ. of California, Irvine, Cerritos College; *andresc2@uci.edu*

The role of the lateral line system in foraging by zebrafish larvae

Adult fish use the lateral line system to localize prey by sensing water flow, but it is unclear when this ability is acquired over the course of growth. We investigated the role of the lateral line in foraging by zebrafish (*Danio rerio*) over the first month of development. By filming individual larvae as they preyed upon *Artemia* nauplii, we found that compromising the lateral line with neomycin had no adverse effect on feeding rate under illuminated conditions at any age. However, a functional lateral line began to significantly enhance feeding in the dark in larvae older than 20 days−post fertilization. To understand what causes this enhanced sensory ability, we visualized lateral line hair cells with a vital stain. Consistent with prior studies, we found that the both the number of lateral line receptors and number of cells per receptor increased monotonically with age. These enhancements appear to contribute to the improved mechnosensory ability to localize mobile prey in older larvae. Thus, vision plays the major role in daytime feeding, but the development of the lateral line system could facilitate foraging at night or within turbid waters and thereby expand the potential niche for the larval stage of a fish species.

P3.34 CARTER, AW*; ZIMMERMAN, LM; PAITZ, RT; BOWDEN, RM; Illinois State University , University of Illinois; *afwilso@ilstu.edu*

How do yolk corticosterone and fluctuating incubation temperatures affect hatchling behavior and physiology?

The environment an organism experiences early in development can have profound and persistent effects on phenotype. In reptiles, both thermal and endocrine environments are influential in determining offspring phenotype. Using the red−eared slider (*Trachemys scripta*), we are exploring the effects of exposure to thermal fluctuations during incubation and maternal corticosterone on aspects of hatchling phenotype including physiology, morphology, and behavior. In the first study, we incubated eggs in a split−clutch design under three thermal flux regimes, all with the same average temperature and fluctuation amplitude during incubation. The incubation regimes only differed in their fluctuation frequency with a normal frequency (24 hr cycle), a hypo−flux (48 hr cycle), and a hyper−flux (12 hr cycle). While the hypo− and hyper− flux treatments may not directly reflect nest conditions readily observed in nature, they disentangle temperature and fluctuation effects on offspring phenotype. In the second study we dosed freshly laid eggs in a split−clutch design with corticosterone (0, 0.05, 0.15, 0.5 ng/ 5µl) and incubated eggs under a constant temperature. In both studies we are quantifying how these factors influence multiple ecologically important endpoints including morphology, sex, behavioral type (a suite of correlated behaviors across different contexts), and immunocompetence. Through these studies, we will be able to describe how incubation fluctuations, independent of temperature, as well as how corticosterone influence a variety of offspring traits and determine if these traits influence dispersal and survival in the field.

P2.83 CARTER, L*; WEBB, JF; University of Rhode Island; *carterl@my.uri.edu*

Development of the Cranial Lateral Line Canal Pores in Two Species of Cichlid Fishes with Functionally Distinct Canal Morphologies

The cranial lateral line system (LL) is composed of a series of bony, pored canals that are integrated within a conserved subset of dermatocranial bones. Neuromast receptor organs are located in the canals between positions of adjacent canal pores (bony pores and pores in the overlying epithelium), which link the fluid within the canals to the fluid of the external environment. Pore size and inter−pore distance are important for predicting the functional properties of the canal, and thus the way in which canal neuromasts respond to external water flows. It was hypothesized that the size of these pores decreases and the number of pores decreases as a fish grows. This hypothesis was tested using two species of Lake Malawi cichlids that are characterized by differences in pore size − *Tramitichromis* sp., which has small pores and narrow canals, and *Aulonocara stuartgranti*, which has larger pores and widened canals. Pore length, width, and cross−sectional area (approximated) were analyzed in the supraorbital and mandibular canals of larvae and juveniles from 6.0−19.5 mm SL using histological material, juveniles visualized using SEM, and adults stained with methylene blue and then cleared and stained for bone. Preliminary data show that there are complex relationships between the timing of formation and the size and number of bony and epithelial pores through ontogeny in both species. In juveniles, bony pores are larger than epithelial pores especially in *Aulonocara*. The complexity of ontogenetic trends in pore number and morphology predict unappreciated variation in LL function through ontogeny. Supported by NSF grant IOS−0843307 to JFW.

49.2 CASAS, J*; VOISE, J; University of Tours (F); *casas@univ−tours.fr*

ECHOLOCATION IN WHIRLIGIG BETTLES USING SURFACE WAVES: AN UNSUBSTANTIATED CONJECTURE

Whirligig beetles use surface waves in a wide range of situations and it has been hypothesized that they could use the echo of their own waves to scan the water surface. These insects were also suspected to perceive menisci, i.e. static deformations of the water surface. However, no manipulative experimental studies, based on quantitative predictions of the surface deformation, have been conducted to determine if echolocation or meniscus perception is used. The aim of this work was to test the hypothesis that whirligig beetles detect the meniscus around immobile objects. If the perception of an immobile object on the water surface can be explained by resorting to the meniscus only, then the hypothesis of echolocation should be reconsidered. We used cylinders of varying diameter and wettability crossing the water surface to experimentally modify the meniscus profiles. Contacts between beetles and cylinders were recorded using a high speed camera. Loops in trajectories before or after a contact, as well as unfolding of forelegs before a contact, were used as criteria for the distance at which cylinders were perceived. Based on a theoretical modeling of the meniscus profiles, we predicted the distance at which one type of cylinder was detected based on the meniscus amplitude corresponding to the distance of perception of another type of cylinder. Both diameter size and wettability affected cylinder perception. Our predictions were unfortunately contradictory, and the unfolding of forelegs could not be explained by meniscus perception only. We obtained conflicting evidence about meniscus perception, with the statistically most powerful of our tests being strongly in favor of it. Thus, echolocation by whirligig beetles should still be considered as a conjecture, at best.

P3.23 CASTO, J.M.*; SMITH, A.R.; DE BIASIO, D.; Illinois State University; *jmcasto@ilstu.edu*

Within−clutch Patterns of Yolk Steroids: Does Egg Collection Method Matter?

Oviparous vertebrates transfer steroid hormones to egg yolk during folliculogenesis, and these hormones can influence offspring development. In birds, variation in within−clutch patterns of maternal steroid transfer has prompted adaptive explanations, such as parental favoritism of early− or late−laid eggs. However, these patterns may also be influenced by steroid metabolism occurring before the eggs are collected. Very early in embryogenesis, yolk steroids such as testosterone (T), corticosterone (B) and progesterone are metabolized and conjugated to water−soluble forms, but these processes require developing embryos. If embryonic steroid metabolism begins in eggs prior to clutch completion, then whether the eggs are collected and frozen individually on the day they are laid or collected as a group after completion of laying could influence the concentration of steroid hormones detectable in individual eggs. In turn, this could affect measured within−clutch patterns of steroid concentration such that patterns of variation among eggs could be created, eliminated, intensified or minimized by the specific collection method. Here we test the effects of two published egg collection regimens − collected either individually on the day of laying or as an entire clutch after laying ceases − on within−clutch patterns of yolk steroid concentrations in the eggs of European starlings (*Sturnus vulgaris*). Preliminary data from a subset of clutches suggest that for eggs laid earlier in clutches (but not later laid eggs), both yolk T and B titers tend to be higher in clutches in which eggs were collected daily than in clutches collected once laying ceased. If confirmed, this pattern likely reflects the onset of steroid metabolism in laid eggs prior to clutch completion.

P1.66 CAWTHORNE, AM*; PINZON, JH; MYDLARZ, LD; University of Texas at Arlington; *alexandra.cawthorne@mavs.uta.edu*

Restricted Signs of Disease May be Due to Varying Basal Immune Levels Within a Coral

Natural and anthropogenic factors are devastating coral reef ecosystems globally, with disease playing a major role in coral and coral reefs decline, especially in the Caribbean. New pathogenic infections and more frequent disease outbreaks are common in this geographic region. The levels of infection within and between populations are variable, likely due to differences in genetic composition between individual colonies. Here we tested if there are differences in basal immune levels between colonies of corals in four coral species (*Montastraea faveolata, Diploria strigosa, Porites porites* and *Porites astroides*). We sampled three random locations within five healthy looking colonies from each species (n = 60), and performed five biochemical immune assays (melanin concentration, prophenoloxidase, peroxidase, superoxide dismutase and catalase activity) on each sample. The results indicate that constitutive levels of immune traits in corals are variable between species, but not across colonies within the same coral species. Although we did not find differences between colonies in a species, there appears to be a relationship between many of the immune traits. There is a negative relationship between melanin and its synthesis enzyme, prophenoloxidase and antioxidants. These results indicate that colonies within a species are similarly prepared to fight infection, suggesting that the differences in infections within the species might be due to different immune responses that occur upon pathogen attack. This work furthers our understanding of the variation in immunity among and between species and the general patterns of how coral colonies are prepared to withstand the spread of disease.

77.3 CEASE, A.J.*; ROGERS, S.M.; DODGSON, T.; SIMPSON, S.J.; The University of Sydney; *arianne.cease@sydney.edu.au*

Diet modulates gregarization in the Australian Plague Locust

Locusts are grasshoppers that exhibit a density−dependent polyphenism, switching between a lone−living solitarious phase and a gregarious phase that forms migratory swarms. Gregarization is promoted by high local population density and its primary trigger is through mechanosensory stimulation from other locusts and subsequent species−specific neurohormonal responses. In the lab, gregarious behavior can be elicited by repeated mechanical stimulation with a paintbrush. It is not known however, if environmental factors may modulate the propensity of a locust population outbreak to develop into a migratory swarm by changing locusts' receptivity to this mechanical stimulation. In many insect species poor host−plant quality promotes migration to enhance growth and survivorship. We tested the effects of diet quality on growth performance and propensity to gregarize in the Australian plague locust, *Chortoicetes terminifera* . We reared locust nymphs on one of five synthetic diets; all isocaloric, but differing in their macronutrient balance (protein to digestible carbohydrate ratio). We reared locusts in either isolated or crowded conditions. Isolated locusts were further split into two groups. One group received a paint−brush stimulation treatment, and the other did not. In contrast to the migratory hypothesis, locusts exhibited the most gregarious behavior when reared on more optimally−balanced diets. These results suggest that the Australian plague locust, and perhaps other migratory animals, fit an alternative scenario where access to high quality food resources may be necessary to support long distance migration. These data indicate that diet quality, in addition to population density, may be an important ecological factor influencing the development of locust swarms.

P3.43 CEASE, A.J.*; FAY, M.; ELSER, J.J.; HARRISON, J.F.; The University of Sydney, Arizona State University; *arianne.cease@sydney.edu.au*

Dietary phosphate strongly and nonlinearly affects performance of an omnivourous herbivore

Comparison of the nitrogen, carbohydrate and phosphorus contents of plants and herbivores suggest that phosphorus (P) limitation should be common in herbivores; however, the effect of dietary P on the performance of most clades of herbivores has received little attention. We examined the effect of dietary %P in the context of artificial diets containing near−optimal contents of other nutrients on the growth, development and survival of the polyphagous grasshopper *Schistocerca americana*. Dietary phosphate levels had a nonlinear effect. Over the range of % P found in 90% of terrestrial foliage, higher P stimulated growth rates and increased survival, with an optimal dietary %P of roughly 0.5%. Higher P levels reduced growth and survival. We then tested grasshoppers for three days during either the third or final juvenile instars (rather than throughout development). During the three−day period, grasshoppers from all dietary %P treatment groups ate similar amounts of food, but grasshoppers eating low−P diets selectively absorbed more and excreted less P than high−P diets. Third instar nymphs assimilated more P on high P diets than final instar nymphs, which had high P excretion rates. Target experiments in which grasshoppers were provided with pairs of diets low and high in P demonstrated that grasshoppers select among foods to attain a P intake target of 0.6% P. Despite the clear importance of P to performance of grasshoppers confined to artificial diets, P may be less important in field contexts as the requirement for P is quantitatively much less than for carbohydrate or protein; thus selective feeding on a few P−rich leaves may enable grasshoppers to overcome low P levels in most of the foliage. In contrast, P−limitation seems more likely for herbivores with reduced mobility or host diversity.

P1.108 CERVINO, S.*; BUTLER, L. K.; The College of New Jersey, Ewing, NJ; *steccer@gmail.com*

Intraspecific variation in body feather structure in a globally−distributed bird

Ecogeographic rules describe general patterns of intra−specific variation in animal traits such as body size, limb size, and pigmentation. Despite the important functions of body feathers in the lives of birds, ecogeographic patterns in macro−structural properties of body feathers have received little attention. We examined global geographic variation in body feather morphology of the House Sparrow (*Passer domesticus*), a small−bodied songbird with an historic range in the Palearctic and a modern range that spans human−dominated habitats around the planet. Five feather characteristics barb count, barb angle, tangential packing, barb length, and barbule count were measured on the downy and pennaceous parts of ventral body feathers of specimens from six locations: the British Isles, Morocco, and Mauritius (Palearctic/Afrotropic), and Kansas, Texas, and Hawaii (Nearctic/Oceania). Sample variance was attributed to four factors: location, sex, individual, and feather within individual. ANOVA revealed significant differences between males and females for barb count and barb angle, and between locations for barb count, barb length, tangential packing, and barbule count. Additionally, Palearctic/Afrotropic populations differed in multiple ways from Nearctic/Oceania populations. These results provide evidence that the intra−specific variation in body feather morphology in House Sparrows depends on sex, environment, and evolutionary history.

104.3 CESPEDES, A.*; MATOS, M.; WAHLBERG, N.; DEVRIES, P.J.; Univ. of New Orleans, Biology Centre AS CR, Univ. of Turku ; *acespede@uno.edu*

The flight environment, behavior, and adaptive wing shape evolution in rainforest floor butterflies (Haeterini: Nymphalidae)

Wing shape is influenced heavily by flight performance during ecologically relevant flight behaviors. Flapping and gliding are two common butterfly flight modes that possess conflicting demands on wing design, as there exists a trade−off between glide efficiency and force production. The Neotropical tribe, Haeterini, exhibits a rare flight mode wherein males in all but one of five genera glide near the forest floor. It is hypothesized that radiation to the forest floor has resulted in the evolution of this behavior and consequent evolution of wing shapes that meet the theoretical design requirements for gliding flight and the exploitation of ground effect, a phenomenon known to increase flight efficiency in biological fliers. Our previous results revealed that the pattern of wing shape evolution within the Haeterini suggests multiple parallel trends towards theoretically optimal wing shapes. For 545 individuals covering all species, we used landmark−based geometric morphometrics to measure fore− and hindwing shape, the range of shapes allowed by wing rotation, and the degree of sexual dimorphism within each species. To determine a model of wing shape evolution and reconstruct the macro−evolutionary processes resulting in the diversification of this tribe, we placed morphological data into a phylogenetic comparative framework, using newly developed methods to directly estimate shifts in selection regimes as well as diagnose the occurrence and extent of convergence in wing shape. In the context of the broader historical biogeography of the family Nymphalidae, we present a comprehensive model of adaptive wing shape evolution and diversification for the Haeterini.

112.5 CHADWELL, BA*; YOUNG, JW; NEOMED; *jwyoung@neomed.edu*

Torque production and stability during narrow branch locomotion

During locomotion on narrow branches, lateral movement induces increases in the angular momentum of the center of mass (COM) that, if unchecked, will topple the animal from the branch. Grasping appendages may facilitate balance on narrow branches by allowing animals to exert opposing torques about the branch, thereby minimizing disruptive angular momentum. To investigate the relationship between torque production and stability, we collected high−speed video of two marmoset monkeys (*Callithrix jacchus*, mean body mass: 392g) moving across broad (5cm diameter) and narrow (2.5cm diameter) horizontal supports. We used a custom array of 6 force poles to measure applied torques about the support, and adapted force plate ergometry methods to quantify the angular momentum of the COM. Here, we analyze a preliminary dataset of 13 strides on the broad support and 12 strides on the narrow. Preliminary data indicate that net torque across locomotor strides remains quite small (5cm mean: −0.115 Ncm; 2.5cm mean: −0.074) and does not differ between pole diameters (p=0.21). Low net torque is partially due to the cancellation of torques between the right and left limbs. On average, right− and left−side torques have opposing orientations but similar magnitudes (Right mean: 0.367 Ncm; Left mean: −0.465 Ncm), such that they are negatively correlated (rho=−0.6, p=0.028). Changes in angular momentum induced by applied torques are generally opposed to the angular momentum of the COM about the pole, and on average explain 35% of the within stride variation in COM angular momentum. Overall, these data support the assertion that grasping appendages facilitate stability by permitting arboreal animals to exert opposing torques about the branch, though other mechanisms of balance control are no doubt important as well. Supported by NSF BCS−1126790.

P2.144 CHAMBERLAIN, J/D*; GIFFORD, M/E; Univ. of Arkansas, Little Rock; *jdchamberlai@ualr.edu*

The influence of prey size and abundance on patterns of energy allocation in watersnakes

Fat is utilized for a variety of functions within the body including growth and reproduction. Variation in fat storage and use is predicted to be a function of prey availability and size. Energetic demands often change throughout the year and are associated with reproductive activity. Spatial variation in the availability and size of prey could drive population−level differences in patterns of energy allocation. In this study we test the hypothesis that prey availability will influence the amplitude of annual fat−cycling and reproductive output in diamondback watersnakes (*Nerodia rhombifer*). We studied watersnakes from four sites that varied in prey size and abundance (two fish farms producing large prey, one fish farm producing small prey, and one lake site with variable prey size and abundance). For annual fat−cycling and reproductive activity, we measured fat−body, liver, and gonad masses of 20 individuals (10 of each sex) from each population at three different time periods (April/May, July/August, and September/October). We also sampled approximately 20 pregnant females from each population to examine reproductive traits. Preliminary data suggest that both reproductive output and patterns of annual fat cycling vary among populations.

108.7 CHAMPAGNE, AM*; ALLEN, HC; WILLIAMS, JB; Ohio State University; *champagne.7@osu.edu*

Seasonal differences in the organization of lipids and water through the stratum corneum of birds

Accounting for over half of total water loss in birds, cutaneous water loss is regulated by lipids in the stratum corneum (SC), the outermost layer of the epidermis. The SC is composed of layers of corneocytes each embedded in a lipid matrix. The relative abundance of lipid classes within this matrix may affect the barrier properties of the SC. Because most studies of the SC assume that lipid composition remains constant through the entire thickness of the SC, little is known about how differences in lipid composition between different layers of the SC affect CWL. We tested the hypothesis that CWL differs between seasons, and that these differences are associated with variation in lipid organization within different layers of the SC. We captured House Sparrows (*Passer domesticus*) in the summer and winter in Ohio and measured their CWL. We then used attenuated total reflectance Fourier transform infrared (ATR−FTIR) spectroscopy to measure water content and water and lipid organization in the SC for 10 layers of approximately 1 ¼m each, thus obtaining a depth profile of the full thickness of the SC. We found that birds captured in the winter had lower rates of CWL than birds captured in the summer. Our ATR−FTIR studies revealed that although both groups retained more water and had greater lipid disorder in deeper layers of the SC than in superficial layers, birds captured in the winter retained less water overall and the decrease in water and lipid disorder from deeper to more superficial layers was reduced compared with summer−caught birds. These data indicate that birds can alter the lipid composition of different layers of the stratum corneum to reduce water content and lipid disorder during the winter, when the ambient vapor pressure is low.

P2.164 CHAMPAGNE, CD*; TIFT, MS; HOUSER, DS; CROCKER, DE; National Marine Mammal Foundation, Sonoma State University; *cory.champagn@gmail.com*

Corticosteroid Secretion Varies Following Adrenocorticotropic Hormone Stimulation in Northern Elephant Seals

During molting, northern elephant seals exhibit substantial alterations in circulating cortisol concentrations, probably to facilitate pelage synthesis while fasting. How these changes influence the hypothalamic−pituitary−adrenal (HPA) axis and the stress response, however, is not known. To investigate the modulation of the HPA axis during molting, we administered ACTH (25 units, intramuscularly) to sixteen juvenile elephant seals at the beginning (n=6), middle (n=5), and end (n=5) of their spring molting period in a cross−sectional study design. Blood samples were collected immediately before, and then periodically for 2.5 hrs after, ACTH administration. We quantified circulating concentrations of ACTH, and the responses of cortisol and aldosterone. Both cortisol and aldosterone concentrations markedly increased following stimulation by ACTH and remained elevated for the duration of sampling. There were no detectable differences in the magnitude of cortisol response to ACTH administration among the study groups ($F = 0.9$, $p = 0.4$) whereas aldosterone showed a more variable response, with the greatest total secretion occurring in the middle of the molting period ($F = 4.7$, $p = 0.03$). ACTH is not a strong aldosterone secretagogue in terrestrial mammals but several studies have measured increased aldosterone after ACTH stimulation in marine mammals, indicating its potential importance in osmoregulation during stress in these species. Cortisol and aldosterone increased in parallel following ACTH stimulation, and the slope of this relationship varied among the study groups. This suggests that the release of these hormones is closely coupled in this species and possibly other marine mammals.

84.2 CHAN, K.Y.K.*; PADILLA, D.K. ; JIANG, H.S. ; Woods Hole Oceanographic Inst. , Stony Brook Univ. ; *kchan@whoi.edu*

Organismal−, ciliary− motion and resulting fluid disturbances of freely swimming veligers

Planktonic larvae of marine invertebrates play significant roles in shaping abundance and distribution of benthic adult populations. To successfully recruit to adult populations, these larvae need to efficiently filter and gather food particles while minimizing predation risk. Many larvae use ciliated structures to generate flow for both propulsion and particle capture, suggesting a potential tradeoff. In the face the common challenge of "to eat and not be eaten", we hypothesize that larval from different taxonomic groups follow similar optimized scaling rules to balance the need to feed and to swim. By adapting small−scale, particle image velocitmetery techniques, previously applied on larger holoplankton such as copepods, we quantified swimming speeds and feeding currents of veliger larvae. The focal species were the Atlantic slipper shell, *Crepidula fornicata*, and the Atlantic oyster, *Crassostrea virginica*. Both species have larvae that use cilia arranged on elongated structures, the velum, for swimming and feeding. At the same day post−hatching, the larger *C. fornicata* veligers had greater variability in average swimming speed (0.6− 4 body length s^{-1}). Velar lobe extension and orientation affected swimming speed but not ciliary beat frequency. Such independency between swimming and feeding at the ciliary level may aid in "cryptic swimming" of larval *C. fornicata*. *C. fornicata* had a relatively shorter convergence distance in particle paths in the wake of the larval shell compared to *C. virginica*, and hence, a smaller area of fluid of disturbance. Differences in fluid disturbance could translate into different predation risk. Quantification of larvae−fluid interaction is therefore essential for understanding larval feeding, predation, and transport.

42.3 CHANG, J*; RABOSKY, DL; ALFARO, ME; Univ. of California, Los Angeles, Univ. of Michigan; *jchang641@gmail.com*

Crowdsourced morphometrics: a novel method to overcome bottlenecks in collecting phenotype data

The "bioinformatics revolution" has assembled massive genomic data sets; however, our ability to collect phenotypic data at a similar scale has not kept pace. Phenotypic data collected for a species or family are quite common, but comprehensive data sets across large radiations are rare. We present a method to distribute geometric morphometric landmarking tasks to untrained users over Amazon Mechanical Turk, an online crowdsourcing platform. We use this method to explore how shape diversity has evolved across the ray−finned fishes, the largest radiation of vertebrates. We asked remote workers to digitize landmarks of over 1000 lateral fish photographs, and evaluate the repeatability and accuracy of these crowdsourced data. We also construct a morphospace and examine the major axes of body shape variation, and compare these results to previous studies. Compared to the traditional approach of a single trained digitizer, our method gathers crowdsourced data at low cost and competitive accuracy, with significant speed increases for larger workloads. We will also discuss plans to increase the sampling density of this study, and its potential to reveal patterns of shape diversification and convergent evolution in the ray−finned fish radiation.

102.2 CHAPPELL, M.A.*; LONGONO, G.A.; JANKOWSKI, J.E.; ROBINSON, S.K.; Univ. of California, Riverside, Univ. of British Columbia, Vancouver, Univ. of Florida, Gainesville; *chappell@ucr.edu*

Thermal Physiology, Climate, and Altitude Zonation in Andean Birds

Tropical bird communities along the eastern slope of the Andes are characterized by striking altitude limits on species distributions. Over habitats ranging from hot, humid lowland forest up to cool highland cloud forest and alpine grasslands, numerous bird species are restricted to narrow altitude ranges, often encompassing 1000 m or less. Range limits may result from abiotic or biotic factors, or a combination of the two. We used measurements of thermal physiology and weather data to explore the possible role of an important abiotic factor, ambient temperature, in determining altitude limits for a sample of about 200 bird species from southeastern Peru. We used data from respirometry to test if thermal conductance and body temperature differed across altitudes (400 − 3000 m). Birds (3− 300 g) were mist−netted and measured at night under conditions appropriate for eliciting minimal thermal conductance (ambient temperature 10 °C, body temperature > 35 °C). Both thermal conductance and body temperature decreased as altitude increased. We combined these results with weather data to estimate the energy costs of thermoregulation across altitudes. Thermoregulatory costs were compared to basal metabolic rate (BMR) to see if they exceeded several potential limits that might prevent species from occupying particular altitudes. We found little indication that thermal constraints could account for altitude range limits in our sample of Peruvian birds.

81.3 CHARPENTIER, C.L.*; COHEN, J.H.; University of Delaware; *charpecl@udel.edu*

Effects of predator odor on photobehavior, visual sensitivity, and morphology of crab larvae

Many zooplankton exhibit specialized behavioral and morphological predator defense strategies that are induced by predator detection. For example, exposure to predator odor enhances photobehavior in the larval crab *Rhithropanopeus harrisii*, likely exaggerating light−driven vertical migration patterns that are thought to aid in predator avoidance. Although predator−induced behavioral changes have been observed, we lack a physiological mechanism to explain these changes, and predator−induced morphological defenses have not been examined in crab larvae. Following short (1 h) exposures to either odor−free seawater or odor from the zooplanktivorous fish *Fundulus heteroclitus*, behavioral assays were conducted on two species of crab larvae (*R. harrisii*, *Hemigrapsus sanguineus*) to confirm that predator odor enhances photobehavior, which it did. To test the hypothesis that altered photobehavior was mediated by increased visual sensitivity at the primary photoreceptor level, response−irradiance (V−Log$I$) curves were generated from extracellular electroretinogram recordings. In addition, external morphology at each larval stage of both species was compared between individuals reared in odor−free or predator−odor containing seawater. Exposure to predator odor shifted V−Log$I$ curves to lower irradiances, suggesting that predator odor induces behavioral changes by increasing visual sensitivity at the retinal cell level. Predator odor also affected morphology, namely body size and length of anteriorly protruding spines. These data suggest that chemosensory inputs such as predator odor induce behavioral and morphological predator−avoidance strategies in *R. harrisii* and *H. sanguineus* and that altered photobehavior is mediated at the photoreceptor level.

P2.2 CHAVEZ, S.D.*; MERZ, R.A.; Cerritos College, Norwalk, California, Swarthmore College, Pennsylvania; *samicat11@gmail.com*

The hairy hermit crab, Pagurus hirsutiusculus, differs from other species of intertidal hermit crabs in shell selection, escape behavior, and reactions to predators

Intertidal hermit crabs of Puget Sound include *Pagurus hirsutiusculus*, *P. granosimanus*, and *P. beringanus*. Both *P. granosimanus* and *P. beringanus* individuals were found in shells about four times their body weight while *P. hirsutiusculus* were typically in shells slightly lighter than body weight; except for gravid females that carried shells nearly twice their body weight. Unlike *P. granosimanus* and *P. beringanus*, which always retreat into their shells when picked up, 73% of *P. hirsutiusculus* (n=126) abandon their shells. Gravid female *P. hirsutiusculus* were less likely to display this behavior − only about 23% abandoned their shells. *P. hirsutiusculus* is an especially active hermit crab; after being startled by a controlled thump on its holding tank a crab would recover normal behavior in about 6 sec.; *P. granosimanus* took twice as long. When placed in water that had previously contained rapidly moving, visual and chemosensitive predators (either *Cancer productus* or *C. magister*), *P. hirsutiusculus* displayed the same or a slower recovery from the startle stimulus while the behavior of *P. granosimanus* remained unchanged and relatively slow. In contrast, hermit crabs exposed to water that had contained the slow moving, chemosensitive predatory starfish *Pycnopodia helianthoides* either retained their high recovery rate (*P. hirsutiusculus*) or increased it (*P. granosimanus*). These findings suggest that *P. hirsutiusculus* is a "shell minimalist" selecting small, relatively lighter shells that it readily abandons, relying on quick escape behavior in the presence of slow moving predators. These behaviors are modified in gravid females or in the presence of rapidly moving visual predators.

P1.156 CHAVEZ, A; NOLAN, K*; HORN, R; MILLER, B; SCHREIBER, A.M.; St. Lawrence University, NY; *aschreiber@stlawu.edu*

Doxycycline inhibits organ resorption, but not organ growth, in metamorphosing Xenopus laevis tadpoles

Xenopus laevis metamorphosis is characterized by the complete resorption of some tadpole−specific organs (tail and gills), the growth and differentiation of adult−specific organs (limbs), and the remodeling of other organs from a tadpole to a frog form (brain, gut). Virtually all of these different developmental programs of metamorphosis are mediated by thyroid hormone (TH). Matrixmetalloproteases (MMPs) are enzymes that remodel the extracellular matrix and facilitate changes in organ shape. The mRNAs of several amphibian MMPs are known to be upregulated directly (i.e. stromelysin−3) or indirectly (e.g. gelatinase A and MT1−MMP) by TH. Although MMP mRNAs are known to be upregulated in diverse tissues during metamorphosis, the actual roles of MMP activity in these tissues remain unclear. To determine the influence of MMP activity on diverse developmental programs of metamorphosis, we raised Nieuwkoop−Faber stage 50 tadpoles in the presence of the broad−spectrum MMP inhibitor, doxycycline (DOXY, 65 ug/ml) for 7 days in the presence or absence of TH (5 nM T3). Treatment of tadpoles with TH alone induced multiple metamorphic programs, including the shortening and cross−sectional remodeling of the gut, gill resorption, tail resorption, brain thickening (due to cell proliferation), and growth of the limbuds. Treatment of tadpoles concurrently with TH+DOXY had no effect on limb or brain growth, but did significantly inhibit gut remodeling and resorption of both the gills and tail. These findings suggest that MMP activity plays an important role in organ resorption and remodeling, but is less prominent in organ growth.

51.1 CHEN, J.S.; TANG, W.J.; MAHAFFY, J.M.; ZELLER, R.W.*; San Diego State Univ., Benaroya Research Institute at Virginia Mason; *rzeller@mail.sdsu.edu*

Specification the ascidian larval peripheral nervous system

The peripheral nervous system of the ascidian *Ciona intestinalis* is composed of a number of ciliated epidermal sensory neurons (ESNs) that are present in the trunk and along the dorsal and ventral midlines of the larval tail. Other laboratories have shown that both FGF and BMP signaling in the early embryo are required for the proper specification of the ESNs in the larval tail. As in many biological systems, Notch−Delta mediated lateral inhibition is then used to specify the final number of ESNs in the larval tail. Here we define a preliminary gene regulatory network (GRN) that operates downstream of Notch−delta signaling. We performed a series of carefully staged *in situ* hybridizations and mis−expression studies to define this network. From these analyses we determined that at least four transcription factors function downstream of Notch−Delta: MyT1, Pou4, Atonal and NeuroD−like. Our studies established the epistatic interactions between these factors and determined that these transcription factors operate linearly. Interestingly, these same factors are known to be important for the specification of sensory neurons in a variety of bilaterians. Lastly, we show that the microRNA miR−124 is activated at the end of this transcription factor cascade and negatively feeds back on Notch−Delta signaling. Mathematical modeling of this feedback interaction has provided insight into how Notch−Delta activity patterns the ESNs along the embryonic tail midlines during development.

27.3 CHENEY, JA*; BEARNOT, A; SWARTZ, SM; Brown University, Providence, RI; *Jorn_Cheney@Brown.edu*

Bat wing skin mechanical behavior

In addition to the typical protective and regulatory functions of vertebrate skin, in bat, the skin of wings serves as a critical organ for locomotion: during flight, this skin membrane, often less than 50 µm thick, is cyclically loaded with multiple body weights of force. Although bat wings share this function with the wings of other flying animals, wing skin, composed of a double−layer of skin, has little in common with the material of other wings. The skin is very compliant, with an elastic modulus approximately two orders of magnitude less than that of feather keratin and insect wing cuticle. Because of its combination of compliance and thinness, bat wing skin has negligible bending stiffness, unlike bird and insect wings. Thus bats wings cannot support an aerodynamic load without the skin deforming and cambering, until the tension generated by passive deformation supports the load. Understanding the mechanical characteristics of the wing membrane skin can provide insight into both aerodynamic performance and the evolutionary transformation of skin as it acquired locomotor function. To characterize wing skin mechanical properties, we performed uniaxial tensile tests on skin sampled along the wing chord and in the perpendicular direction, along the wingspan. The wing membrane exhibited a J−shaped stress−strain curve, and was anisotropic, with greater compliance and an extended "toe" region in the spanwise direction. We model the wing skin fiber composite with an isotropic matrix of modulus comparable to that of other mammalian skin. The extended "toe" region and greater compliance arises from wrinkling induced by elastin fibers with spanwise orientation. These fibers and the imposed wrinkling create a membrane with excess length, which influences aerodynamic performance by generating larger than expected passive camber.

54.1 CHENG, B*; TOBALSKE, BW; HEDRICK, TL; POWERS, DR; WETHINGTON, SM; DENG, X; Purdue Univ., Univ. of Montana, Univ. of N. Carolina, George Fox Univ., Hummingbird Monitoring Network; *chengbograd@gmail.com*

Mechanics of Escape Maneuvers in Hummingbirds

We undertook the present study to begin to compare control strategies for flight maneuvers in small vertebrates and insects. Escape maneuvers of four species of hummingbirds that vary in body mass and wing and tail morphology (Blue−throated, 8 g; Magnificent, 8 g; Black−chinned, 3 g; Broad−billed, 3 g) were recorded and analyzed. The maneuvers were initiated by startling the hovering hummingbirds during feeding. Despite the differences in body morphology and wingbeat frequency, for all the species, the maneuvers consist of rapid pitch−roll body rotations, accompanied by minor yaw rotation. Specifically, hummingbirds start with major nose−up pitching and yawing to the direction of turn, which is followed by rolling and pitching back to the normal flight posture (hover or forward flight). The pitching direction maintained nose−up throughout the maneuver despite the changes in rolling and yawing. Such a rotation sequence results in a global yaw turn and body translation away from the feeder. Average yaw rate reaches about 1500 degs/s for blue−throated hummingbirds, while the peak pitch and roll rates reach 2000 degs/s and 3000 degs/s, respectively, substantially higher than those observed in escape maneuvers in hawkmoths. Blue−throated and Magnificent hummingbirds show conspicuous wing kinematic changes during the maneuver, including wingbeat frequency and asymmetry in the left and right wing deviation angles. Average wing kinematics during up and down strokes correlate strongly and linearly with the body angular velocities during maneuvers. For example, roll rate correlates with the difference in left and right wing deviation during downstrokes ($p<=0.006$); and pitch rate correlates with the magnitude of downstroke wing velocity ($p<= 0.0009$). NSF CMMI−1234737.

38.2 CHIBUCOS, K.*; WENDLING, A.; BURGESS, H.A.; Eunice K. Shriver National Institute of Child Health and Human Development, Bethesda, MD; *kandice.chibucos@nih.gov*

Coding of postural information by otoliths in larval zebrafish

Vestibular information is integrated with many other sensory inputs such as visual and somatosensory, making defining underlying neural mechanisms of vestibular−induced behavior challenging. In this study, we examined how otoliths code vestibular cues and identified signal to motor system pathways involved in postural control in larval zebrafish. To test vestibular coding, we disrupted utricular and saccular otoliths in larvae using morpholino knock−down and then analyzed behavioral responses to vestibular stimulation. Larvae missing both utricles (Utr−) had unstable roll balance, which improved under lit conditions showing an increased reliance on visual cues to maintain roll balance. Utr− also decreased routine turn (R−turn) initiation during swimming. Intact controls also showed reduced R−turns during vestibular disruption after exposure to strong vibration. Thus, R−turns may largely depend on utricular sensory input. Larvae were then exposed to a horizontal acceleration as a controlled vestibular stimulus; all groups except Utr− increased R−turns when oriented perpendicular to the motion. Utr− instead increased scoots (forward swims) but only when oriented with the motion. Last, we examined vertical swimming, finding that larvae controlled body pitch via passive drifting to orient downward, scoots to orient upward and R−turns for large angle pitch changes. While the utricle is known to be critical for roll balance, the vestibular function of the saccule was yet undetermined. Here we show that the saccule is directionally sensitive to vestibular stimuli and is associated with scoots, while the utricle may stimulate R−turns. Taken together, our results indicate that R−turns and scoots have distinct roles in ongoing pitch and roll corrections.

60.4 CHIPMAN, AD*; AUMAN, T; The Hebrew University of Jerusalem; *ariel.chipman@huji.ac.il*

Following cell division and cell shape in the segmenting growth zone of arthropods

The molecular basis of segmentation in arthropods has been studied intensively over the past decade or so, and a picture is gradually emerging wherein a series of transcription factors and signaling molecules work together to generate a repeated pattern at the molecular level, which is then translated into morphological segmentation. However, this molecular picture is missing crucial elements and still fails to provide a full mechanistic description of how segmentation occurs. We have been using the milkweed bug *Oncopeltus fasciatus*, an insect with a more typical segmentation process than the well−studied fruitfly, *Drosophila melanogaster*, to integrate elements of cell behavior into the process of segmentation. We have mapped cell division patterns and cell shape parameters onto the segmenting growth zone, in parallel with an analysis of the expression of key growth zone / segmentation genes such as *caudal*, *delta, evenskipped* and Wnt ligands. We have also analyzed changes to cell behaviors following perturbation of these segmentation genes. The combination of the cell level analysis and gene expression patterns provides a first glimpse into what cells are doing in the growth zone during the segmentation process and how these cell behaviors are linked to gene activity to drive the process of segmentation.

P2.20 CHMURA, HE*; KRAUSE, JS; PEREZ, JH; SWEET, SK; ASMUS, A; BOELMAN, NT; GOUGH, L; WINGFIELD, JC; University of California, Davis, Columbia University, University of Texas, Arlington; *hechmura@ucdavis.edu*

Interannual variability in arctic phenology and reproductive success in the White−crowned sparrow (Zonotrichia leucophrys gambelii) and Lapland longspur (Calcarius lapponicus)

Spring in the high arctic is notoriously harsh with interannual variability in snow−melt and resource availability. With climate change the frequency and intensity of extreme weather events, such as late snowstorms, is expected to increase. Late storms have dramatic effects on breeding biology in migrant songbirds by affecting phenology of food resources, energy reserves for parental behavior, and reproductive timing. This can be detrimental to reproductive success as the breeding season for these species is already constrained by migration and the short arctic growing season. The 2013 breeding season on the North Slope of Alaska featured late spring snowstorms and delayed snowmelt followed by record breaking summer heat while 2012 featured less extreme weather. We use these two seasons as a case study to test the relationship between interannual variability in weather and reproductive success. To examine how the effects of climatic variation may be different across species, we monitored nests in the shrub breeding White−crowned sparrow *(Z.l. gambelii)* and the open tundra breeding Lapland longspur *(Calcarius lapponicus)* in the vicinity of Toolik Lake Research Station, Alaska. While reproductive success was similar for White−crowned sparrows between the two years, Lapland longspurs had lower reproductive success in 2013. We explore possible explanations for differences in reproductive success between species and between breeding seasons using data collected on nest micro−habitat, phenology of food resources, nestling body condition, and other factors.

P3.119 CHOW, M.H.*; MANCIA, S.I.; HUANG, X.; MCMILLAN, B.; JACOBS, M.W.; McDaniel College, Bryn Mawr School; *mhc006@mcdaniel.edu*

Mind your step: What is the effect of soil compaction on soil invertebrate movement?

Human foot−traffic and livestock treading can cause levels of soil compaction that can influence the abundance and composition of soil invertebrate communities. We hypothesized that the levels of soil compaction found in hiking paths may slow or even stop soil invertebrate movement. We collected soil cores (4−inch diameter x 4−inch depth) from a non−compacted area and placed them in Berlese−Tullgren funnels. At the bottom of the funnels, organisms had to move through either a compacted or non−compacted ½ inch layer of sterile soil before dropping into a jar of ethanol. We compared total soil invertebrate abundance and abundance of selected individual taxa after 6 and 162 hours. Cumulative total organism abundance after 162 hours was significantly higher in samples with no compacted layer compared to samples with a compacted layer. This suggests that soil compaction serves as a barrier. Soil compaction may also have slowed invertebrate movement: we observed a strong trend for lower abundance in the compacted treatment in the 6 hour sample, but not in the 162 hour sample. Our results suggest that compacted areas such as human walking paths could present enough of a migratory barrier to separate soil invertebrates.

P1.203 CHRISTENSEN, L.A.*; MEYERS, R.A.; GOLLER, F.; Weber State University, Ogden, UT, University of Utah; *rmeyers@weber.edu*

Lack of Song in Females Does Not Drive Sexual Dimorphism in Syringeal Muscle Composition

The avian syrinx uses four pairs of intrinsic muscles to control song production. Previous work in our lab using immunohistochemistry revealed two fiber types, fast and superfast. Superfast fibers are rare fibers found in sound−producing animals and contract up to 250 Hz in songbirds. We studied songbird species from different families to understand the role of superfast fibers in singing. Male songbirds typically sing more complex songs than females, who may sing occasionally or not at all. In species where males sing and females sing at least occasionally (European Starlings, *Sturnus vulgaris*; White−crowned Sparrows, *Zonotrichia leucophrys*; House Sparrows, *Passer domesticus*; Red−winged Blackbirds, *Agelaius phoeniceus*; Yellow−headed Blackbirds, *X. xanthocephalus*), both sexes had similar composition with superfast fibers outnumbering fast. In two Estrildids where males sing and females do not (Zebra Finches, *Taeniopygia guttata*; Bengalese Finches, *Lonchura domestica*), males possess a greater percentage of superfast fibers than females (80% in males, 25% in females). This difference in fiber percentage supports the hypothesis that superfast fibers are important in singing. However, two other species with sexually dimorphic singing behavior (Brewer's Sparrows, *Spizella breweri*; Brown−headed Cowbirds, *Molothrus ater*), had superfast fibers outnumbering fast in both males and females. These findings suggest that singing does not account for the occurrence of superfast fibers in the syrinx and the presence of these fibers is likely a taxonomic factor. Our lab is currently investigating other Estrildids to test that hypothesis. Further investigation is needed to determine if superfast fibers are necessary for other non−singing functions.

46.6 CHULAKOTE, SSY*; YAMADA, J; SMITH, CM; University of Hawaii at Manoa, College of Micronesia − FSM; *scottsyc@hawaii.edu*

Local or Exotic Cuisine? Quantifying Herbivory Pressure and Preference for Macroalgae.

Although assessments of Hawai i's reefs document fish biomass and assemblages, herbivory pressure remains understudied. Herbivore studies try to determine preference by using pairwise and multiple−choice comparisons of native and invasive macroalgae. These studies were conducted *in situ* and in a simulated reef tank in order to quantify grazing pressure and preference. Grazing pressure *in situ* varied in summer seasons 2012 and 2013, however was moderately low for all macroalgae in both years. Preference for the invasive algae *Gracilaria salicornia* and *Acanthophora spicifera* were both detected in the pairwise comparisons and in the controlled multiple−choice preference study. Observed fish bites in timed tests showed native reef herbivores *Zebrasoma velliferum*, *Acanthurus xanthopterus*, and *Kyphosus cinerascens* were top contributors towards the consumption of *G. salicornia* and *A. spicifera*. These results may suggest low herbivore abundance, rather than preference in grazing, is an obstacle to re−establishing native reef communities. Among many steps leading to healthier reefs, further feeding experiments of *Z. veliferum*, *A. xanthopterus*, and *K. cinerascens* could lead to new management options for the control of invasive algae.

P3.169 CIERI, R.L.*; FARMER, C.G.; University of Utah; *bob.cieri@gmail.com*

Phase−contrast MRI analysis of Diapsid respiratory flow patterns in situ

The study of fluid flow in biological structures has historically been hindered by the difficulty of observing realistic fluid motion *in situ*. Respiratory flow is especially difficult to study because body tissues that affect ventilation, such as the bones and muscles involved in costal ventilation, prevent direct observation of flow and artificial ventilation of excised respiratory structures may produce ventilatory patterns different from those *in vivo*. Here we present a novel method of observing flow patterns in diapsid lungs. The respiratory systems of euthanized and intubated animals encased in airtight PVC chambers are filled with water. Ventilation of water at a biologically−relevant Reynolds number is then accomplished by programmed changes in air pressure on the lizard body to more accurately simulate *in vivo* inhalation and exhalation. The direction of respiratory system fluid flow is recorded in three planes with phase−contrast (PC) MRI throughout several ventilatory cycles. These data are then integrated into whole−lung vector maps in MATLAB. Our results confirm unidirectional airflow patterns previously discovered in *Varanus exanthamaticus* using heated thermistor air flow probes and provide additional information on regional flow patterns in the lungs of *V. exanthematicus*. This method should enable accurate determination of ventilatory flow patterns in a diverse range of taxa with costal ventilation, providing for a more accurate phylogenetic placement for the origin of unidirectional airflow patterns in the lung. In addition, because PC MRI flow data is collected at each point during the entire ventilatory cycle and the duration and speed are easily variable, this method may help to determine the morphological and behavioral parameters influencing lung flow patterns.

5.4 CLAESON, KM*; ASCHLIMAN, NC; UNDERWOOD, CJ; PCOM, St. Ambrose University, Birkbeck College; *kerincl@pcom.edu*

The Role of Guitarfish in the Origin of Skates and Rays

Recent phylogenetic analyses based on molecular data, paleontological data, or extant morphology consistently recovered a paraphyletic "Rhinobatiformes" (guitarfishes) but disagreed on the position of their close relatives. This prompted our investigation into the evolutionary processes that shaped early batoid diversity. Specifically, we sought to determine the extent to which patterns and rates of phenotypic evolution varied among the "rhinobatiform" taxa indicated to be ancestral to more derived lineages of Batoidea. We examined phenotypic trajectories using morphometrics of the synarcual, a well−supported synapomorphy of Batoidea, across a concatenated time−calibrated tree based on modern and fossil data. We found evidence of repeated similar phenotypic trajectories among disparate batoid groups. For instance, synarcual hyaline and tessellated cartilages became longer and were perforated by more and more spinal nerve foramina (i.e., the synarcual is short and incipient in Jurassic taxa but more massive and complex in derived batoids). At the same time, the relative position of the first free vertebral centrum is found more posterior along the synarcual. Previously demonstrated for skates, this is now noted in electric rays, stingrays, and "guitarfish" independently. These changes coincide with modifications in lifestyle from an early (Jurassic) batoid rhinobenthic habitus of bottom dwelling/feeding plus caudal propulsion, to parallel adaptations for less caudal forms of locomotion and additional pectoral specializations. Similarities between Jurassic batoids and modern guitarfishes are superficial; therefore modern guitarfish paraphyly may indicate rapid diversification after the appearance of taxa restricted to the Jurassic. Similarities between skates and rays are convergent occurring most recently in rays.

119.6 CLAGHORN, GC*; THOMPSON, Z; KAY, JC; HAMPTON, TG; GARLAND JR, T; Univ. of California, Riverside, Mouse Specifics Inc; *gclag001@ucr.edu*

Gait characteristics of mice bred for high voluntary wheel running

Mice from lines that have been selectively bred for nearly 70 generations for high levels of voluntary wheel running (HR lines) show many differences from their non−selected control (C) lines, including more symmetrical hindlimb bones, greater treadmill endurance, and higher voluntary running speeds and daily distances on wheels. Despite continued selection, wheel running reached an apparent plateau at ~ generation 20. One proposed physical limit is the maximum limb−cycling frequency at the highest speeds during wheel running. We explored gait differences between HR and C mice, as well as differences related to the mini−muscle phenotype, characterized by a 50% mass reduction in the triceps surae and total hindlimb muscle mass, which has increased in frequency within 2 of the 4 HR lines. The unique DigiGait Imaging System (Mouse Specifics Inc) captured and analyzed high−speed, high−resolution, ventral−plane videos, and automatically calculated over 30 metrics of posture and locomotion to characterize the gait. Young adult mice were tested on the DigiGait treadmill at speeds of 30, 50, 70 and 90 cm/s. After 6 days of wheel access, the mice were retested. We analyzed several characteristics of gait, including stride length, stride frequency, stance width, and paw area using a nested ANCOVA with body size as a covariate. Preliminary analyses indicate that HR mice have decreased stance width following wheel access, mini−muscle mice have a larger paw area following wheel access than normal−muscled HR or C mice, the relative size of male and female paw areas changes with wheel access, and males take longer, less frequent strides . Supported by NSF GRFP to GC and IOS−1121273 to TG.

38.3 CLARDY, T*; HILTON, EJ; VOGELBEIN, WK; Virginia Institute of Marine Science; *tclardy@vims.edu*

Morphology and ontogeny of multiple lateral line canals in the prickleback genus Xiphister (Cottiformes: Zoarcoidei: Stichaeidae)

Several members of the prickleback family Stichaeidae have multiple, complexly branching trunk lateral line canals that are supported by small, dermal, ring−like ossifications. Multiple lateral lines are rare among teleostean fishes and are found in representatives of only twelve other families. In this study, we examined the morphology and ontogeny of lateral line canals in the prickleback genus *Xiphister*. Both species in the genus, *X. mucosus* and *X. atropurpureus*, develop three paired, branching lateral line canals along the length of their body, plus a short, mediodorsal canal that extends from the neurocranium to the dorsal fin origin (canals 1−4 in dorsal to ventral sequence). Canals 1 and 2 develop rostro−caudally at 30mm, followed by canal 4 caudo−rostrally at 38mm, and, finally, by canal 3 rostro−caudally at 40mm. Trunk canals 1 and 2 connect to the cephalic sensory canals, which feature branches radiating from the infraorbital bones that also are supported by ring−like ossifications as found on the trunk. Canal 4 develops a short loop around the abdomen, and the left and right sides are connected by a short, anterior medioventral extension. The distribution of neuromasts, the sensory components of the mechanosensory lateral line system, was examined using histology. Canal neuromasts were observed in all of the cephalic canals and trunk canals 2 and 3. Canals 1 and 4, while similar in structure to other canals, lacked neuromasts and therefore cannot serve a sensory role in *Xiphister*. The functional role of multiple lateral line canals in *Xiphister* and other members of Stichaeidae warrants further investigation.

P2.88 CLARK, AJ*; TRIBLEHORN, JD; College of Charleston; *clarkaj@cofc.edu*

Mechanical properties of the cuticles of three cockroach species in relation to wind−evoked escape behavior

Many insects employ rapid movements or body armor to protect against predatory attack. There are often tradeoffs between these behavioral and morphological forms of active defense. For example, in a heavily armored insect, the increased body weight reduces its ability to perform rapid escape responses. This tradeoff can be found in cockroaches (Blattaria). *Periplaneta americana* exhibits strong wind−evoked escape responses involving rapid turning and running. This response is weaker in *Blaberus craniifer* and absent in *Gromphodorhina portentosa*, putting these species at greater risk of being struck by a predator. These two larger species possess more robust exoskeletons that could provide more protection from predatory strikes compared to the lighter exoskeleton of *P. americana*, but the protective biomechanical properties of cuticle in these three species have not been quantified. Here, we measured these properties by testing the tensile strength and puncture resistance of the thoracic and abdominal cuticles in these three species. As predicted, the cuticles of both *B. craniifer* and *G. portentosa* were significantly stronger and more resistant to puncture forces than the cuticles of *P. americana*. Relative to *P. americana*, tensile strength of the thoracic and abdominal cuticles was three times greater in *B. craniifer*, and six times greater in *G. portentosa*. Peak puncture forces were five times greater in *B. craniifer*, and twenty times greater in *G. portentosa*. Our results, coupled with results from previous studies on wind−evoked predator avoidance behaviors in these cockroach species, support the hypothesis of an important tradeoff between rapid body movements and robust cuticles.

98.6 CLARK, X*; SIMPSON, SJ; CLISSOLD, FJ; University of Sydney, NSW, Australia; *ximonie.clark@sydney.edu.au*

Plant nutrients, mouthparts and temperature: the intricacies of insect nutrition

Plant tissues, temperature and mouthparts all affect the amount and ratio of nutrients an insect can obtain from its host plant. When investigating herbivorous insect nutrition it is therefore important to not only examine the nutritional composition of the plant but also the insect's ability to acquire these nutrients. Chewing insects need to break open plant cell walls to gain access to nutrients. Insect mandible size is important as many insects do not chew their food but simply bite off sections. The particle size produced by each bite is an indication of the amount of cells broken open and therefore nutrients released. We have shown that smaller locusts are able to extract more nutrients from a given meal of grass than larger locusts; an outcome that supports the assumption that relatively more plant cells are crushed and ruptured because of their smaller bite size. Additionally, temperature has been shown to affect the amount and ratio of nutrients obtained by a larger locust, *Locusta migratoria*, leading to impacts on final body size. A smaller locust species, *Chortoicetes terminifera*, however showed no effect, again indicating smaller insects are more efficient at extracting nutrients, thereby conferring relative independence from temperature effects on nutritional outcomes. We will present our latest results and reveal the implications that behaviour and morphology have for locust nutrition in thermally variable environments.

77.2 CLARK, R.M.*; ZERA, AJ; BEHMER, S; Texas A&M University, University of Nebraska−Lincoln; *r11clark@gmail.com*

Nutrient availability influences resting metabolism in wing−dimorphic Gryllus firmus crickets

Nutrient availability shapes physiological function, yet connections between feeding, metabolic physiology and life−history trade−offs have rarely been explored. We examined how variation in the availability of dietary protein and carbohydrate affects feeding and resting metabolic rates of female *Gryllus firmus* crickets from a population selected to produce either flightless (short−winged; SW) or flight−capable [long−winged; LW(f)] adults. In this species, flight ability trades−off with early fecundity; SW females reproduce sooner than their LW counterparts. We gave newly molted adult females (n=130) one of 13 diets with different relative and absolute amounts of protein and carbohydrate and allowed them to feed for five days, before measuring resting metabolism via indirect calorimetry (carbon dioxide production). Feeding patterns were similar for both morphs, and highest on dilute diets with balanced ratios of protein to carbohydrate. The crickets could not fully compensate for nutrient dilution, however; individuals on high−nutrient diets obtained twice as much total protein and carbohydrate, and SW crickets gained more mass than LW crickets, especially on high−protein foods. Despite these differences, nutrient availability influenced mass−independent resting metabolic rates equivalently for both morphs; crickets that acquired more nutrients had higher resting metabolism. The latter finding demonstrates a direct connection between food quality and resting metabolism, while the morph−specific mass gain patterns indicate further complexity at play in the expression of the dispersal−reproduction life−history trade−off.

47.3 CLARKE, DN*; MILLER, PW; LOWE, CJ; NELSON, WJ; Stanford University; *clarken@stanford.edu*

Evolution of the Cadherin−Catenin Adhesion Complex: Insights from the Starlet Sea Anemone, Nematostella vectensis

A simple epithelium is a sheet of cells that separates the inside of an organism from the surrounding environment, and is thought to be the first organized multicellular tissue to occur in animal evolution. Epithelial cells adhere to each other via specialized cell−cell adhesion proteins. The Cadherin−Catenin Adhesion Complex (CCC), consisting of classical cadherin, ²−catenin, and ±−catenin, has been shown to be necessary for the initial formation of epithelial cell junctions in bilaterian model systems, and plays a critical structural role by linking the plasma membrane to the internal actin cytoskeleton. As the emergence of the core components of the CCC corresponds with the origin of animals, the adhesive function of the complex may have been coincident with animal multicellularity, or it may have been a later refinement of the Bilateria, but as the basic functions of the constituents of the CCC remain untested outside of bilaterians, this hypothesis remains untested. Furthermore, recent findings indicate that despite a high level of sequence conservation in the CCC across the Metazoa, the functional properties of its constituent proteins are quite variable between bilaterian taxa. We currently lack the functional and molecular descriptions of CCC components from a basally branching metazoan to determine conservation and variability in CCC function. We therefore examined CCC protein interactions and sub−cellular localization in the anthozoan cnidarian, *Nematostella vectensis*. Our results, based on *in−vitro* protein biochemistry and immunofluorescence using affinity−purified, cross−reactive antibodies, show that the basic functional interactions and localization to cell contacts of the Cadherin−Catenin Complex are conserved outside of the Bilateria.

P3.68 CLAY, T. A.*; GIFFORD, M. E.; University of Arkansas at Little Rock; *tclay1@gmail.com*

Thermal Sensitivity of Energy Assimilation among Plethodon from Different Elevations

Energy assimilation should be optimized for local environmental conditions and has the potential to limit species' distributions. Within *Plethodon* there are numerous examples of elevational zonation between montane endemics and lowland congeners. Previous work suggests that montane endemics are physiologically restricted in distribution; whereas, interspecific competition primarily limits the distribution of the lowland species. In the laboratory, we determined the thermal sensitivity of energy assimilation for several montane and lowland *Plethodon* by measuring energy assimilation rates across a range of ecologically relevant temperatures. Preliminary data suggest that thermal sensitivity of energy assimilation differs between high and low elevation species, but is similar between species inhabiting similar elevation ranges. In particular, high elevation species appear to have narrower thermal performance curves than low elevation species, suggesting specialization to a narrower range of temperatures. In addition, high elevation species appear to optimize energy assimilation at cooler temperatures than do low elevation species. Preliminary data were collected from species that are phylogenetically closely related; species sharing similar habitats are sister species. We've expanded on this data set by including additional species from independent lineages and have analyzed the data from a phylogenetic perspective, allowing us to tease apart if phylogeny or similar adaptive responses characterize the observed patterns. In summary, preliminary physiological patterns support earlier predictions, that montane endemics are physiologically limited to colder, and perhaps more stable environments, and these cooler high elevation habitats should not preclude the low elevation species through compromised energetics.

119.5 CLEMENTE, C. J.; University of Queensland; *c.clemente@uq.edu.au*

Lizards popping a wheelie: Bipedal running in Australian agamid lizards

Bipedal locomotion is widespread among various taxa. While the reasons for bipedal locomotion in other taxa vary from energetic advantages to reassignment of the forearms to other uses, within lizards reasons for bipedal locomotion are still unclear. Recent modeling studies suggest bipedalism in lizards may be a consequence of a caudal shift in the body centre of mass (BCOM), combined with quick busts of acceleration, together which cause a torque moment at the hip lifting up the front of the body. Lizards are essentially popping a wheelie'. Some lizards appear to run bipedally sooner and for longer than might be expected from this simple model, and it has been suggested that these lizards have exploited the consequence of bipedal locomotion. However, it is unclear how common this exploitation is among lizards. Do some lizards try to run bipedally or do most simply run bipedally by accident? We examined morphological data for 78 species across the squamate phylogeny and show that a rearward shift in the BCOM is associated with bipedal lineages. We then examined strides from 10 species of Australian agamid lizards, and recorded acceleration during bipedal or quadrupedal locomotion. Five of the 10 species were capable of steady state bipedal locomotion. We estimated the empirical acceleration threshold for these species to switch between quadrupedal and bipedal locomotion using logistic regression and compared this to thresholds estimated from morphological parameters alone. With the exception of two species, lizards were able to run bipedally at lower than expected accelerations based on morphology, suggesting that kinematics have a significant influence on bipedalism. Together, these results suggest most agamids have exploited changes in BCOM to become bipedal, suggesting that bipedalism in this group may convey some advantage, though what this advantage is remains the subject for future investigations.

P3.140 CLEMENTE, C J*; WILSON, R S; The University of Queensland; *r.wilson@uq.edu.au*

Surviving in the slow lane: speed and maneuverability jointly determine escape success

The interaction between prey and predators is an asymmetric game of life and death: unsuccessful predators go hungry, while unsuccessful prey are killed. As such, predation is considered one of the most pervasive selective pressures affecting individual fitness. But what performance characteristics enable individuals to escape predation? Intuitively, we expect faster individuals to be better at avoiding predation, and studies of animal performance have almost exclusively focused on the role of maximal speeds during escape from predators. However, focusing on maximal performance vastly oversimplifies the dynamics between predators and prey. In reality, an individual's escape performance is likely to be defined by both their speed and ability to rapidly change directions, or maneuverability. We tested this idea using a custom, tablet−based game that simulated encounters between predator and prey. Ten human subjects were asked to capture simulated on−screen prey by touching them as they moved across the tablet's screen (>1000 trials each); with prey varying in size, speed and maneuverability. Using these data we were able to quantify the interactive importance of speed and maneuverability for our simulated prey's ability to escape predation. We found that escape success was determined by both speed and maneuverability − slow prey could escape predation only when highly maneuverable, while prey that was poorly maneuverable could only escape when fast. Our results highlight the importance of including both speed and maneuverability in tests of animal escape performance.

31.5 CLEMMENSEN, S.F.*; HULSEY, C.D.; University of Tennessee, Knoxville; *sclemmen@utk.edu*

Dynamic gene expression and rates of gene evolution underlying divergence in a cichlid key innovation

Trophic divergence in cichlid fish is linked to shifts in pharyngeal jaw morphology. The changes in the genetic and developmental architecture underlying this key innovation are largely unknown. Gene expression plasticity, or the differences in gene expression in response to changes in environment, may have large effects on the rate of gene evolution. Using next−gen whole transcriptome sequencing, we measured shifts in gene expression in the muscular sling of the cichlid pharyngeal jaw in response to a diet shift in lab−reared cichlids. We examined the relationship between changes in gene expression and the rate of sequence evolution (d_N/d_S) among genes to determine if genes with high differential expression showed more adaptive divergence than did genes with low differential expression.

P3.166 CLIFTON, GC*; CARR, JA; Concord Field Station, Harvard U., Bedford, MA, CFS, Harvard U., Bedford, MA; *glenna.clifton@gmail.com*

Musculoskeletal specializations of foot−propelled swimming birds

Within the great diversity of birds, numerous lineages have colonized aquatic environments. Birds that swim using their feet face opposing constraints for locomotion on land versus through water. On land, birds require powerful muscles to produce large ground reaction forces and must position their feet so that the body is stable. On the surface or underwater, the production of hydrodynamic forces does not solely rely on muscle power, but also on foot shape and velocity. A swimming animal's limb orientation is not constrained by terrestrial stability, though contributes to body drag. Due to these differing conditions, we expect hindlimb musculoskeletal morphology to vary with the degree of aquatic specialization. To examine this, we have dissected the hindlimbs of birds ranging from completely terrestrial to highly aquatic: Helmeted guinea fowl (*Numida meleagris*), American coots (*Fulica americana*), Mallards (*Anas platyrhychos*), Double−crested cormorants (*Phalacrocorax auritus*), Western grebes (*Aechmophorus occidentalis*), and Red−throated loons (*Gavia stellata*). Unlike those of guinea fowl and coots, the legs of loons and grebes are almost completely incorporated into the body musculature, allowing the insertions of several hip muscles to attach more distally along the tibiotarsus. Furthermore, the distribution of muscle mass shifts more distally with increased swimming ability, ranging from 70% proximal in guinea fowl to 50% in cormorants to 30% in grebes. Specialized swimmers have exceptionally enlarged gastrocnemius muscles and digital flexors, all with a low degree of pennation. Since, many of these groups have evolved foot−propelled swimming independently, these observed trends in hindlimb morphology may represent key adaptations to swimming prowess in foot−propelled birds.

77.5 CLISSOLD, F.J.*; SIMPSON, S.J.; The University of Sydney; *fiona.clissold@sydney.edu.au*

Plant chemistry and temperature both influence host plant choice

Fitness of herbivorous ectotherms is strongly influenced by temperature and diet, mediated via effects of temperature on metabolic rate. We have shown in the laboratory that, although metabolic rate increases with temperature, the most significant effect temperature has on life history outcomes in a model herbivore, the locust, is its influence on the rates and balance of protein and carbohydrate absorbed from particular host plants; i.e. host plant quality' is temperature dependent. Furthermore, locusts were able to choose body temperatures so that protein and carbohydrate were differentially absorbed to redress experimentally imposed nutrient imbalances. Here we demonstrate in the field that locusts choose to maximize growth at the cost of delaying adult maturity; thus in an ecological setting host plant choice is dependent on both temperature and host plant availability.

77.6 CLISSOLD, F.J.*; RICHARDSON, A.; LENHART, P.; BEHMER, S.T.; SIMPSON, S.J.; The University of Sydney, Texas A & M University, Texas A & M University; *fiona.clissold@sydney.edu.au*

Is the ability to gain carbohydrate driving the evolution and ecology of an insect herbivore, the grasshopper?

Nitrogen is generally thought to limit the performance and fitness of herbivores. However, using chemically defined artificial diet it has been shown that growth, development and reproduction are maximized when insect herbivores are able to obtain an optimal blend of nutrients, especially the macronutrients protein and carbohydrate, rather than by maximizing the intake of any one or all of these. However, while the specific blend of nutrients for each herbivore can be ascertained in the laboratory, this information cannot simply be transferred to natural foods by grinding up plant tissues and measuring their chemical composition. The ability of an insect herbivore that chews plant leaves to absorb nutrients depends on how these nutrients have been packaged within the plant, in interaction with the insect's food processing tools (typically the mandibles and gastrointestinal tract) and plasticity of its behavioural and physiological responses. We present morphological, physiological and behavioural evidence demonstrating that the ability to gain carbohydrate appears to be a major factor influencing host choice and the evolution of grasshopper mouthpart morphologies. Evidence suggests nitrogen may be limiting, not through being in short supply, but rather its excess relative to carbohydrate and the control it exerts over nutrient uptake through controlling gut emptying and intermeal intervals.

23.3 CLOSE, RA*; BECKETT, H; MACLEOD, N; JOHANSON, Z; FRIEDMAN, M; University of Oxford; *roger.close@gmail.com*

Getting inside the heads of Cretaceous−Paleogene teleosts: new morphological and functional data from the exceptional fish fossils of the English Chalk and London Clay

Three−dimensional−preserved fossil fishes from the Late Cretaceous (Cenomanian−Campanian) English Chalk and Eocene (Ypresian) London Clay have been known and collected for nearly two centuries. Despite excellent preservation, fishes from these exceptional localities have received scant attention outside of monographs that are all now more than 50 years old. Now, however, computed tomography (CT) scanning has permitted us to extract considerable new morphological and functional information from dozens of fossil fishes from these deposits. Fishes from both the English Chalk and London Clay preserve features like articulated gill skeletons and inflated braincases, character−rich anatomical regions that are generally poorly preserved in flattened specimens found in lithographic limestones or shales. In addition to providing a wealth of anatomical information on early representatives of many major eurypterygian lineages, CT scanning permits the acquisition of functional and ecomorphological measurements previously only accessible from neontological datasets. By harnessing the mature framework that has been developed for quantifying feeding ecomorphology in fish, we are able to critically test previous hypotheses relating to changes in functional diversity between the Mesozoic and Cenozoic in acanthomorph (spiny−finned) teleosts, one of the most successful radiations of modern vertebrates. Using ground−truthed measures of performance, we are able to show a substantial increase in acanthomorph cranial functional diversity between the Late Cretaceous and Eocene, corroborating inferences drawn from sparse cranial landmark constellations applied to taphonomically flattened material from other localities.

P3.31 CLOY−MCCOY, J.A.*; KOHNO, S.; GUILLETTE JR. , L.J. ; Medical University of South Carolina, Charleston ; *jessicacloy@gmail.com*

The influence of environmental quality on ovarian anti−Müllerian hormone (AMH) gene expression in juvenile American alligators.

Studies of wildlife indicate that animals residing in contaminated habitats display an overall decrease in reproductive health. These findings have direct implications for the conservation of wildlife populations, but they also shed light on the possible etiology of human reproductive disorders. Recently, anti−Müllerian hormone (AMH) has gained clinical interest as a quantitative marker for ovarian health. In patients with premature ovarian failure AMH is greatly reduced. In contrast, the AMH levels in patients with ovulatory dysfunction are increased relative to controls. Information regarding the causes and consequences of disrupted AMH signaling in these pathologies is limited. There is evidence that estradiol treatment stimulates AMH expression and inhibits the primordial to primary follicle transition to neonatal rodent ovaries. This finding combined with the fact that environmental estrogens are widespread in our environment, prompted the overall hypothesis that exposures to estrogenic compounds causes a disruption of proper ovarian follicle development by disturbing the AMH signaling pathway. To test this hypothesis we analyzed the expression levels genes involved in the AMH pathway in juvenile laboratory raised alligators derived from a heavily contaminated environment. Our results show that compared to our reference animals the alligators derived from a contaminated site show no difference in the levels of AMH, SOX9, aromatase, estrogen receptor 1/2 (ESR1/2), or androgen receptor (AR) mRNA levels. Next, we intend to expand this study by assessing the levels of AMH and SOX9 in wild juvenile females from the same study sites. The findings of this study serve to clarify the relationship between exposure to environmental contaminants and regulation of ovarian folliculogenesis.

P1.171 COCKETT, PM*; HOGAN, JD; GURSKI, LM; PENNOYER, K; BIRD, CE; Texas A&M University − Corpus Christi; *pcockett@islander.tamucc.edu*

Coastal runoff effects on an exploited Hawaiian fishery

Coastal pollution from fresh water run−off has been implicated in altering the population structure of invertebrates and reducing genetic diversity and adaptive capacity. Overharvested fisheries can be particularly vulnerable to anthropogenic impacts on coastal runoff due to reductions in genetic diversity and resiliency in response to stressors such as sewage, pesticides, fertilizers, industrial chemicals and other contaminants. Hawaiian broadcast−spawning limpets, *Cellana exarata*, are subject to varying levels of harvesting pressure on different islands, ranging from a reduction in fishery output on Maui and Kaua'i to extermination on O'ahu, the most populous of the Hawaiian Islands. Previous analyses of neutral genetic variation in mtDNA and nDNA indicate that gene flow is restricted among islands, indicating that decimated O'ahu populations could experience reductions in adaptively advantageous genetic variation. Here, we use genome−wide surveys of genetic variation on Kaua'i, Maui, and O'ahu to test for adaptive differences among limpets on open−ocean coastlines, coastlines near unpolluted stream outflows, and coastlines near polluted stream outflows (2 replicates per island, 48 individuals per sample). Our data confirm previous conclusions of neutral gene flow restrictions among main Hawaiian Islands, and we identified some reduction in genetic diversity on O'ahu. We also detected significant genetic partitioning among locations within islands, although there is only weak support for an effect of stream outflow on limpet genetic composition. We conclude the population genomic analysis shows great promise for detecting spatial patterns on scales of km or less.

P2.108 COHEN, K.L.*; WARKENTIN, K.M.; Boston Univ.; *kcohen@bu.edu*

Do distinct hatching glands mediate hatching at different ontogenetic stages in red−eyed treefrogs?

Most anurans hatch by releasing proteolytic enzymes from hatching glands (HGs), transient, microvilliated cells on the head. In many species, HGs peak in abundance before hatching and continuously release enzyme, slowly degrading the membrane. Arboreal embryos of red−eyed treefrogs, *Agalychnis callidryas*, hatch early to escape deadly flooding, dehydration, pathogens, and predators, with no prior general degradation of the membrane. In Gamboa, Panama, embryos hatch rapidly in snake and wasps attacks as early as age 4.4 d, cued by physical disturbance. Videos show localized membrane rupture at the snout seconds after stereotyped shaking behavior. We used strong hypoxia to probe the onset of hatching competence and electron microscopy to examine developmental changes in hatching glands. We observed hypoxia−cued hatching as early as 3.8 d, substantially before predator−induced hatching, within 15 min after flooding. We found two types of HGs that appear in different locations at different developmental stages. Small HGs with medium−length microvilli are widely distributed and abundant at the onset of hatching competence, but scarce in 5−6 d embryos. Large HGs with short microvilli become highly concentrated on the snout by 5 d, increase in abundance until hatching, then quickly regress. Scanning TEM revealed large HGs of unhatched animals to be full of secretory vesicles, but seconds after hatching these HGs had emptied at least half their contents; epithelial and ciliated cells were unchanged. These results suggest that *A. callidryas* use different mechanisms to hatch in different contexts and stages: small hatching glands that mediate relatively slow, very early hatching responses to hypoxia, and larger, more prominent hatching glands that enable rapid hatching to escape from predators at later stages.

97.5 COHN, BRIAN*; COLLIN, SHAUN; WAINWRIGHT, PETER; SCHMITZ, LARS; W.M. Keck Science Department, Claremont McKenna, Pitzer, and Scripps Colleges, School of Animal Biology and the Oceans Institute, The University of Western Australia, Department of Evolution and Ecology, University of California Davis; *bcohn12@BrianCohn.com*

Influence of zooplanktivory on retinal ganglion cell topography in labrid reef fishes

While the majority of labrid reef fishes prey on bottom−dwelling invertebrates, this very speciose and ecologically diverse clade contains multiple independent evolutionary transitions to a plankton−based diet. These zooplanktivores hunt mainly on small, partially transparent copepods drifting above the reef, posing a visual challenge for these predators. We hypothesized that retinas of zooplanktivores are modified to meet the requirements of plankton−feeding, with higher visual acuity and a centrally located peak in retinal cell density. We sampled retinas of two zooplanktivores and each of their closest phylogenetic relatives for a total of 15 species, yielding spatial density measurements of ganglion cells. In order to achieve a precise visualization of ganglion cell maps, we developed an R code that projects the density surface onto an easily readable polar heat−map. We also utilized a new retrotransformation program to retistruct' the hemispherical nature of RGC data and applied thin plate spline interpolation for contour smoothing. While there is only a weak indication of interspecific variation in the total number and peak density of RGCs, their distribution across the retina varies between zooplanktivores and others. Transitions to plankton−feeding coincide with the presence of only one spatial retinal peak in acuity, while other labrids have two retinal peaks. Our results support the hypothesis that zooplanktivory is a major axis of diversification in visual morphology.

128.4 COLANTUONO, B*; IRVINE, S; University of Rhode Island; *bcolantuono5735@my.uri.edu*

Recapitulating Heterochrony in Ascidian Development

Solitary ascidian life history can be thought of as separating Romer's somatic and visceral organ systems. Embryonic and larval development are dominated by somatic systems (sensory and locomotory), while at metamorphosis the somatic systems are largely replaced by the visceral (digestive and reproductive). In many colonial ascidians however, somatic and visceral organs develop together in the embryo and larva. We are examining the expression of candidate genes expressed at the larva−juvenile transition in the solitary ascidian *Ciona intestinalis* and the colonial ascidian *Didemnum vixellum*. In addition, we have constructed an inducible expression vector which is used to express putative "metamorphosis genes" at earlier stages in *C. intestinalis* to determine whether gene batteries for visceral development can be activated during embryonic development in the solitary ascidian. These experiments are aimed at recapitulating the evolutionary changes that may be involved in the heterochrony seen in the type of life history apparently derived multiple times from solitary ancestors.

73.2 COLEMAN, DM*; WILLIS, MA; Case Western Reserve University; *dmc125@case.edu*

Inability to make bilateral olfactory comparisons affects the plume tracking flight of the moth, Manduca sexta.

Males of the hawkmoth *Manduca sexta* use their olfactory system to identify and track airborne plumes of female pheromone, but how they maintain contact with the plume is unresolved. Recent studies suggest they may compare odor cues from each antenna to remain near the center of the plume. If bilateral odor comparisons are important, we predict that moths with one antenna will track a pheromone plume, but their success locating the source and the structure of their behavior will be altered. To test this idea, we compared the tracking behavior of *M. sexta* males with one antenna to intact controls. Antennal removal was conducted in two ways: (1) surgical removal of an antenna 4 hours prior to experiments and (2) surgical removal of an antennal imaginal disc from the last larval stage prior to metamorphosis. The adult antennae of insects that undergo complete metamorphosis develop from bundles of determinate cells that lay dormant through the larval stages known as imaginal discs. Adult moths with only one antenna developed after removing an antennal imaginal disc from male larvae. In this study, 96% of the controls found the odor source with successively significantly fewer of antennectomized moths (44%) and imaginal disc removal moths (24%) locating the source. The flight paths of antennectomized and imaginal disc removal moths were also different from the controls, and each other. These results support the idea that *M. sexta* uses odor information detected on both antennae to maintain contact with a plume and track it to the source. We thank Jen Milligan and John Dutton for their assistance. DMC was funded by the Support of Undergraduate Research and Creative Endeavors center at CWRU and MAW was supported by a NSF grant IOS−1121498.

21.3 COLLARD, M*; DEHAIRS, F; DUBOIS, P; Laboratoire de biologie marine, Université Libre de Bruxelles, Belgium; Laboratorium voor Analytische Chemie, Vrije Universiteit Brussel, Belgium, Laboratorium voor Analytische Chemie, Vrije Universiteit Brussel, Belgium, Laboratoire de biologie marine, Université Libre de Bruxelles, Belgium; *marie.collard9@gmail.com*

Acid−base regulation in sea urchins: differential susceptibility to ocean acidification?

Even though previous researches have been led on the acid−base balance of the coelomic fluid of sea urchins, most of them were carried out on regular euechinoids. To this date, very little is known on the acid−base status of cidaroids and irregular euechinoids. We have investigated this status within regular euechinoids, irregular euechinoids, and cidaroids from different regions including the temperate intertidal zone, the tropical subtidal zone and the Antarctic waters. Our survey pointed out the same pattern within all regions: 1) *Regular euechinoids* have a coelomic fluid (CF) pH of about 7.2, an increased buffer capacity of the CF due to an increased concentration of bicarbonate ions and high molecular weight compounds; the $HCO3^-$ ions most probably originate from the surrounding seawater (witnessed by a similar isotopic signature of the carbon), 2) *Irregular euechinoids and Cidaroids* have a CF pH of about 7.0, a buffer capacity and a concentration of bicarbonate ions of the CF similar to that of seawater and an isotopic signature of the carbon different from that of the surrounding seawater. This pattern is quite regular in its occurrence and shows a difference of baseline physiology within the different echinoid groups. These differences lead to different responses when these animals face hypercapnia and/or acidosis, resulting in different sensitivities. More research on the physiology and acid−base balance and regulation needs to be undertaken in order to understand the occurrence of sea urchins in variable or unfriendly environments, as well as how they will be able to cope with climate change.

69.4 COLLINS, CE*; RUSSELL, AP; HIGHAM, TE; University of California, Riverside, University of Calgary; *clint.collins@email.ucr.edu*

The ups and downs of desert life: Movement, habitat structure, and biomechanics of a Namib day gecko

Successful predator evasion depends on many attributes of an animal along with the structural attributes of its natural habitat. Understanding the relationships between habitat structure, movement, morphology, and biomechanics permits contextualization of escape behavior as modulated by the physical constraints imposed on the animal. Gecko adhesion is considered an innovation permitting the exploitation of inclined and inverted surfaces. However, the deployment of adhesion can also limit locomotor speed. It is unclear whether geckos living in relatively horizontal habitats exhibit a reduced adhesive apparatus in association with alleviating these negative impacts. For four populations of *Rhoptropus afer*, a Namibian day gecko, we measured habitat availability, escape behavior, and morphology (macro and micro). We also estimated work and habitat−dependent stride parameters using high−speed video. Along with a relatively reduced adhesive system, *R. afer* relies on high speeds to escape predation. Habitats varied in substrate angularity (−65° to +76°), slope, and the occurrence of slopes e10° (0 − 72%). Populations differed in the percentage of escape on slopes e10°, which is important because such slopes may trigger deployment of the adhesive system. Although selection appears to favor a reduced adhesive system in this fast species, populations may experience varying degrees of selection depending on habitat structure. We discuss differences in toe pad area and setal dimensions between the populations. Overall, although adhesion is important for climbing, it may be unnecessary for, or even counterproductive to, the evasion of predators on relatively level surfaces. Supported by NSF IOS−1147043 and NSERC 9745−2008.

24.2 COMBES, S.A.*; SALCEDO, M.K.; GAGLIARDI, S.F.; Harvard Univ.; *scombes@oeb.harvard.edu*

Effects of environmental conditions on Drosophila flight performance

Wild insects inhabit a world of radically varying environmental conditions, where temperature, humidity and light levels vary substantially over multiple spatial and temporal scales. While we understand how many of these factors affect development, respiration, reproduction and other physiological traits, our understanding of how environmental conditions affect insect flight performance remains limited. Here, we examined the effects of temperature, light intensity and wind speed on the free flight behavior of fruit flies (*Drosophila melanogaster*), a model species for laboratory−based flight studies, and also an insect that is likely to encounter a range of variable microhabitats in the wild. We allowed lab−reared flies to emerge spontaneously from a vial into a large, open area (>2 m in each dimension) in either the laboratory or outdoors. We quantified flight trajectories within a volume of approximately 1 m^3, while recording temperature, visible and UV light intensity, and wind speed. A variety of locations and weather conditions were sampled, and multiple flies were tracked during each release to account for individual variability. We found that flight velocity was strongly influenced by environmental factors, including temperature and light intensity, and that saccade (turning) behavior also varies with environmental conditions. Past studies have demonstrated a positive relationship between temperature and flight speed, but the strong influence of light intensity (~2.5−fold increase in flight velocity from dim lab lighting to bright sunlight) has not previously been shown. These results have important implications for interpreting flight data collected in various settings, as well as for the behavior and ecological interactions of wild insects, which may vary in their sensitivity to environmental conditions.

7.2 CONCANNON, MR*; HU, Y; POWDER, KE; ALBERTSON, RC; UMass Amherst; *mrconcan@cns.umass.edu*

An empirical approach to assess the relationship between evolvability and fitness in East African cichlids

Organismal characters such as developmental plasticity, phenotypic integration, and relative morphology can influence evolvability, but how these factors interact with fitness during major evolutionary events is less clear. In the impressive adaptive radiation of East African cichlids, an initial divergence in benthic and limnetic foragers ultimately led to the incredible species diversity seen today. We designed an experiment to elucidate the interplay of fitness and organismal traits during niche partitioning along the benthic/limnetic axis. We utilized a lab−reared hybrid population that exhibits transgressive segregation in craniofacial morphology along this axis relative to the parental species. We induced competition in hybrids by offering a limited amount of two food choices with identical nutritional content: food dried on rocks to mimic a benthic/scraping diet, and finely ground food to mimic a limnetic/suction feeding diet. Changes in craniofacial shape and phenotypic integration were tracked over the course of the experiment. In addition, we also measured proxies of fitness including growth rate, reproductive investment, and survival. We investigated correlations among all these measures to identify traits associated with peaks on the fitness landscape, which may therefore be paramount in species divergence. Notably, since this experiment is performed in a mapping cross, we have the ability to identify the genetic bases of these traits, thereby lending important and novel insights into the relationships among traits traditionally associated with evolvability and those related to fitness.

P1.71 CONDELL, K/L*; ROBINSON, W/D; MOORE, R/P; STRATFORD, J/A; ROURKE, B/C; California State University Long Beach, Oregon State University, Wilkes University; *klcondell@gmail.com*

Physiological Constraints of Flight Performance in Neotropical Birds

The neotropics are a hotspot for plant and animal diversity. As forests are cleared for human development, habitats are becoming increasingly fragmented, which is detrimental to many species. Birds are typically considered to be some of the most mobile animals, but evidence is emerging that an inability to cross gaps between habitats may limit colonization and dispersal. Contractile protein composition of the flight muscle may dictate flight ability and endurance, as some muscles are limited to short bursts and others are suited to long bouts of activity. We examine flight muscle (*pectoralis major*) and cardiac muscle of eight common species of birds from Panama using SDS−PAGE to detect differences in myosin heavy chain isoform expression. Species with poor flight ability and those with stronger flight ability have previously been identified, and correlations are then made between flight muscle physiology and observed limitations of flight distance (Moore et al. 2008).

66.3 CONNOR, K.M.*; GERMAN, D.P.; GRACEY, A.Y.; Univ. of California, Irvine, Univ. of Southern California; *kconnor@uci.edu*

Thermal Stress and Energetics in the Ecological Dominant Marine Mussel Mytilus californianus along Within−Shore Environmental Gradients

The mussel *Mytilus californianus* aggregates to form beds that dominate the intertidal zone along the rocky coastlines of western North America. During low tide, mussels are exposed to the air and show marked resilience to solar heating, limited oxygen and lack of food. The chronic heat stress and lower feeding time of high shore mussels is reflected in slower growth rates and smaller terminal sizes. While the physiological responses of mussels along the tidal (vertical) gradient are well known, less is known about these responses along the wave exposure (horizontal) gradient: from wave−exposed to wave−sheltered microhabitats. In this study, we investigated mussel physiology in response to horizontal microhabitat variation by first developing markers of energy intake level including measurements of digestive enzyme activity and digestive enzyme gene expression in the digestive gland. Experimentally, we subjected mussels to low, mid and high food feeding treatments and measured enzyme activity and gene expression. We then collected mussels from wave exposed and wave sheltered sites during low tide and assayed the tissues for digestive enzyme activity and gene expression, and levels of heat shock protein. We predict that at a given shore level, variation in heat stress along the horizontal gradient will be greater than that of food intake, suggesting that temperature plays a significant role in reduced growth grates in wave sheltered microhabitats. These results will have marked implications for future predictions regarding the influence of Global Climate change on mussel populations, as it shows that the horizontal microhabitat gradient may be as important as the vertical one.

P2.1 CONTRERAS, A.N.*; COHEN, C.S.; California State University Long Beach, Romberg Tiburon Center, San Francisco State University; *ashleyn_contreras@yahoo.com*

Behavioral Variation Between Two Clades of Leptasterias spp.

In central California, several co−occurring species of the six−rayed sea star, *Leptasterias* spp., are distributed in a range of environments including intertidal walls, boulders, and seagrass habitats. These direct−developing seastars have limited dispersal potential and a life history that is hypothesized to promote local adaptation. This potential for local adaptation may provide the setting for behavioral differentiation as a response to varying selective pressures among habitats. Initial field observations of two phylogenetically distinct clades from differing habitats and locations suggested that behavioral variation may relate to habitat differences among clades. To measure differences in activity, the righting response of overturned seastars was timed at both field sites. Seastars found loosely attached to seagrass at one site demonstrated a faster righting response compared to seastars firmly attached to the irregularities of rocks at another site. As a result of these field behavioral observations, more extensive tests were conducted on individuals from both clades in a common lab setting. Individual behaviors recorded included location in tank, response to food cue, aeration and mobile substrate, attachment surface, and contact with other stars. Seastars collected from mobile substrate (i.e., seagrass and kelp) showed more exploratory behaviors related to arm and tube foot movement compared to seastars collected from wave swept rocks. The experiments provide measures of behavioral variation between clades housed in a common environment, suggesting behavioral variation may be correlated with genetic or fixed phenotypic differentiation.

P1.57 COOPER, R.L.*; MAJEED, Z.R.; SANTIN, J.M.; HARTZLER, L.K.; Univ of KY, Univ of KY; Univ. of Salahaddin, Iraq, Wright State Univ, Wright State Univ; *RLCOOP1@email.uky.edu*

Alteration in synaptic transmission by CO2: glutamate insensitivity

Glutamate receptors at the Drosophila and crayfish neuromuscular junctions (NMJ) decrease their sensitivity to glutamate upon exposure to saline containing CO_2. The indirect effect of CO_2 is potentially by acidification of the muscle cytoplasm given that CO_2 rapidly diffuses across membranes and reduces intracellular pH. Given that saline containing CO_2 also results in a pH drop, saline with lowered pH to the same level as with CO_2 exposure was examined. Synaptic transmission at the NMJ and response to glutamate is reduced with lowered pH extracellularly but does not result in complete decreased sensitivity to glutamate. We examined the drop in intracellular pH and the time domain in association with sensitivity to evoked synaptic transmission. NMJs exposed to saline equilibrated with 75% CO_2 results in a cessation of transmission within 1−2mins. Upon exchanging the high CO_2 saline with room air equilibrated saline transmission resumes in 1−2mins and completely recovers by 3−5mins. These responses are common to both crayfish and Drosophila NMJs. However, monitoring intracellular pH with pH−sensitive fluorescent dyes pyranine (injection, crayfish) or BCECF−AM (incubation, Drosophila), intracellular pH rapidly drops with exposure to CO_2 but remains low for several minutes upon washing away the CO_2 containing saline. The pH recovers with a very slow rise over 20 to 60mins in these muscles. Thus, the proton exchange is slow in these cells at room temperature. Also, synaptic responses return prior to intracellular pH recovering. The rapid synaptic changes suggest that the block in synaptic transmission may be due to molecular CO_2 itself and/or extracellular acidification. We speculate that molecular CO_2 may be blocking the inotropic glutamate receptor directly within the pore or in the binding domain for glutamate to partially account for the effects

P3.21 COOPER, L.N.*; STEELE, L.; SCHROEDER, A.; O'BRIEN, S.; Radford University, Radford, VA, Marian University, Indianapolis, IN; *lncooper@radford.edu*

Habitat fragmentation and avian behavior: a 3−year study examining the underlying complexities of population number and behavioral aggression across habitat size and shape.

Fragmentation of habitat is currently a major issue in wildlife sustainability & management. Fragmented habitat can manifest in numerous ways such as loss of amount of habitat, decreases in connectedness of habitat, and/or increase in edge effects due to the change in shape of remaining habitat. Avian species are highly subject to the effects of human disturbances such as fragmentation because they need to defend territories to maintain effective breeding and foraging home ranges. To understand the pressure human disturbance puts on a local avian species of songbird, we examined the effects of fragmentation on territorial aggression of the song sparrow (Melospiza melodia). Specifically, our study compared not only the degree of territorial aggression displayed between individuals living in fragmented and non−fragmented habitats, but also the suite of types of aggressive behaviors. Additionally we sought to understand the relationship between fragmentation and density of individuals in each habitat type. Overall this study demonstrates the complex relationship of fragmentation and population dynamics, specifically highlighting how site density and aggression affect habitat structure.

63.3 COOPER−MULLIN, C*; JIMENEZ, A.G.; ANTHONY, N. ; WORTMAN, M.; WILLIAMS, J.B. ; The Ohio State University, University of Arkansas, University of Cincinnati Cancer Institute; *cooper−mullin.1@buckeyemail.osu.edu*

Metabolism of cultured skeletal muscle of Coturnix quail selected for different rates of growth

The connection between cellular physiology and whole−organism life history is a nascent field in Physiological Ecology. Growth rate is a fundamental parameter of an organism's life history and varies greatly across bird species. Life histories in wild animals tend to fall on a "slow−fast" continuum with birds from the tropics in general falling on the "slow" end, where species tend to have low metabolic rates, prolonger nestling periods, longer lifespans, and lower investment in single reproductive events, whereas birds in temperate Ohio fall on the "fast" end with their higher rates of metabolism, short nestling periods, and shorter lifespans. To explore how growth rate and rate of metabolism of cells were connected to these whole−organism attributes, we used myoblast cells from Japanese quail (Coturnix coturnix japonica) that had been selected for fast or slow growth for over 60 generations. Cells from the fast−growth line had a significantly higher rates of basal oxygen consumption and glycolysis than the Coturnix Slow line. This led to the hypothesis that attributes of the mitochondria differ between the cell lines. Because mitochondria come from the mother, we tested the idea that mitochondria influence the rate of metabolism of these cells. We developed two hybrid lines, a fast male crossed with a slow female and a fast female line crossed with a slow male line. The data showed that the growth rate of the hybrid lines fell in between the growth rate of the fast line and the slow line. On the cellular level, the hybrid lines had intermediate rates of basal oxygen consumption and glycolysis, indicating that metabolic rates on the cellular level are not dictated by intrinsic properties of the mitochondria.

108.2 COPES, L.E.; SCHUTZ, H.; DLUGOSZ, E.M.; ACOSTA, W.; CHAPPELL, M.A.; GARLAND, T.*; Quinnipiac Univ., Pacific Lutheran Univ., Univ. of California, Riverside, Univ. of California, Riverside; *tgarland@ucr.edu*

Effects of voluntary exercise on spontaneous physical activity and food consumption in mice: results from an artificial selection experiment

We evaluated the effect of voluntary exercise on spontaneous physical activity (SPA) and food consumption in mice from 4 replicate lines selectively bred for 57 generations for high voluntary wheel running (HR) and from 4 non−selected control (C) lines. Beginning at ~24 days of age, mice were housed in standard cages or in cages with attached wheels. Wheel activity and SPA were monitored in 1−min intervals. Data from week 8 were analyzed because mice were adult and had plateaued in body mass, weekly wheel running distance, SPA, and food consumption. SPA of both HR and C mice decreased with wheel access, due to reductions in both duration (min/day with any cage activity) and average intensity of SPA. However, total activity (SPA + wheel running) duration (min/day) was ~1/3 greater when mice were housed with wheels, and food consumption was significantly increased. Overall, food consumption in both HR and C mice was more strongly affected by wheel running than by SPA. Duration of wheel running had a stronger effect than average speed, but for SPA the relative effects of intensity versus duration varied depending on which subset of mice was analyzed. As both HR and C mice housed with wheels had increased food consumption, the energetic cost of wheel running was not fully compensated by concomitant reductions in SPA. Both duration and intensity of both wheel running and SPA were significant predictors of food consumption. This sort of detailed analysis of the effects of different aspects of physical activity on food consumption has not previously been reported for a non−human animal, and it sets the stage for longitudinal examination of energy balance and its components in rodent models.

4.6 COPPLOE, JV*; RUPERT, JE; ROSE, JA; BUTCHER, MT; Youngstown State Univ., Indiana Univ. School of Medicine; *jvcopploe@student.ysu.edu*

Architectural specialization of the forelimb musculature of the groundhog

Scratch−digging animals are commonly described as having large, powerful forelimb muscles for applying high out−force to excavate earth, yet studies quantifying the architectural properties of the musculature are largely unavailable. Our previous work with semi−fossorial badgers identified several features of forelimb muscle design that may represent specializations for scratch−digging. To further test hypotheses about which of these traits is a specialization versus a feature common to the forelimbs of digging mammals, we quantified muscle architectural properties in the forelimb of the groundhog (*Marmota monax*), a generalist burrower that constructs semi−complex burrows. Architectural properties measured were muscle moment arm, muscle mass (MM), belly length (ML), fascicle length (FL), pennation angle, and physiological cross−sectional area (PCSA), and these metrics were used to estimate maximum isometric force, joint torque, and power. Groundhogs possess large humeral retractors and elbow extensors that are capable of applying moderate torques at the shoulder and elbow joints. Most of these muscles have high FL:ML ratios, indicating substantial shortening ability for high power generation. The carpal and digital flexors show relatively greater pennation and shorter fascicles lengths than the humeral retractors and elbow extensors, and thus have higher PCSA:MM ratios and force production capacity. Moreover, the carpal/digital flexors have the capacity for both shortening and force indicating high work and power potential. Overall, the muscle properties found may be common across digging mammals, whereas more complex elbow extensors with the ability to apply much higher torque and power at the shoulder joint may represent specializations for fossorial habit.

120.3 CORDERO, G.A.; Iowa State University; *gcordero@iastate.edu*

Evolution of Shell Kinesis in Turtles: Developmental Origins of a Convergent Phenotype During and After Embryogenesis

Turtles have undergone several adaptive radiations during their 220 million−year history. They have successfully invaded freshwater, marine, and terrestrial ecosystems worldwide. Even so, the turtle body plan consisting of dorsal (carapace) and ventral (plastron) shell components has undergone few changes, suggesting that it is developmentally constrained. Not surprisingly, the most complex modification of the basic turtle body plan, shell kinesis, has evolved multiple times in several unrelated lineages. Shell kinesis enables the absolute concealment of all body parts in some species. By enhancing anti−predator defense, this complex trait likely promoted invasion of terrestrial environments. Is the convergent of evolution of shell kinesis due to change in the same developmental processes in unrelated species in similar environments? I conducted a series of embryological, histological, phylogenetic, and morphometric analyses to answer this question. My results implicate extensive bone remodelling of the plastron during post−natal ontogeny as the shared developmental process in species with shell kinesis. However, changes in the embryonic development of anatomical components associated with this trait likely vary according to phylogenetic distance. My findings suggest that the turtle's unusual body plan is not an "evolutionary straitjacket". Lastly, the development of complex and convergent phenotypes is not limited to embryonic life stages.

P2.16 CORNELIUS, JM*; DINGLE, RDH; WATTS, HE; HAHN, TP; CSU−Monterey Bay; *cornelius@ucdavis.edu*

Obligation versus exploitation: Does mobility affect the evolution of opportunistic breeding in songbirds?

Birds coordinate life cycle events with changing environmental conditions. For many this leads to seasonal partitioning of reproduction and survival−enhancing processes− such as plumage molt. In a few cases, however, unpredictable conditions favor opportunistic schedules. Opportunism results from selection favoring an ability to exploit rare and unpredictable resources and, because such opportunities may be limited, opportunism is traditionally assumed to be obligate (i.e., obligate opportunism). Obligate opportunists should invest in reproduction at the expense of survival when a reproductive opportunity arises and maintain readiness to initiate breeding at any time. We suggest an alternative: Species with high mobility may be good at locating unpredictable resources and may therefore breed opportunistically not because they must but because they can (i.e., rich patch exploitation). The two hypotheses make different predictions concerning life history trade−offs. Rich patch exploiters should be more likely to invest in survival−enhancing processes (molt, immune function, stress responsiveness) at the expense of current reproduction. We present data indicating that some opportunists may match the conventional "obligate opportunist" scenario while others may be better categorized as "rich patch exploiters."

55.8 CORNELL, A.E.*; WILLIAMS, T.D.; Simon Fraser University; *acornell@sfu.ca*

Physiological Components of Chick Quality at a Critical Life History Transition

In passerines, the immediate post−fledging stage is marked by high levels of mortality, making the developmental "milestone" from nestling to fledgling a critical life history transition. Although many studies have shown positive relationships between nestling mass and survival, other physiological components of chick quality or phenotype at fledging have rarely been studied. Here we present data on individual variation in a range of key physiological components of condition' or quality at fledging that might determine post−fledging survival in European Starling chicks (*Sturnus vulgaris*) just prior to, and at the fledging stage (day 17 and day 21, post−hatch). We measured hematocrit, hemoglobin, reticulocyte counts, oxidative stress, feather length, and body mass, as indices of oxygen carrying capacity, red blood cell production, oxidative imbalance, feather growth rate, and overall functional maturation, respectively. We focus on comparison of physiological quality' of chicks from first versus second brood, because second brood offspring are known to have lower post−fledging survival and recruitment. Preliminary analysis shows a) rapid increase in hematocrit and hemoglobin just before fledging, even though mean trait values at fledging remain lower than adult values, b) lower hematocrit, hemoglobin, and body mass in second versus first brood chicks, and c) an average decrease in total mass just before fledging which is greater in first broods (5.7% versus 0.7%). Our long−term goal is to relate individual variation in physiological quality of chicks to flight performance (measured at fledging in a flight chamber) as a putative index of fitness.

P2.123 CORNWELL, F.J.*; KRAJNIAK, KG; Southern Illinois Univ. Edwardsville; *fcornwe@siue.edu*

The Effects of FMRFamide and its Related Peptides on the Isolated Crop−Gizzard of the Earthworm Lumbricus terrestris.

The contractile activity of the smooth muscle of *L. terrestris* can be regulated by a variety of neurotransmitters, including the family of FMRFamide−related peptides (FaRPs). Previously we used the recently identified earthworm FaRP, APKQYVRFamide, to explore the effects of FaRPs on the crop−gizzard of *L. terrestris*. Since valine is substituted for methionine in the tetrapeptide core of the earthworm peptide we decided to determine the importance of this substitution using tetrapide sequence FVRFamide. The crop−gizzard was isolated and suspended inside of a tissue bath composed of worm saline. Contractions were recorded using a Grass force transducer, and the data was displayed utilizing Iworx Labscribe 2. Increasing concentrations of each peptide were applied and allowed to take effect. The changes in activity were used to create log−dose response curves. FVRFamide caused a decrease in amplitude with a threshold of 10^{-8} followed by an increase in activity at higher concentrations. APKQYVRFamide caused a concentration dependent decrease in contraction amplitude with a threshold of 10^{-6} M, while FMRFamide caused the same response with a threshold of 10^{-8} M. These results show that the valine substitution does not change the threshold value for decreasing the amplitude and thus the receptor readily binds the two peptide sequences. We are currently exploring the effects of other substitutions found in worm peptides.

63.4 COSENZA, K. S.*; KIM, K. S.; CHANG, E. S.; MYKLES, D. L.; Colorado State Univ, UC Davis Bodega Marine Lab; *kcosenza@rams.colostate.edu*

Effect of molting hormones (ecdysteroids) on myostatin and mTOR expression in skeletal muscle and limb regenerates in the blackback land crab, Gecarcinus lateralis

During premolt, increasing ecdysteroid levels cause claw muscle atrophy in *Gecarcinus lateralis*, allowing withdrawal of the claw at ecdysis. Myostatin (Gl−Mstn) is negatively correlated to ecdysteroids, while protein synthesis is up−regulated to allow myofibril remodeling during premolt. Our hypothesis is that ecdysteroids inhibit *Gl−Mstn* expression through the ecdysteroid receptor. Gl−Mstn, in turn, inhibits protein synthesis via Smad transcription factors. Using DNA walking, an ecdysone receptor response element (EcRE) was located near the 5' end of the *Gl−Mstn* promoter, suggesting that *Gl−Mstn* expression is directly regulated by ecdysteroids. *Gl−Mstn, Gl−EF2, Gl−mTOR, Gl−Rheb, Gl−Akt*, and *Gl−S6K* mRNAs were quantified by qPCR. After two weeks of daily 20−hydroxyecdysone (20E) injections, *Gl−Mstn* mRNA levels were significantly decreased in claw muscle. By contrast, a single 20E injection had no effect on gene expression over a 24−hour period. Limb bud autotomy, which suspends premolt by lowering hemolymph ecdysteroids levels, increased *Gl−Mstn* mRNA levels in claw muscle. Unexpectedly, expression of *Gl−mTOR, Gl−Rheb, Gl−Akt*, and *Gl−S6K* was increased by LBA. The data suggest that *Gl−Mstn* expression is regulated by ecdysteroids. However, there was no consistent linkage between expression of *Gl−Mstn* and expression of mTOR signaling components in claw muscle. However, *Gl−Rheb* and *Gl−S6K* expression was decreased in growth−suspended limb buds, compared to growing limb buds. The *Gl−Mstn* promoter was fused to luciferase and transfected into HeLa cells, along with *Uca pugilator* EcR (Up−EcR) and Up−RXR, to determine whether the EcRE is functional. Supported by NSF (IBN−0618203).

P2.48 COTHRAN, RD*; STIFF, AR; CHAMPAN, K; WELLBORN, GA; RELYEA, RA; Univ. of Pittsburgh, Univ. of Oklahoma; *rdcothran@gmail.com*

Turns out males are picky: no evidence for reproductive interference in an amphipod species complex

The co−occurrence of phenotypically similar species at local scales challenges traditional explanations for how communities are structured in nature. This challenge arises because we typically invoke species differences or similarities (e.g., abiotic tolerances, ability to compete for resources or ability to deal with natural enemies) to explain why species do or do not coexist on local scales. However, when species share the same mating biology, reproductive interference (i.e. interspecific mating interactions that are costly for at least one of the species involved) may affect species distributions. Here, we explored the potential for reproductive interference to explain the distribution of cryptic amphipod species that co−occur at local scales in lakes. Through a series of experiments, we discovered that these amphipod species are unlikely to interfere with each other's reproduction. When not given a choice (i.e. conspecifics were not available as mates), heterospecific mating occurred in 5% of trials. When given a choice, however, heterospecific mating dropped to 0.04%. Surprisingly, detailed behavioral observations revealed that males avoid heterospecifics as mates despite circumstantial evidence that males mate indiscriminately within a species. We discuss these results within the context of a broader research program centered on understanding the distribution of these species and conclude that tradeoffs between competitive ability and predator avoidance likely explain the distribution of these species across microhabitats in lakes.

P1.80 COUGHLIN, DJ*; LONG, GM; GEZZI, NL; Widener Univ., Chester, PA; *djcoughlin@widener.edu*

Smelt Muscle in Winter: The Effects of Urea, Glycerol and Trimethylamine Oxide on Contractile Properties

Rainbow smelt, Osmerus mordax, experience a wide range of temperatures in their native habitat. In response to extremely cold temperatures in the North Atlantic (approaching −2.0°C), smelt express antifreeze proteins, glycerol, trimethylamine oxide (TMAO) and urea to avoid freezing and maintain function. The physiological influence of these osmolytes are not well understood. Urea is known to destabilize proteins when present in large amounts throughout the blood and muscle tissues, while TMAO is thought to counteract the protein−destabilizing forces of urea. Glycerol's influence on muscle function has not been explored. We examined the effects of urea, glycerol, and TMAO through muscle mechanics experiments with treatments of the three osmolytes at physiologically relevant concentrations. The contractile properties of white muscle bundles were determined in normal saline and in the presence of 50mM urea, 50mM TMAO, and 200mM glycerol in saline. Muscle exposed to urea and glycerol produced less force and displayed slower contractile properties. However, treatment with TMAO led to higher force and faster relaxation by muscle bundles. Preliminary experiments suggest that TMAO also increased power production during cyclical activity. When muscle bundles were exposed to a combination of all three compounds, they displayed no change in contraction kinetics relative to control. The results suggest that maintenance of muscle function in winter smelt requires balanced combination of urea, glycerol and TMAO. The mechanisms of action of these osmolytes, particularly TMAO, will provide insights into muscle function in a variety of fishes that employ these osmolytes for freeze resistance and osmotic balance.

P1.213 COUZENS, A.M.C*; SKINNER, M.M; EVANS, A.R; PRIDEAUX, G.J; Flinders University, University College London, Monash University; *aidan.couzens@flinders.edu.au*

Hide and seek patterning: using X−ray microcomputed tomography to explore the developmental basis, homology, and apparent re−emergence of primitive dental traits in macropodoids

The re−emergence of primitive traits in derived taxa can offer insights into the developmental and evolutionary properties of phenotypes. In mammals the outer enamel surface (OES) provides information about taxonomy but the developmental basis of the OES is generally poorly understood. In mature teeth, the enamel−dentine junction (EDJ) delineates the position of the basement membrane, where species−specific cusp patterns emerge early in tooth morphogenesis. Analysing the relationship between EDJ and OES shape can thus provide insights into the development and homology of tooth structures. In macropodoid (kangaroo) molars, two transverse shearing blades (lophs) are often associated with longitudinal crests. An example is the posthypocristid, which is directed posterolingually from the hypoconid, marking the buccal end of the posterior lophid. This crest is present in macropodids and balbarids up to the middle Miocene, but is lost for at least 10 myr before apparently re−emerging in derived macropodids. We used X−ray microcomputed tomography to extract OES and EDJ surfaces from fossil and modern teeth. Posthypocristid expression in derived and primitive kangaroos seems to be underlain by an EDJ prominence suggesting posthypocristid establishment early in development and the re−emergence of an ancestral patterning pathway in derived taxa. Aberrant terminal molars in the extinct Pliocene kangaroo *Prionotemnus* and extant Red Kangaroo (*Macropus rufus*) seem to capture an extreme variant of posthypocristid patterning. The striking re−emergence of the posthypocristid in these teeth, and more subtle expression at species−level, may have been facilitated by interplay between enamel thickness and taller teeth.

129.3 COVI, JA; University of North Carolina at Wilmington; *covij@uncw.edu*

Fine Time−scale Observation of Development following Cryptobiosis yields a non−conventional Model for Toxicology

Embryos of some micro−crustaceans survive decades to centuries of continuous anoxia by reversibly arresting metabolic and developmental processes. While the ecological and evolutionary implications of these cryptobiotic egg banks' are active topics of study, the impact of environmental pollutants on dormancy, resumption of development, and early hatching events remains uncharacterized. Lipophilic compounds readily pass through arthropod cuticular barriers. Given that this is the primary permeability barrier for invertebrate embryos, and that dormant invertebrate embryos lack the metabolic capacity to deal with chemical loads, it is possible that these embryos will display bioaccumulation of toxins that are otherwise short lived in larvae and adults. Thus, prolonged exposure to low levels of pesticides during periods of obligate dormancy could adversely affect the long−term viability of a population even when titers in the surrounding water are permissive for the larvae or adults. We propose that the long−term susceptibility of micro−crustacean populations to lipophilic toxins is dependent upon both their reliance on a dormant embryonic stage and the permeability of its embryos to lipophilic chemicals. The brine shrimp, *Artemia franciscana* was developed as a model system to address this hypothesis. A detailed study of early development in encysted *A. franciscana* embryos was conducted using light microscopy. Classic morphologies associated with "normal" and "abnormal" development were observed and placed in clear developmental sequences that include newly identified characteristics of early development. A novel model of divergent and convergent paths in early development of encysted *A. franciscana* embryos was generated. An introduction to toxicological tests using this reference model will be presented.

P1.138 COVINO, K.M.*; MOORE, F.R.; MORRIS, S.R.; JAWOR, J.M.; University of Southern Mississippi, Canisius College; *covinok@gmail.com*

Testosterone Production Capability in a Songbird during Spring Migration

The connection and interaction among phases of the annual cycle in migratory species are poorly understood. Testosterone may be an important signal for the onset of vernal migration in songbirds: Elevated testosterone induces migratory activity, testosterone levels increase throughout spring migration in some species and early arriving males on breeding grounds generally have higher circulating levels. Presumably, migrants must have sufficient levels of testosterone in circulation soon after arrival on the breeding grounds to facilitate necessary breeding behaviors. We investigate whether testosterone production may be modulated during migration to take advantage of beneficial effects while avoiding negative consequences of elevated testosterone en route. To do so, we determined both circulating testosterone levels as well as testosterone production capability in a boreal breeding migrant. We performed GnRH challenges via an intra−muscular injection on male and female Swainson's Thrushes (*Catharus ustulatus*) at two stopover sites representing different distances remaining to the breeding grounds. Males at both locations were capable of producing more testosterone than naturally circulating levels, and capability was higher in males sampled closer to their breeding grounds. Females showed conflicting results: while testosterone production capability was higher than naturally circulating levels in individuals at both locations, those sampled farther from the breeding grounds showed a higher capability compared to those sampled closer to the breeding grounds. We are currently exploring the possibility that the proportion of testosterone that is converted to estradiol may change throughout migration.

S6.3−3 COWAN, N. J.*; DANIEL, T. L.; Johns Hopkins Univ., Univ. of Washington; *ncowan@jhu.edu*

Control and dynamics of movement in biology II: what does control theory have to offer integrative biology?

Control theory was developed with the objective of guiding manmade systems, not analyzing biological ones. Thus, it is natural to question its potential value (or not) in the analysis of the evolved−−−rather than designed−−−"wetware" that seems to be at the reigns of biological systems. Worse yet, with an animal, it is not even clear what is "controller" and what is "plant": both brain and body co−evolved. On the other hand, it is unquestionable that biological systems have a dynamic character, and so it is reasonable to argue that it is better to stick with the generality of dynamical systems theory (which has a long tradition in analyzing existing systems) instead of specializing to the subdiscipline of control theory (invented for synthesis, not analysis). Nevertheless, here, we argue that the somewhat teleological approach of applying control theoretic analysis to biological systems serves to enhance our understanding of the challenges that evolution, development, neural plasticity, etc all have in "tuning" a biological system to achieve certain "goals". In so doing, we must realize that feedback is not the purview of one part of the system alone; for example, during movement, it is not solely the nervous system responsible for properties like stability, but rather the musculoskeletal system itself has also been tuned to simplify control, and thus holds just as many of the secrets. But, with this important proviso in mind, fundamental features such as stability, robustness, controllability, observability, etc, which are all constructs of the field of control theory, are essential in developing a comprehensive understanding of integrative biological systems.

91.6 COX, S.M.*; PATEK, S.N.; University of Massachusetts, Amherst, Duke University; *scox0@bio.umass.edu*

Does cavitation limit the speed of mantis shrimp?

With one of the fastest feeding strikes in the animal kingdom, mantis shrimp strike prey with a raptorial appendage that can reach velocities of 30 m/s with accelerations of $1x10^5$ m/s^2 in water. Fast movement can lower local pressure causing cavitation bubbles that collapse and emit shockwaves powerful enough to erode holes in metal. Some mantis shrimp generate cavitation while using hammer−shaped appendages to smash hard−shelled prey. Cavitation bubbles form upon impact with their prey and may enhance prey processing. However, cavitation is rarely produced during the extremely fast rotation preceding impact, a time when cavitation bubble collapse would damage the exoskeleton and not provide benefits. Thus, mantis shrimp may have features that reduce cavitation during forward rotation, yet little is known about the conditions for cavitation formation in biological systems. Here we test whether mantis shrimp operate at an upper boundary of speeds that do not produce cavitation. We measured the maximum speeds for 7 individual *Odontodactylus scyllarus* striking under naturalistic conditions and noted cavitation presence before impact. In addition, *O. scyllarus* appendages (10 individuals) were attached to a mechanical model of the mantis shrimp strike called 'Ninjabot' and rotated at and above animal strike speeds. When rotated at the same and higher speeds than in natural animal strikes, the appendages cavitated regularly. A stainless steel cylinder of same scale as *O. scyllarus* appendages rotated with Ninjabot also cavitated above, at and well below mantis shrimp maximum strike speeds. These results suggest that cavitation is difficult to avoid in these conditions and mantis shrimp may indeed be circumventing cavitation through shape and kinematics.

94.3 COX, R.M.*; MCGLOTHLIN, J.W.; University of Virginia, Virginia Tech; *rmc3u@virginia.edu*

Developmental erosion of between−sex genetic correlations in a sexually dimorphic lizard

Selection often favors dramatically different phenotypes in males and females, but quantitative−genetic theory predicts that the subsequent evolution of sexual dimorphism is potentially constrained by between−sex genetic correlations for shared traits. However, these correlations are not fixed constraints, but evolving features of the genomic architecture that can respond to selection. Moreover, estimates of between−sex genetic correlations often vary across ontogeny, suggesting that sex−biased developmental changes in gene expression may contribute to the relaxation of genetic constraint. Here, we present a comparative study of the quantitative genetics underlying body size and shape in two island populations of a highly dimorphic lizard, *Anolis sagrei*. Although selection favors extreme sexual size dimorphism in both populations, the extent to which males exceed females in body size varies significantly between populations, even under controlled laboratory conditions. Using a paternal half−sib breeding design, we show that the between−sex genetic correlation for body size decreases sharply as ontogeny progresses, and that the magnitude of this effect is greater in the population with greater sexual size dimorphism. We discuss this result in light of similar ontogentic patterns for sexually dimorphic shape traits, and with respect to the potential for maturational changes in gene expression to facilitate the developmental erosion of genetic constraint between the sexes.

94.4 COX, C. L.*; HANNINEN, A. F.; REEDY, A. M.; COX, R. M.; The University of Virginia; *clcox@virginia.edu*

Testosterone pleiotropically regulates sexual dimorphism in multiple traits

Sexual dimorphism is predicted to evolve slowly as genetic correlations are gradually eroded. However, this theoretical expectation is at odds with the observation that closely related species often differ in the direction and magnitude of sexual dimorphism, as well as in the trait combinations that exhibit dimorphism. This phylogenetic lability may be facilitated by the evolutionary coupling and decoupling of pleiotropic modifiers, such as sex steroids, to conserved developmental pathways that are shared between the sexes. To begin to assess this possibility, we tested for pleiotropic effects of testosterone on a suite of physiological and morphological traits in the sexually dimorphic brown anole lizard (*Anolis sagrei*). In two separate experiments on captive animals, we administered either testosterone or placebo implants to (1) intact males and females at approximately the age (6−7 mo) when sexual dimorphism first becomes pronounced, and (2) intact females and castrated males at an age (10−11 mo) when developmental trajectories are highly divergent between the sexes. In both sexes and at both ages, testosterone stimulated (1) growth in length and mass, (2) growth and coloration of the dewlap, (3) resting metabolic rate, (4) utilization of fat bodies, and (5) size of the gonads. These results confirm that testosterone regulates many sexually dimorphic traits and suggest that males and females share the same physiological and genetic potential to respond to this pleiotropic developmental modifier.

8.1 CRALL, JD*; RAVI, S; MOUNTCASTLE, AM; COMBES, SA; Concord Field Station, Harvard University; *jcrall@oeb.harvard.edu*

Bigger but not always better: Tradeoffs between maneuverability and flight speed with body size in bumblebees

Body size has important consequences for nearly every aspect of phenotype, including locomotion. For example, scaling predicts increased speed but decreased accelerations and maneuverability with larger body size. Despite strong a priori predictions, however, tradeoffs between flight speed and maneuverability in flying insects have rarely been tested. Here, we examine this tradeoff in bumblebees (*Bombus impatiens*) in a novel but ecologically relevant flight context; maneuvering around three−dimensional objects. In agreement with predictions, top flight speed increased with body size, while speed through an obstacle course decreased, supporting the prediction of a tradeoff between top flight speed and maneuverability with body size. However, in contrast to predictions from scaling, maximum accelerations and turning rates increased rather than decreased with body size. Larger bumblebees took longer flight paths through the obstacle course, as well as flying at lower instantaneous speeds. Surprisingly, obstacle orientation (i.e. whether bees were forced to fly up and down or side−to−side through the course) had no significant effect on mean flight speed. Together, these results indicate that locomotion through complex environments may be limited by collision avoidance rather than simply maximum force production and top flight speed. These results also have important implications for the evolution of body size of insects in complex three−dimensional environments.

P1.113 CRANE, E.; GERSTNER, G.E.; ROTHMAN, E.; MONTUELLE, S.J.*; WILLIAMS, S.H.; University of Michigan, Ohio University; *willias7@ohio.edu*

Functional data analysis of mammalian feeding: What are we missing from traditional analyses of masticatory kinematics?

In most studies of mammalian masticatory kinematics, the analysis focuses on extracting a discrete number of variables to represent the gape cycle (e.g., phase durations) and provide insight into the dynamics of the behavior. However, mastication involves rhythmic and coordinated movements of the jaw and tongue which are complex and difficult to characterize with a discrete set of kinematic variables. These analyses also leave the bulk of the data unanalyzed. Here, we compare traditional analyses of mammalian mastication to a new approach called Functional Data Analysis (FDA) utilizing sample chewing cycles from goats and pigs. FDA is a potentially informative approach because it utilizes the entire movement profile instead of extracting specific kinematic variables. We use the results of traditional event−driven kinematic analyses and those of FDA to discuss the benefits and limitations of each method for detecting differences in the amplitude and timing of chewing movements, as well as in their respective variability. FDA analyzes the entire gape cycle movement trajectory and identifies portions of the gape cycle that significantly differ between species, which may not be identified with traditional analyses. Our data also show that significant differences in the variability of the chewing movements exist between species, confirming the power of FDA for the study of movements. As such, FDA is a potentially transformative approach for understanding the dynamics of continuous and complex movements in functional morphological research.

15.2 CRAWFORD, C.H.*; BALANOFF, A.M.; MAISEY, J.G.; NAYLOR, G.J.P.; College of Charleston, American Museum of Natural History; *crawford.callie@gmail.com*

Evolution of the Skeleton in Chondrichthyan Fishes

Current understanding of Chondrichthyan phylogeny lags behind that of most vertebrate classes. Of the studies conducted to date, many have produced conflicting topologies. In an effort to address the lack of consensus about Chondrichthyan phylogeny, we are examining both molecular and morphological data in the development of a Chondrichthyan Tree of Life. Molecular estimates will be constructed from approximately 1000 single copy orthologous nuclear genes while morphological data will be based on comparative skeletal anatomy derived from CT scanned specimens. In this presentation, the skeletal component of the Tree of Life project and the processes which go into creating interactive digital representations of the CT scan data will be discussed. Additionally, I will present some skeletal structures we have encountered to date and discuss their implications in the context of competing hypotheses of evolutionary relationships at the family level.

S8.2−3 CRESPI, Erica J; Washington State Univ.; *erica.crespi@wsu.edu*

Developmental plasticity in amphibians: mechanisms, adaptations and constraints

It is well known that environmental conditions during early life stages can alter specific developmental processes that influence phenotypic expression and performance throughout the life of an animal. Fluctuating levels of environment−responsive hormones, such as glucocorticoids, often mediate alterations in developmental processes throughout an organism that have both short− and long−term effects on phenotypic expression. What is less understood is whether hormone−mediated developmental plasticity is adaptive, maladaptive or neutral in its effects on fitness, and even less is known about how this form of developmental plasticity influences phenotypic evolution. Hormone−mediated developmental plasticity may accelerate evolutionary responses to environmental change by increasing phenotypic variation in traits associated with fitness, but it may also restrict phenotypic expression or the ability to adaptively respond to environmental changes experienced later in life, thus, constraining evolutionary dynamics. Amphibians provide an excellent model system in which to study the evolutionary impacts of hormone−mediated developmental plasticity because their biphasic life cycle emphasizes the importance of considering the effects of environmental variability in different life history stages and there is a large literature describing the ecology and population dynamics associated with developmental plasticity. There also is an increasing understanding of how hormone−mediated developmental plasticity is related to post−metamorphic morphology, behavior, physiology, and fitness in amphibians. This knowledge allows for the inclusion of indirect environmental effects in evolutionary models to better predict how populations will respond to selection caused by climate change or other environmental perturbations currently threatening populations.

P3.57 CRESPO, J.G.*; GOLLER, F.; VICKERS, N.J.; University of Utah; *jose.crespo@utah.edu*

Influence of ambient temperature on the pre−flight and flight activities of pheromone−stimulated male moths

Male moths fly upwind when detecting pheromone molecules emitted by a conspecific female. In order to sustain flight, endothermic insects require their flight muscles be sufficiently heated for take−off. This pre−flight shivering behavior is also affected by environmental conditions such as ambient temperature and wind speed. Our previous results showed that male *Helicoverpa zea* started to warm up earlier, took−off at lower thoracic temperatures and spent less time warming up when exposed to the attractive pheromone blend as opposed to incomplete pheromone blends. Here, we investigated the effects of take−off temperature as well as that of varying ambient temperatures on pheromone tracking performance. We tested this by simultaneously recording the thoracic temperature of freely behaving *H. zea* males during pre−flight warm−up (with an infrared camera) and their subsequent flight tracks when flying upwind towards an attractive pheromone source. Moths were tested at 3 ambient temperatures in the wind tunnel, 19°C, 22°C and 26°C. As expected, male moths took less time to warm−up before taking flight in warmer temperatures. Interestingly, these males flew faster and arrived at the source earlier than male moths tested in colder conditions. And finally, a higher percentage of males flying in warm temperatures successfully tracked the odor and arrived at the source. These findings indicate that ambient temperature is not only affecting the amount of time male moths need to spend warming up, but also how their flight tracking abilities vary when following the plume of an attractive odor. Acknowledgments: Supported by NSF IOS−1147233 to NJV, NSF DDIG IOS−1110836 to JGC and NIH DC06876 to FG.

S1.2−1 CREWS, David; University of Texas at Austin; *crews@mail.utexas.edu*

Epigenetic Synthesis, or How Environmental Contamination Has Changed the Course of Evolution

Evolutionary theory accounts for the process of change in life forms. It has had two epochs. The first, Darwinian evolution, established the principle of change through selection. The second, the Modern Synthesis, provided the units of heredity and their control, particularly change in DNA by recombination and mutation. Until very recently species evolved in the absence of anthropogenic endocrine−disrupting chemicals, so the long−term evolutionary consequences of worldwide contamination are only now beginning to manifest. This fact of life today heralds a third epoch of evolutionary theory, or the Epigenetic Synthesis. This emerging perspective combines elements of the previous iterations and incorporates environmental modulation of temporal and spatial control of gene expression without altering the underlying DNA sequence. Molecular biology and genetics will continue to be the dominant disciplines in biology, and fortunately their practitioners have re−discovered' the importance of the environment. This has led to increasing research into molecular epigenetics and the interface between the environment and gene regulation. Another change is the realization that axioms such as genes determine traits' or GXE is more ideology than proof. In most situations it is how the genome is regulated, not the nucleotide sequence itself that is important. Ancestral exposures combine with significant events in the individual's life history to determine the individual's phenotype and likelihood of reproducing. Future research should focus on how two categories, namely germline−dependent and context−dependent epigenetic modifications, shape evolutionary change.

S8.3−4 CREWS, David; Univ of Texas, Austin; *crews@mail.utexas.edu*

Diversity of Phenotypic Plasticity

Developmental plasticity has the potential to generate novel phenotypes. These may be nuances or wholesale transformations, adaptive or maladaptive. The environment dictates such outcomes. The generation of phenotypes is usually in the dimension of epigenetics and not by traditional genetic bases for inheritance. Epigenetic effects are defined as changes in the phenotype and/or specific traits that result from the environmental modification of the molecular factors and processes around DNA that regulate genome activity yet are independent of the DNA sequence. Environment is defined as inclusive of all stimuli, both internal and external to the individual that may impinge on the organism during its life cycle. In studies on environmental epigenetics, the goal is to identify a phenotypic outcome − but which one(s)? The term phenotype' is not meant to convey a unitary physical feature but, in most instances, a consolidation of multiple traits. Traditionally a trait is defined as any measurable aspect of the individual. In general, a deeper understanding of a particular phenotype increases proportionally with the number of traits that are measured in the same individual. Selection of particular genetic, morphological, physiological, behavioral, and brain traits should be predicated on the pertinent literature and demonstrated to be important for the question at hand. In this perspective a gene has no greater meaning than body mass, circulating concentration of a hormone, etc. Indeed, because expression of individual genes only has meaning in the context of other genes within and outside their functional categories, and because higher order traits are compounded and transformed from lower levels (e.g., emergent properties of the combination of traits at lower levels of biological organization), the expression of any particular gene has relatively little importance due to epistasis and redundancy.

66.2 CRICKENBERGER, S*; WALTHER, K; MORAN, A; Clemson University, University of Hawaii at Manoa; *scricke@gmail.com*

Lower thermal tolerance of larvae and adults of the introduced barnacle Megabalanus coccopoma: implications for range limits

As tropical species make their way into historically temperate climates, cold temperatures will likely set their range limits and determine the extent they can expand out of the tropics. The barnacle *Megabalanus coccopoma* is native to shorelines from Baja California to Peru and has been introduced to a number of places worldwide including the Atlantic US SE coast, where it was first recorded in 2006. Its current range extends from Ft. Pierce, FL north to Cape Hatteras, NC with seasonal populations found as far north as Kitty Hawk, NC. Larval tolerances to temperature may be a primary factor setting range limits of marine species, but this hypothesis has rarely been tested. To address this question in *M. coccopoma*, we reared larvae at 22, 19, 16, 13, and 10°C and measured size, protein accumulation, and accumulation of different lipid classes throughout development, as well as testing whether larvae could metamorphose to the cyprid and juvenile stages. We also determined the lower functional temperature (FT_{50}) and lower lethal temperature (LT_{50}) of adult *M. coccopoma*. Larvae were able to develop through to metamorphosis at temperatures as low as 16°C and larvae reared at 22°C were able to metamorphose into juveniles at temperatures as low as 13°C, suggesting that larvae could successfully develop and metamorphose at temperatures far colder than seen in their current adult range. FT_{50} estimated the potential northern range limit of *M. coccopoma* to occur slightly north of their current adult range and our lethal estimate, LT_{50}, predicted the northern range limit much further north. Our results suggest that adult thermal tolerances, in particular thermal sensitivity of function (rather than mortality), contribute most strongly to setting the northern range limit of the barnacle *M. coccopoma*.

56.3 CRISWELL, KE*; FINARELLI, JA; COATES, MI; University of Chicago, University College Dublin; *kcriswell@uchicago.edu*

Gills, structure, and feeding mode: specialization in a remarkably early gnathostome

Articulated gill skeletons are rarely preserved in early fossil fishes, leaving gaps in the knowledge of the early evolution of this major structural and functional component of vertebrate crania. The Middle Devonian putative shark *Gladbachus adentatus* preserves the oldest known complete gill basket of any gnathostome, and provides new information on primitive visceral arch morphology. Using CT technology, we have investigated the branchial arch morphology of *Gladbachus* in detail. The gill basket encompasses four arches each comprising a pharyngobranchial and an epibranchial dorsally, and a ceratobranchial ventrally. Midline accessory cartilages are also preserved. The first three ceratobranchials are long and thin with ventral grooves, while the fourth is wide and flat, and articulated with the pectoral girdle. Teeth might be present in this supposedly toothless fish, and the cranium is wide and short. Here, we suggest that this early gnathostome was a filter feeder, making *Gladbachus* the first Paleozoic representative of such a unique ecomorphotype. The skeleton of this fish is specialized and exceptionally complete, and warrants careful comparison with modern analogs, such as the basking shark and paddlefish, to identify convergent functional morphology. As the earliest known fish with a complete gill skeleton, *Gladbachus* also offers insights into ancestral conditions of the vertebrate visceral skeleton.

56.2 CROFTS, S. B.; Univ. of Washington, Seatttle; *croftss@uw.edu*

Variation in Placodont tooth morphology and the effects of structure on tooth function.

One of the identifying characters of Placodonts, an extinct clade of marine reptiles that lived during the Mesozoic, is the presence of palatal teeth modified to crush hard prey items. The basal most placodont possesses relatively long thin teeth on the palate, maxilla, premaxilla and dentary. In stem lineages, palatal teeth are flattened to form a crushing plate, teeth on the maxilla and the corresponding teeth on the dentary are reduced in number and bulbous in shape, while the teeth in the pre−maxilla and the corresponding dentary teeth remain relatively long, and procumbent. In the crown group this pattern of decreasing tooth number with increased specialization for hard−prey crushing is continued, however, tooth morphology remains diverse. To better understand this tooth diversity, we asked two questions: (1) is there an ideal tooth shape for crushing prey, and (2) how do different shapes withstand these high forces? To determine if there is an ideal shape for crushing prey, we constructed physical models of idealized tooth shapes and tested them on rapid−prototype models of shells. We found that convex teeth, especially those with tall skinny cusps require less force to break shells. We then used FEA to see which of these tooth shapes would be most likely to fail. This study indicated that shapes with tall skinny cusps are the most likely to deform and break. Taking these two studies together indicates that there are functional trade−offs in tooth morphology, and that tooth variation is likely due to differences in diet and the relative importance of tooth.

59.1 CRONIN, D.T.; WOLOSZYNEK, S.; MORRA, W.; HONARVAR, S.; LINDER, J.; O'CONNOR, M.P.*; HEARN, G.S.; Drexel Univ., Philadelphia, PA, Arcadia Univ., Glenside, PA, James Madison Univ., Harrisonburg, VA; *mike.oconnor@drexel.edu*

Long term monitoring of a bushmeat market in Bioko, Equatorial Guinea

Since 1997, the Bioko Biodiversity Protection Program has monitored the market for wildlife sold as food (bushmeat) in Bioko Island, Equatorial Guinea. A 13 year long record of nearly every carcass sold in the market reveals substantial changes over time in the species taken, the number of carcasses, the methods by which animals were captured, and seasonal variation in the number of carcasses sold. Rate at which carcasses are sold has increased across the record, with three distinguishable periods (epochs). In particular, carcass rates of monkeys has increased strongly in recent years. Boundaries between the epochs correspond to significant governmental and political events suggesting that the bushmeat market is susceptible to modification by government action. Shifts in carcass rates, carcass prices, and changes in the market operation (including methods by which animals are taken) suggest that the bushmeat market on Bioko may be an increasingly commercialized, luxury market rather than a subsistence market as is thought typical of other bushmeat markets in sub−Saharan West Africa. Taxonomic makeup of the market and seasonality of the take are related to a shift from trapping as the most common method of animal capture to the use of shotguns.

74.1 CROSSLEY II , DA*; ELSEY, R; EME, J; Univ of North Texas, Louisiana Depart of Wildlife and Fisheries,, McMaster University ; *dane.crossley@unt.edu*

Cardiovascular regulation in embryonic American alligators during chronic exposure to reduced environmental oxygen.

In response to chronic developmental stress, embryonic reptiles exhibit phenotypic plasticity resulting in multiple morphological and physiological modifications. In the majority of these studies, animals have been investigated in a laboratory setting under normoxic conditions (21% O2). Although this experimental paradigm has been useful in the identification of plasticity in cardiovascular development, adjustments in regulation in alligator embryos during chronic exposure to hypoxic conditions are unknown. The goal of this study was to determine how embryonic alligators maintain convective O2 transport in continuous hypoxic conditions during late development. . Embryonic alligators were incubated under normoxic and hypoxic (10% O2) conditions. At 70% and 90% of incubation embryos were instrumented to measure arterial pressure and then continuously exposed to10% oxygen. In continuous hypoxia both normoxia and hypoxia−incubated embryos were relatively bradycardic and hypotensive at 70% and 90% of development. Measurement of cholinergic and adrenergic tone revealed that cholinergic tone on heart rate was absent during chronic hypoxia, but both beta and alpha adrenoceptor tone was present. In addition the hypoxia−incubated embryos exhibited an intensified beta adrenergic tone on heart rate, relative to the normoxic group, when measured in continuous hypoxic conditions while the alpha adrenergic tone on the vasculature was constant. Our findings suggest that during chronic hypoxic conditions embryonic alligator reduce heart rate and blood pressure possibly due to the direct actions of low oxygen. However, this bradycardic and hypotensive phenotype appears to be offset by the presence of beta adrenergic tone on heart rate and alpha adrenergic tone on the vasculature, thus ensuring adequate tissue oxygen delivery.

P1.90 CROWTHER, L. N. *; SIKES, J. M.; University of San Francisco; *lncrowther@dons.usfca.edu*
Mechanisms of axial polarity modification during postembryonic development of the basal bilaterian Convolutriloba retrogemma
Acoel flatworms in the genus *Convolutriloba* are notable in their varied manners of asexual reproduction that dramatically modify the A−P axis postembryonically. For example, *C. retrogemma* reproduces via reversed polarity budding where progeny develop from budding sites with a complete reversal of the A−P axis of the parent. This process is thought to require a brief absence of polarity then reestablishment of a novel AP axis in the developing bud. Previous research has indicated that Wnt and Hedgehog signal transduction may play roles in the loss and reestablishment of A−P polarity in *C. retrogemma*, but little is known about the specific roles of these signaling pathways in the budding process. We have manipulated both Wnt and Hedgehog pathways through the use of RNA interference and pharmacological inhibitors to reveal distinct loss of axial polarity that appears to mediate the reversal of the pre−existing A−P axis. In clarifying the roles of these two signaling pathways during axial repolarization during acoel post−embryonic development, this study suggests both Wnt and Hedgehog signals specify axial polarity in these basal bilaterians.

P2.59 CUPP, JR., P/V; Eastern Kentucky University; *paul.cupp@eku.edu*
Long−term nest site fidelity in some male green salamanders, Aneides aeneus
Previous studies indicate that male and female *Aneides aeneus* exhibit site fidelity from one year to the next in their use of rock crevices, including breeding crevices. The present study examines the use of breeding crevices by *A. aeneus* males at field sites in SE KY over a 12−22 year period. Crevices in specific rock outcrops were monitored for the presence or absence of males prior to or during the deposition of eggs by females during the summer breeding period. Of the visible rock crevices with *A. aeneus* present, only a relatively few had brooding females with eggs. These crevices were often used every year or in alternate years over several years to brood eggs and hatchlings. Long−term site fidelity was shown by males (n=6) over a range of 4−13 years during which individual males were found in the same crevices in subsequent years at about the same time of year. Nest site fidelity by males may influence the continued use of these crevices. These crevices must have properties that result in their selection by males (and females) as breeding sites.

P2.49 CUNNINGHAM, G.B.; St. John Fisher College; *gcunningham@sjfc.edu*
Responses of Red−tailed hawks (Buteo jamaicensis) to prey and novel odours
Red−tailed hawks (*Buteo jamaicensis*) are sit−and−wait predators that hunt for mice, voles and cottontails from exposed perches. These raptors also take small birds on the wing. It is well established that Buteos use visual cues while hunting, and may use UV cues found in prey scent marks (urine) to help locate areas where the likelihood of encountering prey is high. It is currently unknown whether a Buteo has a functioning sense of smell. Some members of another well−studied group of birds, the procellariiformes, however, are known to use olfactory cues to locate productive areas of the ocean where prey is likely to be found. Once identified these seabirds likely switch to visual cues to locate individual prey items. Given this well−understood foraging strategy in seabirds, I tested migrating red−tailed hawks for sensitivities towards the scent of one of their prey items: the house mouse (*Mus musculus*). Forty−five hawks were caught and then hooded, causing them to enter into a calmed state. After 15 seconds of acclimation hawks were exposed to three odors: mouse urine and feces mixed with wood shavings, 1 mM phenylethylalcohol (rose scent) mixed with wood shavings and distilled water mixed with wood shavings. Birds responded by moving their head, or gulping at the air, and responded significantly different to the three deployments, suggesting that that they possess a widely tuned sense of smell. Thus, a hawk moving through an area may be able to detect the presence of prey by scent, and elect to perch in areas where prey is likely to be encountered.

P3.1 CURETON II, J.C.; BROUGHTON, R.E.; KNAPP, R.*; Univ. of Oklahoma; *rknapp@ou.edu*
Evolution of parental care in fishes
Relative to other vertebrates, bony fishes exhibit a great diversity of parental care behaviors and associated morphology. The evolution of most of the various modes of parental care is not particularly well understood and deserves more attention in light of recent revisions to our understanding of teleost evolution. We used the new phylogenetic hypothesis and revised classification of bony fishes from the Euteleost Tree of Life project (EToL; Broughton et al. and Betancur−R et al. 2013. *PLOS Currents−Tree of Life*) to quantify the number of times each mode of parental care has evolved and to identify transitions between paternal and maternal care and parental care types. Parental care is currently known from 95 bony fish families. Transitions between care giver and/or type of care have occurred within at least 24 families. Paternal care and nest guarding are the most frequent modes of parental care, with internal gestation, oral brooding, and external egg carrying also being very common. Similar to earlier studies (e.g., Mank et al. 2005. *Evolution*), we find that no care seems to be the likely ancestral condition among the bony fishes generally and for the evolution of particular modes of care more specifically. Of the 77 transitions identified in our analyses, only 21 (27%) are transitions between two types of care. The improved resolution of bony fish phylogeny provided by the EToL tree, especially among the Percomorpharia, allows us to explore potential physiological and behavioral factors that allow, or more likely constrain, the evolution of various modes of parental care.

85.5 CURREA, J; Florida International University; *jcurr001@fiu.edu*

Motion Perception of Composite Patterns in Fruit Flies

Reliably detecting visual motion in a natural environment is an important survival trait for many animals, but a computationally difficult problem. Despite a radically different eye structure, insects are a surprisingly useful model for human motion perception. For example, they detect and respond to both first− and second−order motion, flying with patterns in a way analogous to human eye tracking. However, here we show that in the important stimulus category of plaids, or composite drifting sinusoidal gratings, fruit fly tracking diverges from human perception. Tethered flies tend to steer to follow motion in front of them, consistent with minimizing retinal slip, or correcting for unintended flight deviations. We overlaid pairs of drifting sinusoidal gratings and displayed them to the frontal visual region of rigidly tethered flying fruit flies, and tracked their steering responses. Plaids have the property that when viewed through an aperture, there is no way to discriminate two sinusoids moving independently from a fixed single pattern moving in a different direction, called the rigid direction. We constructed several common plaids in which humans and flies perceive opposite directions of motion, humans tracking the rigid direction and flies steering approximately to the vector sum of the sinusoids. This may result from the computational limits of fruit fly brains, or different adaptive strategies between humans and flies.

P3.181 DABE, E.C.*; CITARELLA, M; KOHN, A.B.; MOROZ, L.L.; UF Whitney Laboratory for Marine Bioscience ; *edabe2@ufl.edu*

Comparative Single−Neuron Transcriptomics: An analysis of master regulators in terminal differentiation of serotonergic neurons in the sea slug Aplysia californica

Aplysia neurons are some of the largest somatic cells in the animal kingdom with enough genetic material per cell to allow for in depth genomic analysis with single−cell resolution. In order to understand gene regulation and expression changes underlying complex neuronal phenotypes, next generation RNA−seq was performed on freshly isolated individual *Aplysia* neurons. To efficiently analyze large−scale transcriptome information, we performed initial assemblies using an automatic pipeline and housed data on a specialized sequencing database called Neurobase. Using this database, single−cell RNA−seq projects were annotated and quantified against a hybrid *Aplysia* transcriptome generated for the *Aplysia* genome sequencing project as well as *Aplysia* predicted gene models created in conjunction with the Broad Institute. We first compared the left and right metacerebral cells (MCCs) − an evolutionary conserved pair of modulatory neurons critical for the initiation of feeding behaviors in gastropods. MCC neurons have the same serotonergic phenotype and function, but also represent a unique model to study genomic bases of bilateral symmetry in nervous systems in general. We then compared MCCs with several other classes of identified neurons in the feeding and defensive circuits. Using this robust single−cell transcriptome approach, we identified an unbiased list of potential master regulators for left−right patterning,serotonergic terminal differentiation, and then started validating these candidates in terms of their neuron−type specificity and evolutionary conservation across close and more distantly related species.

P2.30 DAHLHOFF, VC*; IKONEN, S; HANSKI, I; DAHLHOFF, EP; Bates College, University of Helsinki, Santa Clara University; *edahlhoff@scu.edu*

Adaptation to thermal stress in a Finnish butterfly threatened by climate change

A consequence of climate change is that organisms living at high latitude may experience increased exposure to thermal extremes due to warmer summers and drier winters. These more severe conditions may adversely affect population persistence due to alteration of individual performance or reproduction. In a metapopulation of the butterfly *Melitaea cinxia* found on the Aland Islands of Finland, extirpation and re−colonization is linked to differences in dispersal, which is dependent on differences in flight metabolic rate among *phosphoglocuse isomerase* (*Pgi*) genotypes. Here we report that thermal tolerance (CTmax, LT50), flight performance, and metabolic rate are highest for *Pgi* heterozygotes after mild heat stress, but after extreme stress, individuals homozygous for a *Pgi* allele common in Central Europe, but rare in Finland, performed or survived best. Furthermore, male mating activity was reduced after exposure to elevated temperatures regularly experienced in nature. Ongoing studies will determine if genetic differences later effects of temperature on male mating success. Taken together, these data suggest that Finnish populations of *M. cinxia* may be vulnerable to stressful environmental conditions that may become more common as climate change proceeds.

45.5 DALEY, MA*; BIRN−JEFFERY, AV; Royal Veterinary Colleg, University of California Riverside; *mdaley@rvc.ac.uk*

Scaling of avian bipedal locomotion: How does body size influence gait dynamics in level and uneven terrain?

Most studies on scaling of locomotion are based on steady movement over level terrain. It is well established that leg posture changes substantially with body size, such that small animals run with crouched legs, and large animals run with straighter legs. Yet, evidence is sparse and sometimes conflicting on whether scaling influences gait dynamics. For example, duty factor is often considered a key indicator of leg loading during locomotion; yet some studies suggest duty factor does not scale with body size, and others show weak support for a scaling effect. Here we re−visit the scaling of gait dynamics in striding bipeds using a recently collected dataset on ground birds spanning a 530−fold mass range from quail to ostrich. We test for scaling effects on duty factor, fore−aft impulse, and model−based parameters such as effective leg stiffness and damping ratio. We also explore the scaling of non−steady locomotion, using measures of fall risk and body stability. We found weak negative allometry in the scaling of duty factor with body size in both level and uneven terrain. However, the data are more suggestive of inter−specific variation rather than a strong scaling trend. Leg contact conditions and fore−aft impulses do exhibit substantial scaling effects. Overall, we find that larger species run with relatively steadier gait dynamics over both level and uneven terrain, indicated by smaller stride−to−stride variance in forward velocity. Larger species also use leg contact conditions indicative of minimising fluctuations in leg loading, which may reflect pressure among larger species to minimize injury risk. Small animals use leg contact conditions indicative of minimising fall risk in both level and uneven terrain.

P1.212 DALY, M*; REFT, AJ; LAW, E; O'LEARY, M; Ohio State University, University of Heidelberg, Harvard University, Stony Brook University; *daly.66@osu.edu*

The wisdom of the expert crowd: a crowd−sourcing task for character discovery from nematocyst ultrastructur

Innovations in both DNA−sequencing technology and computational methods have catalyzed progress in assessing the structure of the Tree of Life. The availability of detailed phylogenies has infused ecology, physiology, and other fields with comparative perspective. In contrast to the explosive growth in methods for generating and analyzing DNA data, studying phenotypes has remained complex and slow. Thus, the phenotypes of e.g., physiology, anatomy, and behavior that scientists often want to study or interpret with these trees are much less accessible and much more difficult to evaluate that the DNA−sequence data used to build the tree. In response to a US National Science Foundation challenge to improve the speed at which we "Assemble, Visualize, and Analyze the Tree of Life," we are working to adapt methods of computer vision, machine learning, crowd−sourcing, and natural language processing to increase the ease with which phenotypes can be translated into characters for analysis and exploration in a phylogenetic context. Here we report on one component of this project, engaging academic scientists to collaboratively discover characters from nematocysts ultrastructure on a crowd−sourcing platform called Curio.

S6.1−1 DANIEL, TL*; COWAN, NJ; Univ. of Washington, Seattle, Johns Hopkins Univ., Baltimore; *danielt@uw.edu*

Control and dynamics of movement in biology I: what integrative biology has to offer control theory

The notion of stability and control has enjoyed a rich history in research on animal locomotion. For locomotion in terrestrial, aerial, and aquatic systems, our field has grappled with how neuromuscular systems conspire with the dynamics of the body and its interaction with the environment to understand how movement is controlled and how stable or maneuverable an animal may be. Beginning with early research in cybernetics and culminating in applications of control theory today, we see the emergence of simple (and complex) engineering concepts to reveal principles of design and control in animal locomotion. Drawing on recent research, we review the basic notions of stability and feedback control in three case studies of animal locomotion: insect terrestrial locomotion, fish swimming, and insect flight. We conclude with examples of biological systems where sensing, actuation, and control are deeply intertwined in ways that challenge common assumptions about the flow of information in engineered control systems wherein sensing, actuation, and computation are almost invariably achieved via distinct components. These biological examples demand the development of new concepts in control theory.

P3.94 DANNENBERG, L.C.*; SEAVER, E.C.; Whitney Laboratory for Marine Biosciences, St. Augustine Fl.; *leah.dannenberg@bobcats.gcsu.edu*

Evidence of compensation for loss of the germ line in the marine polychaete annelid, Capitella teleta

The germline is necessary for reproduction, and thus survival of the species. Primordial germ cells (PGCs) are undifferentiated stem cells that give rise to germ cells (sperm and egg), and in many species, PGCs are the sole contributors to the germ line. Many widely used model systems cannot compensate for loss of germline, but these organisms also lack regenerative capabilities. The marine polychaete annelid, *Capitella teleta*, reproduces sexually, is an excellent model system with a fully sequenced genome, has regenerative ability, and the origin of most larval cell types have been determined. Germline compensation can be studied in this system by deletion of the germline precursor cell in early stage embryos. Macromere 3D, the parent cell of 4d and a germline precursor, was deleted using an infrared laser. Experimental animals were examined for expression of the germline marker *CapI−vasa* by in situ hybridization in larvae. *CapI−vasa* is expressed in two PGC clusters, the posterior growth zone and foregut of control larvae. In experimental larvae in which 3D was deleted, *CapI−vasa* was detected in the posterior growth zone and foregut, but most larvae lacked PGC clusters (n=16/23). However, some larvae had either one or two PGC clusters (4/23). PGCs are detected in larvae following deletion of a non−germline macromere precursor. Our preliminary data indicates evidence of germline compensation in *Capitella teleta*.

50.1 DANOS, N*; AZIZI, E; Univ. of California Irvine; *ndanos@uci.edu*

Passive Properties of Anuran Hindlimb Muscles

Frog muscles are unusually compliant compared to mammalian muscles. An important implication of this muscle property is that frog muscles can be stretched to long lengths and can operate on the descending limb of the active force−length curve during jumping. In addition, increased muscle compliance may allow for larger range of motion at joints during jumping. However, it is unclear whether the compliance observed in the hindlimb muscles of anurans is a general pattern within the group or whether these passive properties are a jumping specialization. We examined the correlation between locomotor mode and muscle compliance within a single phylogenetic group, the Anura, which exhibits variation in both locomotor modes and hindlimb muscle stiffness. Four species representing four locomotor specialists were chosen: Rana catesbeiana (jumper), Bufo marinus (hopper), Xenopus laevis (swimmer) and Kassina senegalensis (runner/walker). We hypothesized that smaller angles at the knee and ankle joints during locomotion will be associated with more compliant extensor muscles. We measured passive muscle tension in fiber bundles isolated from the cruralis and plantaris muscles of each species. Bundles were subjected to cyclical stretching (5 Hz) and laser diffraction was used to determine sarcomere lengths and define L_0. We find that ankle joint range of motion is a good predictor of plantaris passive stiffness, but that all cruralis muscles showed similar passive properties. The differences are likely due to other factors affecting passive moments at joints, such as relative muscle mass, muscle moment arms and total joint excursion. The ankle undergoes larger joint excursions than the knee and the plantaris, being the dominant ankle extensor and a much bigger muscle than the cruralis, appears to play a more significant role in constraining joint angles.

P1.154 DARAKANANDA, K*; VILLARREAL, C.M.; SUZUKI, Y; Wellesley College, Wellesley, MA; *kdarakan@wellesley.edu*

Appendage remodeling during metamorphosis and regeneration is characterized by a switch in Hedgehog signaling activity in the flour beetle, Tribolium castaneum

One of the key innovations in insect evolution is holometaboly or complete metamorphosis. Insects that undergo complete metamorphosis typically undergo three morphologically distinct phases: the larval, the pupa, and the adult stages. In particular, appendage morphology changes during dramatically during metamorphosis. This transition is known to be mediated by a key hormone called juvenile hormone (JH). Yet, how the specific genetic and hormonal components regulate maintenance and regeneration of larval structures, and the transition from the larval to the adult morphology remains poorly understood. To identify signaling pathways that might interact with JH, an RNA−Seq screen was conducted. Hedgehog (Hh) pathway was identified as a candidate pathway that becomes activated during metamorphosis. Using the red flour beetle, *Tribolium castaneum*, the role of Hh and its antagonist, the receptor Patched (Ptc), were examined using RNA interference. Downregulation of Hh resulted in disrupted limb patterning during metamorphosis and inhibition of larval limb regeneration. In contrast, the absence of Ptc led to over−proliferation of cells and ectopic outgrowths in larval limbs. Thus, during larval phase, Hh signaling is actively suppressed by Ptc but becomes activated during metamorphosis, indicating a potential interaction between Hh signaling and JH. In addition, given that Sonic hedgehog is also necessary for vertebrate regeneration, our results suggest a possible conserved role for Hh signaling during regeneration across metazoans.

70.5 DARNELL, M.Z.; Nicholls State University, Thibodaux, LA; *zachary.darnell@nicholls.edu*

Size−at−age vs. size−at−stage: Environmental control of blue crab growth rates

Blue crab (*Callinectes sapidus*) size−at−maturity has decreased throughout much of their range where there are commercial fisheries. It has been hypothesized that this may be due to either genetic or environmental factors. Field surveys throughout the range have found both temporal and spatial trends in size−at−maturity, supporting the hypothesis that size and growth rates are strongly influenced by the environment. In particular, crabs reach maturity at larger sizes in low salinity, cool areas, while they reach maturity at smaller sizes in high salinity, warm areas. Like all crustaceans, blue crabs grow discontinuously, increasing in size only during the molt. Growth rate is thus defined by two factors: intermolt period (IMP), the length of time between molts, and the growth per molt (GPM). We investigated the effects of salinity and temperature on blue crab IMP and GPM in a laboratory experiment. Crabs were collected as megalopae and held in one of six treatments until the 6th juvenile stage. All crabs were fed daily and measured following each molt. While salinity did not have a significant effect on any aspect of growth, temperature significantly affected both IMP and GPM. Higher temperature reduced both IMP and GPM. Thus, crabs reared at 30°C molted more frequently than crabs reared at 20°C, but exhibited less growth at each molt, resulting in a smaller size at each stage. These results suggest that temperature plays an important role in determining blue crab growth rates and size−at−maturity. Although salinity did not affect growth in this experiment, relationships between salinity and size observed in the field may be due to indirect effects of salinity on growth mediated through effects on food quality or food availability.

P1.134 DAS, S.*; NAJAR, F.Z.; LAI, H.C.; ROE, B.A.; DURICA, D.S.; University of Oklahoma; *sunetra.das−1@ou.edu*

RNA−seq analysis of stage−specific limb regenerates in the fiddler crab, Uca pugilator

Although an annotated genome of *Daphnia pulex* is available, crustacean genomic sequence data are exceedingly meager. While lack of genomic annotation is still a limiting factor in facilitating gene identification, with the advent of next generation sequencing technology, researchers have been able to generate transcriptomes in several arthropod models involved in developmental, evolutionary and ecological investigations. We study the hormonal basis of limb regeneration in *Uca pugilator* and have produced limb bud transcriptomes for three developmental phases using Illumina sequencing. Staging was based on time since limb loss, limb bud size, growth rate and circulating ecdysteroid titers: 1) early blastemal phase associated with cellular proliferation and differentiation; 2) early proecdysial phase associated with rapid limb bud growth and low hormone titers; 3) late proecdysial phase associated with plateau of growth seen just before molt and high circulating ecdysteroid titers. Following sequencing, *de−novo* assembly of quality reads was performed using the SOAP assembly program to generate 1,853,990 contigs (all libraries combined). Analyses of the sequence data are available online at http://www.genome.ou.edu/crab.html. Although 80% of these reads were not assignable in GenBank, these contigs could be mapped to a total of 144,593 metazoan sequences against the GenBank non−redundant protein database (E−value cutoff: e^{-3}). Among the metazoan contigs, 44,959 were assigned to a KEGG metabolic pathway. DESeq analyses identified over 500 genes differentially expressed with a e 5−fold change between blastema and early proecdysial growth phase. Further analyses were performed to obtain metabolic profiles using the KEGG database to study gene networks relevant to limb regeneration.

P1.205 DAUGHTRY, T. K.*; KHONG, G. M.; LEE, T. E.; BROKAW, J. M.; Abilene Christian University; *jmb97t@acu.edu*

Phylogentic relationships in the rodent genus Thomasomys

Phylogenetic relationships in the genus *Thomasomys* were analyzed based on sequences for the mitochondrial cytochrome b gene and the nuclear RAG1 gene. The primary objective of this study was to test previous taxon descriptions for species of *Thomasomys* to facilitate creation of an updated key for the mammals of Ecuador. New sequences were collected primarily from animals in Sangay National Park of Ecuador and combined with sequences from GenBank. New sequences were generated using the primers P484 and P485 for cytochrome b and newly designed primers for RAG1 and standard extraction, amplification and sequencing protocols. Sequences were edited and aligned manually. Maximum likelihood (ML) searches were performed with gaps treated as missing data and each codon position treated as a separate partition. In the ML reconstruction using cytochrome b alone, nodes at the species level were well resolved, and most species of *Thomasomys* were shown to be monophyletic, with the exception of *T. baeops*. A subclade of *T. baeops* was grouped together with *T. ischyurus* (95% bootstrap), but all of the *T. baeops* specimens were otherwise grouped together (85% bootstrap). In contrast, most deep nodes joining multiple species into clades had bootstrap values lower than 70%. One exception was the grouping of *T. silvestris* and *T. caudivarious* (73% bootstrap). These species were collected from the eastern slope and western slope of the Andes respectively, suggesting allopatric speciation. Mitochondrial DNA has been found to contain more homoplasy than nuclear DNA. To address this deficiency, we are exploring the RAG1 gene to potentially obtain better resolution of the deeper nodes in order to test hypotheses of speciation.

70.1 DAVIDOWITZ, G.*; DAWS, A.D.; MOORE, A.F.; HELM, B.R.; STILLWELL, R.C.; University of Arizona, North Dakota State Univ., Fargo, Univ. of Lausanne, Switzerland;
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Nutrient effects on energy allocation among body parts within an individual.

We use a common currency, calories, to examine relative investment among body parts (head, thorax, legs, wings, abdomen) within individuals as a function of body size, diet quality, and sex, in the hawkmoth *Manduca sexta*. 50−90 moths per sex, per diet (478 total), were disarticulated and each body part dry weighed. Separate calibration curves for the caloric content of each body part, diet, and sex were generated using a bomb calorimeter. These calibration curves were used to calculate the predicted caloric content of each of the 5 body parts in the 478 moths. As expected, moths invested more into individual body parts as diet quality increased. Contrary to our prediction, however, males and females allocated resources very differently when diet quality varied. For example, mass−specific (cal/g) allocation to the thorax in females increased with thorax size on high quality diet but decreased on low quality diets. This trend was opposite in males: as thoraces increased in size, cal/g decreased on high quality diet but increased on low. To our surprise, tradeoffs in caloric investment were seen only between the abdomen and other parts. The head, thorax, wings and legs did not trade off with each other in caloric content. These patterns of tradeoffs held for both sexes and all diets. Together these results show that males and females have different rules of mass−specific caloric investment into individual body parts when diet quality varies. These results help explain differences in flight performance between males and females, but further implications of these different allocation rules require further study.

96.6 DAVIES, S/W*; MATZ, M/V; Univ. of Texas, Austin;
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Heritability of dispersal−related traits and gene expression in larvae of reef−building corals

Reef−building corals are declining as a result of both direct and indirect anthropogenic influences, including elevated sea surface temperatures due to global warming. Range shifts enabled by enhanced dispersal capability is one of the most likely mechanisms by which a coral species can escape the adverse effects of climate change. Since the majority of corals release gametes into the water producing planktonic larvae, selection for dispersal potential is limited to optimizing larval traits and can be investigated through classical quantitative genetics and functional genomics using laboratory−reared larvae. We hypothesize that climate change selects for genotypes capable of longer−range dispersal favoring behavioral and metabolic adaptations that lower larval responsiveness to settlement cue early in life and enable extended planktonic larval duration. We have generated 20 full−sib larval families and quantified four traits that are hypothesized to be relevant for determining larval dispersal potential: early responsiveness to settlement cue, rate of lipid loss, rate of protein loss and red fluorescence. For two of these traits (settlement and fluorescence), considerable broad−sense heritability was observed (> 0.4). To identify the genes underlying this variation, we used RNA−seq to profile gene expression in all larval families prior to exposure to the settlement cue and also in young recruits post settlement, representing two life history stages. We observe significant signatures of heritability in gene expression at both life stages with most of the heritable gene expression variation associated with regulatory processes. These data elucidate the molecular mechanisms underlying dispersal potential, which may be the targets of natural selection under climate change.

P1.166 DAVIES, S/W*; TREML, E; KENKEL, C; MATZ, M/V; Univ. of Texas, Austin, Univ. of Queensland; *daviessw@gmail.com*

Migration−selection balance: The added complexity of symbiosis in reef−building corals

The ability of a species to adapt to local environments while maintaining high migration rates provides an interesting evolutionary conundrum. If local selection is sufficiently strong, unfit immigrants will be effectively removed from the population by natural selection. However, if migration is stronger than selection, potentially adaptive alleles could be swamped out by the arrival of less fit immigrants. How then might highly dispersive species, such as the majority of broadcast spawning corals, adapt to their local environments? Genetic analyses of population structure in two species of acroporid coral hosts across the Micronesian Pacific have demonstrated broad genetic connectivity spanning hundreds to thousands of kilometers. These data are also well supported by our spatially explicit biophysical model of larval dispersal and our coalescent modeling using MIGRATE−n. Algal genetic data (*Symbiodinium sp. genotypic clade C2) extracted from the same coral hosts reveal much more differentiation, according to eight microsatellite loci. Symbiont populations are consistently differentiated between islands and even between reefs on the same island. It is therefore possible that local adaptation in the coral holobiont might be achieved through an association of broadly dispersing coral hosts with less dispersive, locally adapted symbionts. This framework may be one explanation for the overwhelming prevalence of horizontal symbiont transmission in broadcast−spawning corals.*

103.4 DAVIES, S*; DEVICHE, P; Arizona State University;
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Advanced reproductive phenology of an urban bird is not mirrored in the underlying reproductive physiology

For seasonally breeding animals, the decision of when to begin breeding each year has considerable effects on fitness. Birds cycle between periods of breeding activity and inactivity, which is associated with large changes in reproductive physiology and morphology. These changes require time, so birds begin to develop their reproductive system well before environmental conditions are optimal for breeding. To do this, they use environmental cues that predict conditions favorable for reproduction. Environmental conditions in urban areas of Phoenix differ from those of outlying desert areas in many respects. We hypothesized that environmental differences are associated with differences in the timing of development of reproductive morphology and physiology between urban and desert birds. To test this hypothesis, we compared the development of gonads and cloacal protuberances (a secondary sexual characteristic in male birds) between urban and desert adult male Abert's Towhees, *Melozone aberti*. To investigate the mechanism controlling reproductive development, we also measured plasma concentrations of the key reproductive hormone testosterone, which is thought to promote development of the cloacal protuberance and expression of reproductive behavior. Compared to desert conspecifics, development of reproductive morphology was advanced in urban birds. The vernal increase in testosterone, however, was similar in urban and desert birds. The reason for the discrepancy between development of reproductive morphology and physiology is unclear. It may reflect the lability of plasma hormone levels over short periods and/or it may suggest that physiological processes other than or in addition to reproductive hormones transduce environmental information to reproductive development.

P2.14 DAVIES, S*; DEVICHE, P; Arizona State University; *Scott.Davies@asu.edu*

Breeding in an urbanizing world: Reproductive adjustments of seasonally breeding birds to urban areas

Urbanization is altering the environment at an unprecedented rate. Urban animals inhabit an environment vastly different from that of their non−urban conspecifics and to survive they must adjust to these modified environmental conditions. For seasonally breeding birds, the timing of breeding has a considerable effect on fitness and reflects adjustments to local environmental conditions. We used a meta−analytical approach to compare the timing of seasonal breeding of birds inhabiting urban vs. corresponding non−urban areas. Our analysis included 17 published studies that encompassed a paired comparison of the same species in both urban and non−urban areas during the same breeding season. Studies of lay, clutch initiation, and hatch dates indicate that, on average, urban birds breed 3.1 days earlier than their non−urban conspecifics. Furthermore, effect size is positively related to the latitude of the city. To identify the driving force behind this advancement, we also used meta−analysis to examine whether the change in timing of breeding is mirrored in the timing of gonadal development and the seasonal increase in plasma levels of reproductive hormones. Vernal gonadal development in both male and female birds occurs earlier in urban birds compared to their non−urban counterparts. However, this habitat−related difference is not associated with a difference in reproductive hormone levels between urban and non−urban birds. Thus, the observed difference in timing of breeding and gonadal development appears to be controlled by factors other than reproductive hormone levels.

P1.14 DAVIS, A.G.*; LEARY, C.J.; Univ. of Mississippi; *agdavis@go.olemiss.edu*

Stress hormone diminishes directional selection on call rate in the green treefrog

There is growing evidence indicating that environmental stressors can influence mate choice by females but whether such effects are related to circulating stress hormone levels (e.g., glucocorticoids) remains largely unexplored. We examined the effects of circulating glucocorticoids on mate choice in female green treefrogs, *Hyla cinerea*. Specifically, we examined whether circulating corticosterone (CORT) level could alter preferences for call rate − an acoustic feature that is under strong directional selection via mate choice by females in most anuran species. Amplexed gravid females were captured in the field and either not treated, injected with saline only, or injected with 4, 8 or 16 ¼g of CORT in saline vehicle. Females were placed in an acoustic chamber 1 hr after treatment and phonotactic responses to broadcast conspecific calls that differed in call rate (2.5 vs. 1.25 calls/sec) were examined in a dual speaker playback design. Females that were untreated, injected with saline only, or injected with a low dose (4 ¼g) of CORT exhibited a preference for calls broadcast at a high rate. However, females that were injected with 8 or 16 ¼g of CORT exhibited a significantly greater probability of choosing calls broadcast at the low call rate. Our results thus indicate that CORT diminishes directional selection on call rate in this species. Such hormonally−mediated variation in female mate choice could influence signal evolution.

129.2 DAVIS, J.E.*; CALE, K.M.; NICHOLAS, S.A.; Radford University; *jdavis319@radford.edu*

Interactions of major royal jelly proteins and juvenile hormone on growth and development of Madagascar hissing cockroaches (Gromphadorhina portentosa)

Until recently, it was thought that the major royal jelly proteins (MJRP) present in royal jelly were relatively unique to hymenopteran insects, acting in such species to catalyze the development of queen morphotypes. However, recent studies by Kamakura (2011) and others have suggested that MRJP do in fact have a strong effect on non−hymenopteran insects. Here we present the results of recent studies in our laboratory exploring the effects of MRJP supplementation on growth rate, size, morphology and fecundity in the Madagascar hissing cockroach (*Gromphadorhina portentosa*). Protein gel assays revealed that 30 day heat treatment of royal jelly denatures large MRJP. Based on this finding we supplemented the diet of nymphal cockroach colonies with fresh or heat−denatured royal jelly. We found significant increases in growth rate, overall adult size, and fecundity in cockroaches reared with fresh, but not denatured, royal jelly supplementation. To further elucidate the mechanisms through which MRJ proteins may modify growth, we conducted additional studies in which colonies were given royal jelly in concert with methoprene, a juvenile hormone agonist. Methoprene treatment alone produced juviform adults of near normal size, while treatment with methoprene and royal jelly produced adults of dramatically larger size and greater sexual dimorphism than both control groups and groups exposed to royal jelly alone. However, adults resulting from the combined royal jelly and methoprene treatment have thus far failed to reproduce. Findings from these studies demonstrate that the effects of exogenous MRJP are not limited to hymenopterans or even to the broader endopterygotid superorder.

P2.5 DAVIS, D.R.*; EPP, K.J.; University of South Dakota, Ottawa University; *drewrdavis@gmail.com*

Effect of fish species and size on the antipredator behavior of the San Marcos salamander (Eurycea nana)

Prey individuals must constantly balance the time allocation demands of predator avoidance and foraging or mating. To improve efficiency, prey may adjust the intensity of antipredator responses according to the perceived risk posed by a predator, responding less intensely to predators that it perceives as less dangerous. Prey from habitats with diverse predator communities can exhibit sophisticated threat−sensitivity and highly plastic predator responses. We tested whether adults of the San Marcos salamander (*Eurycea nana*), an aquatic species that encounters a diverse array of fish predators, responded in a threat−sensitive manner to the chemical stimuli of large and small, high−risk (green sunfish) and low−risk (black−tail shiner) predators. We found significant effects of both predator species and predator size, and no effect interaction. As expected, salamanders responded (reduced activity) more intensely to sunfish than to shiners; however, they also responded more intensely to small, gape−limited fish than to larger individuals. Given the capacity for plasticity in these salamanders, the seemingly excessive response to gape−limited predators may represent an ontogenetic holdover resulting from a lifetime in captivity. Alternatively, responses might reflect historical ecological relationships, which may have changed with more recent anthropogenic habitat alterations.

P1.157 DAVIS, T*; LIANO, J; BACHMAN, N; INGALLS, J; KITTS, J; HORN, R; MILLER, B; TEMKIN, M; SCHREIBER, A.M.; St. Lawrence University, NY; *aschreiber@stlawu.edu*

Doxycycline inhibits intestinal remodeling during Xenopus laevis metamorphosis

Metamorphosis of the herbivorous tadpole into a carnivorous frog is accompanied by an abrupt remodeling of the gut: the intestine shortens by 75%, the connective tissue and smooth muscle layers thicken, enteric neuronal cell bodies form clusters, and the lumen becomes highly involuted. Virtually all aspects of amphibian metamorphosis are mediated by thyroid hormone (TH), and the mRNAs of several matrixmetalloprotease (MMPs) are known to be upregulated directly (stromelysin−3) or indirectly (gelatinase A and MT1−MMP) in the gut mesenchyme by TH. The influence of MMP enzymatic activity on intestinal remodeling has not been well−described. Here we show that treatment of pre−metamorphic tadpoles (Nieuwkoop and Faber stage 50 and 54) with a broad−spectrum inhibitor of MMP activity (doxycycline, DOXY) inhibits virtually all aspects of intestinal remodeling, including shortening, thickening of the mesenchyme and smooth muscle layers, enteric neuronal clustering and changes in axonal cable diameter, and development of involutions on the lumen compared with controls following treatment with TH (3 nM triiodothyronine) for 4 days. In order to rule out the possibility that DOXY may function in part by inhibiting MMP transcription, mRNA for stromelysin−3 was measured by qRT−PCR. Stromelysin−3 mRNA synthesis from tadpole intestines treated simultaneously with TH+DOXY were not different compared with TH alone. These findings directly support the hypothesis that an upregulation of TH−responsive MMP activity during metamorphosis mediates diverse changes that accompany intestinal remodeling. Ongoing experiments are being conducted to also verify that DOXY does not inhibit MMP translation, and instead functions specifically as an inhibitor of MMP activity.

P1.189 DAVIS, SM*; ZACHARY, ED; JAMES, TA; LATHAM, KL; BALTZLEY, MJ; Western Oregon University; *sdavis12@mail.wou.edu*

Using a sequential y−maze and selective breeding to create Drosophila melanogaster strains with magnetic orientation preferences

There is some experimental evidence that the fruit fly, *Drosophila melanogaster* uses the Earth's magnetic field as an orientation cue. The ability to detect and orient using the Earth's magnetic field has been shown in diverse species, including sea turtles, birds, lobsters, newts, and sea slugs, yet the cellular basis for magnetosensory behaviors has remained elusive. If *D. melanogaster* orients to magnetic fields, the species offers an unprecedented opportunity to study the genetic basis of magnetic orientation and navigation because of their status as a model organism. We are going to attempt to confirm that *D. melanogaster* can orient using the magnetic field and will do this by creating populations with strong magnetic orientation preferences using artificial selection. We developed a maze that allowed us to isolate different individuals with north and south orientation preferences. Two populations of *D. melanogaster* were then created through selective breeding: a north−seeking population and a south−seeking population. We will present the preliminary results of this orientation and selection research. The experiment will continue through 15 generations of selection. The experiment was modeled after a study by Hadler (1964) which was used to ascertain the genetic basis of phototaxis in *D. melanogaster*. We are using this phototaxic behavior of *D. melanogaster* as a positive control.

P1.19 DAVIS, L.M.*; JOHNSON, M.A.; Trinity University; *ldavis1@trinity.edu*

Behavioral and Neural Correlates of Invasive Ability in Lizards

Efforts aimed at detecting and managing potentially invasive populations typically focus on understanding the ecological, genetic, and life history characteristics of invasive organisms. However, an understanding of the behaviors underlying invasion success is lacking. This study explored invasive behavioral mechanisms by comparing the "boldness" behaviors of three lizard species that vary in invasive ability. This syndrome correlates aggressive behavior with high activity levels and behavioral flexibility, all of which play an important role in the invasion process. The species studied include the non−invasive green anole (*Anolis carolinensis*), the invasive brown anole (*A. sagrei*) from both native and invasive ranges, and the less invasive bark anole (*A. distichus*) from its native range. We measured boldness by conducting a series of four behavioral tests on 12 males per species, including tests measuring aggression towards prey, aggression towards a conspecific, overall level of activity, and behavioral flexibility. Preliminary analyses suggest that the invasive brown anole is "bolder" than the native green anole in three of the four behavioral tests, and that the bark anole is "bolder" than the brown anole in two of the four tests. In addition, brain to body mass ratios, generally associated with behavioral flexibility, are significantly higher in the native green anole than the invasive brown anole. The native brown anole and the trunk anole did not differ in the brain to body mass ratio. Our future work will examine neuron size and density in three brain regions involved in aggression and exploratory behavior: the amygdala, the hippocampus, and the hypothalamus. By understanding the behavioral and neural differences between invasive and non−invasive lizards, we may better prevent and predict future vertebrate invasions.

56.5 DAVIS, M.C.*; CASS, A.N.; SCHEIDT, D.C.; MCCUNE, A.R.; Kennesaw State University, Cornell University; *mdavi144@kennesaw.edu*

Cranial musculoskeletal development in the holosteans Amia calva and Lepisosteus oculatus.

The pattern of cranial and pharyngeal musculoskeletal development has been extensively studied in tetrapods and in the derived actinopterygians (teleosts). However, we lack adequate descriptions of muscle and skeletal formation in more basal osteichthyan taxa, such as the non−teleost actinopterygians. Here we assess the patterns of associated cranial muscle and skeletal formation during embryonic and larval development in the holosteans *Amia calva* (bowfin) and *Lepisosteus oculatus* (spotted gar). We use nano−CT imaged specimens, supplemented with immunostaining for myogenic and chondrogenic markers to assess the relative timing, order of appearance, and embryonic/larval anatomy of both conserved and derived muscle complexes in each taxon. Our results show conservation in the early recruitment of muscle groups necessary for ventilation, feeding, and vision in both *Amia* and *Lepisosteus*, a pattern consistent with that observed for many teleosts (e.g. zebrafish) and basal tetrapods (e.g the axolotl). This observation supports the notion that in addition to phylogenetic history, common environmental and physiological constraints may play a role in determining the order (and timing) of appearance of certain functional musculoskeletal systems. Despite such conservation and constraint, the distinctive morphologies that characterize each taxon emerge relatively early in development. When placed in the phylogenetic context of teleost and tetrapod cranial anatomy, our data provide insights into the conserved musculoskeletal developmental pattern considered primitive for osteichthians and more broadly so for gnathostomes. In addition, our results provide crucial tests of hypotheses of muscle homology and evolution in the more derived vertebrate clades.

P1.122 DAVIS, JS*; WILLIAMS, SH; Ohio University; *jd330008@ohio.edu*

Masticatory Musculature of Dietarily Diverse Musteloid Carnivorans

The masticatory muscles of most mammalian species must produce complex masticatory movements while balancing the often−conflicting demands of gape, force generation, and stability. This set of requirements is reflected in their complex architecture. Perhaps because animal tissues are easily digested and require less inter−oral processing than plant foods, carnivorans are generally presumed to have relatively simple masticatory musculature. However, there is little comparative evidence to support this view. Additionally, although most carnivorans retain the carnivorous diet that characterizes the group, there are also several species that are omnivorous and a few have even specialized on plant−based diets. Here, detailed gross dissection and digital imaging were used to compare the masticatory muscles of 4 species of dietarily diverse musteloid carnivorans: the carnivorous domesticated ferret (*Mustela putorius furo*, Mustelidae), the omnivorous ringtailed coati (*Nasua nasua*, Procyonidae) and raccoon (*Procyon lotor*, Procyonidae), and the frugivorous kinkajou (*Potos flavus*, Procyonidae). Lugol's Iodine was used as a contrast solution to facilitate detailed visualization of soft tissues imaged using microCT scanning. 3D reconstructions of muscle compartments were rendered from the contrast−enhanced scans. All species possessed complex masticatory musculature involving myotendinous junctions incompletely separating compartments with diverse fiber directions. However, there are notable interspecific differences, including patterns of fiber orientation within compartments and the size and position of compartments as well as entire muscles relative to the cranium and jaw. These differences are hypothesized to reflect the diverse dietary specializations represented in this group.

P1.193 DAVIS−BERG, E. C.; KOVERMAN, K; JORDAN, D. R.*; Columbia College Chicago; *edavisberg@colum.edu*

Enhancing student understanding with interactive biology exercises created in Mathematica

We created interactive exercises that students can use to explore biological concepts. These active learning experiences are in the Computable Document Format (CDF), which are created with *Mathematica* but can be used with the free *Wolfram CDF Player*. Students can enter data and modify parameters without knowing how to use *Mathematica*. A CDF can include real−time computations, which can involve differential equations, extremely large data sets, and complex systems of equations. The results of the computations can be displayed in a variety of formats. Using the CDF exercises enhances student understanding by allowing them to focus on the biological concepts and visualize the data and calculations without the tedium of hand computation.

This presentation will highlight an interactive version of a biodiversity lab that explores Simpson's Diversity Index. Students are walked through the calculations with a small data set and are then asked to analyze a larger data set. This larger data set is presented as a set of interactive graphs so that they can explore and manipulate the data in order to answer questions. It also allows students to visually experience the concepts without having to complete all the calculations themselves. For our non−major audience, this means that we can have a more sophisticated discussion without getting stuck on the calculations. In the fall 2013 semester, we used this exercise in two classes (*Introduction to Ecology* and *Environmental Science*) and compared student outcomes with and without the interactive calculations. We will present the CDF as well as the assessment results and our future directions.

97.7 DAVIS−BERG, E.C.*; SACHAR, C.; CALLIER, T.; SAAL, H.P.; BENSMAIA, S.J.; Columbia College Chicago, University of Chicago; *edavisberg@colum.edu*

Dynamic adaptation of exploratory movements for texture perception

When we explore a textured surface, vibrations are produced in the fingertip skin that carry information about its texture and excite frequency−sensitive mechanoreceptors. Texture−elicited vibrations − and the response these evoked in receptors − depend systematically on the speed with which a finger scans the surface. To understand the neural basis of texture perception, it is therefore important to understand the exploratory movements used to acquire information about texture and how these depend on task demands as well as texture properties. To this end, we had human subjects explore 15 different natural textures, consisting of everyday materials such as fabrics and sandpapers; subjects rated each texture along one of three dominant textural dimensions, namely roughness, stickiness, and hardness. Subjects' finger movements were recorded with a high−speed camera as they performed the tasks and two−dimensional finger trajectories were extracted using an automated tracking system. We found that scanning speed depended on the task, that is, on the textural dimensions along which subjects provided ratings. Moreover, scanning speed systematically depended on which texture was scanned and varied up to two−fold across textures. These results suggest that scanning speed is rapidly optimized within individual exploratory movements to extract task−relevant features.

103.5 DAYGER, CA*; LUTTERSCHMIDT, DI; Portland State University; *cdayger@pdx.edu*

Glucocorticoid responses to adrenocorticotropic hormone (ACTH) in red−sided garter snakes, Thamnophis sirtalis: Effects of sex and season

Many studies have demonstrated that vertebrate stress responses are often context−dependent. We recently showed that low body condition is associated with greater sensitivity to capture stress and exogenous corticosterone during the spring mating season in female red−sided garter snakes (*Thamnophis sirtalis*). In contrast, body condition does not appear to be related to stress responsiveness in male snakes, although capture stress does not consistently increase corticosterone concentrations in the spring compared to fall. Together, these data suggest that sex differences and seasonal variation in adrenal sensitivity and/or competency may be driving the context−dependent nature of stress responses. To test this hypothesis, we collected male and female garter snakes from a den site in Manitoba, Canada where snakes aggregate during the spring mating season and in the fall before descending underground for winter dormancy. Blood samples were collected immediately upon capture and 1 and 4 hours after treatment with either vehicle or 0.1 IU/g adrenocorticotropic hormone (ACTH). ACTH treatment elicited a significant increase in plasma corticosterone at the 1−hour sampling time in both sexes and seasons. The mean integrated corticosterone response was significantly lower in the spring compared to fall in males but not females, suggesting that adrenal sensitivity to ACTH is suppressed in males during spring mating. Females remained highly sensitive to ACTH regardless of season. Preliminary analyses indicate that corticosterone responses to ACTH do not vary with body condition in either sex. These studies examining variation in responses to ACTH challenge will help illuminate the physiological mechanisms underlying the context−dependency of stress responsiveness.

S7.3−3 DE BEKKER, C.*; QUEVILLON, L.E.; SMITH, P.B.; PATTERSON, A.D.; HUGHES, D.P.; Pennsylvania State University; *c.debekker@psu.edu*

Heterogeneous mechanisms underlying behavioral manipulation by a fungal parasite

Parasite−host co−evolution has driven parasites to evolve strategies to invade, overcome the immune system, and exploit their hosts for their own survival and dispersal. Some parasites also interact with the host's nervous system, changing behavior. One of the most dramatic examples is the fungus *Ophiocordyceps unilateralis* s.l. infecting *Camponotus* species, where ants bite into vegetation before dying to facilitate spore dispersal. To establish this, the fungus not only overcomes the immune system, but also manipulates the brain and atrophies the muscles. We recently succeeded in moving this model system into the lab, allowing us to start unraveling the proximate mechanisms underlying this phenomenon. By combining metabolite profiling with *ex vivo* insect tissue culturing, compounds secreted in different areas of the host were studied. Using this technique we established that generalist and specialist fungal entomopathogens react differently to the same insect tissues. Next to that, these entomopathogens react heterogeneously to brain and muscle tissue by secreting a significantly different array of metabolites. Furthermore, about 70% of the metabolites *O. unilateralis* significantly employs when presented with brains differ when they are derived from different ant species. This is in line with infection studies performed under laboratory conditions: while some ant species display the manipulated biting behavior prior to death, other species do not. As part of this interdisciplinary dataset, we also identified two metabolites that are possibly involved in establishing manipulation. We are now developing the protocols to move towards fungal gene expression of cells surrounding ant brains during manipulated biting behavior.

100.1 DE MEYER, J.*; GEERINCKX, T.; University of Ghent, Belgium; *demeyer.jens@hotmail.com*

Attachment, feeding and respiration in hill stream loaches: using the whole body as a sucker

Hill stream loaches (Balitoridae) are freshwater fishes native to Eurasia. This study focused on the subfamily Balitorinae. These species live in rapid flowing water, which form a harsh environment for small fishes. The general morphology of Balitorinae is characterized by a flattened body and horizontally inserted pectoral and pelvic fins that are expanded, and can as such be used as sucker−like adhesive organs. The main focus of this study is to find out how these animals are adapted to their environment by characterizing in detail the anatomical structures used for attachment, respiration and feeding. Therefore, four species were observed: *Beaufortia leveretti, Sewellia lineolata, Pseudogastromyzon myersi* and *Gastromyzon punctulatus*, of which specimens were used for clearing and staining, CT−scanning and/or serial sectioning. A kinematic study was also performed on *S. lineolata, P. myersi* and *B. leveretii* to understand how these structures are involved in the attachment, feeding and respiration mechanisms. We found that the different species use their whole body, including their pectoral and pelvic fins, for attachment on the substrate. The pectoral fins are also used to remove water from underneath the body and thus prevent detachment. This type of attachment can be adaptive to the environment, as the animals don't show differences in breathing performance while being in still or flowing water. Inflow of water is generated by elevation of the lower jaw, which creates an underpressure underneath the body while the specimens remain attached to the substrate. A comparison of the morphologies with closely related taxa such as Cobitidae who don't show these peculiar traits is made to identify unique features related to Balitorinae.

P3.4 DELCLOS, PJ*; ROSENTHAL, GG; Texas A&M University; *pdelclos@bio.tamu.edu*

Nutritional effects on male traits and female mate choice in hybrid populations of northern swordtails Xiphophorus malinche x birchmanni.

A major goal in evolutionary ecology is to determine how a given environmental factor may affect a suite of ecologically relevant traits within a species, which can have consequences on both how fitness is distributed within a population and on overall population dynamics. For example, differences in nutrient availability among populations have been shown to indirectly affect population size and mean fitness by altering the reproductive allotment of females. Sexual selection via mate choice can further affect population mean fitness. However, our knowledge of how nutrition directly affects female mate choice and sexual selection is very limited. We examined how different environmental factors may affect hybrid *Xiphophorus* populations by measuring male phenotypic traits in the field and correlating these to various aspects of habitat and community. We found a significant positive correlation between the amount of benthic algae within a given site and the coefficient of variation of standard length and dorsal fin length, a secondary sexual trait in males, suggesting an effect of resource quantity on the male phenotypic pool. This result is in accord with previous studies suggesting that well−fed female *X. birchmanni* show weaker preferences than starved ones. We reexamined this study by varying the diets of females from hybrid populations varying in algal abundance. We found that females from the low−algae site that were fed a low−protein diet showed significant preferences for well−fed male chemical cues. All other combinations of site of origin and diet resulted in no significant net preference. This study provides a foundation for future experiments that will examine nutrition as a potential link between our behavioral trials and field data.

S4.3−1 DEMAS, Gregory E.*; Indiana University; *gdemas@indiana.edu*

Integrating Physiology and Ecology within Ecoimmunology

The role of parasites and pathogens in the evolution of life history traits has become of increasing interest to ecologists and evolutionary biologists, giving rise to the field of ecoimmunology. Further, the immune system has become an important area of proximate investigation among animal physiologists and physiological ecologists as a means for understanding changes in disease susceptibility, as well as the neural and neuroendocrine mechanisms that mediate these changes. While ecoimmunologists have made impressive strides in the last decade in both of these areas, they are still often pursued independently of one another. This lack of full synthesis has been driven, in large part, by limits in traditional lab−based techniques, developed for use in model systems that are less tractable for use in non−traditional species or under field conditions. This has proven to be an impediment to integrative biologists interested in pursuing the physiological mechanisms underlying ecological phenomena. The goal of this talk is to discuss ways to integrate ecological, behavioral and physiological approaches to the study of ecoimmunology and to identify areas where improved techniques or experimental approaches will allow for greater synthesis across research areas. An integration of both proximate and ultimate perspectives, while still challenging, will allow for the development of a common theoretical framework within the rapidly−expanding field of ecoimmunology.

25.7 DEMES, B.*; O'NEILL, M.C.; THOMPSON, N.E.; Stony Brook University; *brigitte.demes@stonybrook.edu*

Chimpanzee Bipedal Gait Mechanics and Early Hominin Gait Evolution

Humans share a last common ancestor with chimpanzees. One of the features that set humans apart from chimpanzees is our habitual bipedal locomotor mode and the use of an extended−limb posture. Chimpanzees, in contrast, are quadrupeds that engage in facultative bipedalism using a flexed−limb posture. As terrestrial bipedalism evolved early in the hominin lineage and early hominins were ape−like in many aspects of their postcranial anatomy, chimpanzees provide a useful extant model for the bipedal gait of some of our earliest ancestors. In this study, we present a comprehensive data set on the center of mass (CoM) mechanics of chimpanzee bipedalism. Three−dimensional ground reaction force recordings of > 100 strides of three male chimpanzees (27.3±5.1kg) served as the basis for calculating CoM mechanical energy fluctuations. Chimpanzees use a bipedal walking gait, with duty factors > 0.5 and Froude numbers < 0.5. Exchanges between CoM kinetic and potential energies − a hallmark of human walking − are low to moderate (5−50%). They are lower than for quadrupedal walking recorded in the same subjects, and they are also low in comparison to human bipedal walking. Mediolateral body sway is pronounced in chimpanzee bipedalism. It has a negative effect on energy exchanges that are 5−10% higher without mediolateral kinetic energy being considered. Mediolateral sway in chimpanzee bipedalism therefore requires more mechanical work on the CoM. Chimpanzees resemble several other nonhuman primates studied to date in having compliant bipedal gaits with moderate energy exchanges. Human walking, on the other hand, is more similar to the walking gaits of many nonprimate terrestrial animals, using inverted−pendulum swings on extended limbs and having high mechanical energy recoveries. Supported by NSF BCS 0935321.

P2.130 DEREX, RL*; BURNETT, KG; BURNETT, LE; College of Charleston; *derexrl@g.cofc.edu*

Hydrogen sulfide signaling in the hypoxia responses of the Atlantic blue crab

Across many animal phyla, responses to environmental hypoxia can be observed at the behavioral, organ system, molecular, and biochemical levels. Brachyuran crustaceans exhibit altered ventilation patterns that correlate to hemolymph O_2 tensions, supporting the existence of a cellular O_2 sensor that activates hypoxia−response signaling pathways. Recent studies implicate H_2S as a putative signal that mediates the global response to hypoxia in all vertebrate classes, and it has been demonstrated that invertebrates produce H_2S via the same enzymatic pathways. We are interested in seeing if H_2S production influences the ventilatory patterns produced by exposure to hypoxia in the Atlantic blue crab, *Callinectes sapidus*. The frequency (f_{beat}) and bilaterality of scaphognathite beating, and the frequency (f_{pause}) and duration (T_{pause}) of ventilatory pauses, were measured in crabs acutely exposed to hypoxia (10.0 and 6.7 kPa) or to H_2S (10, 25, and 100 mM) under normoxic conditions. We found f_{beat} increases with hypoxia (77.1 BPM±15.7SEM, 103.0±5.4, and 122.8±7.1 in 20.6, 10.0, and 6.7 kPa, respectively), while f_{pause} and T_{pause} are greatly reduced in hypoxia. Injections of H_2S into the branchial chamber transiently increase ventilation rates, and normal ventilation patterns resume seconds after completion of H_2S injections. *In vivo* inhibition of H_2S−producing enzymes did not reduce changes in ventilatory patterns under hypoxia, although we have not yet confirmed that this inhibition was successful. Future objectives include quantifying changes in the gene transcripts and enzymatic activity of the H_2S−producing enzymes in crabs exposed to normoxia or chronic hypoxia. Evaluating the potential for H_2S to act as a signal will provide valuable insight to the mechanisms underlying crustacean O_2 sensing. (NSF IOS−1147008)

P3.46 DERRICKSON, E.M.*; BRAZIER, L.; Loyola University Maryland, Baltimore; *ederrickson@loyola.edu*

The Influence of Dietary Protein on Reproduction in Peromyscus californicus

Mice of the genus *Peromyscus*, despite their many similarities, differ in body size, geographic range and reproductive characters. Larger members of the genus have smaller litters, slower growth, and more limited ranges, but the reason behind these changes in life history is not well understood. One possible correlate with a slower life history may be an inability to respond flexibly to changes in diet quality. The objective of this study is to determine whether species of *Peromyscus* that naturally have lower reproductive rates are less responsive to changes in dietary protein levels compared to species with higher reproductive rates. In the first stage of this study, our objectives were to determine (1) an "optimal" protein value in the diet in *P. californicus* and (2) the response curves to changing protein levels on pup production and growth, pup endurance, and maternal and pup body composition. Female *P.californicus* were placed on one of five isocaloric diets containing 6.9−23% protein and followed for three litters. Juveniles were tested for endurance when they reached 50% of adult mass. *P. californicus* exhibited a threshold type response to dietary protein with similar pup production and pup growth at all protein levels except the lowest. Optimal protein for pup growth occurred at 9%. Pup response, however, was plastic with pup endurance positively associated with maternal dietary protein. We are currently analyzing pup and maternal body composition patterns. This study provides a baseline in which to compare the response to dietary protein by *Peromyscus* that vary in body size and reproductive parameters.

P3.163 DESLAURIERS, A*; DANOS, N; AZIZI, E; University of California Irvine; *adeslaur@uci.edu*

Do visual cues modulate motor control strategies during landing in toads?

Toads are well adapted to using their forelimbs for landing during bouts of continuous hopping. During the aerial phase of hopping, toads begin to actively shorten their forelimb muscles in anticipation of landing. Upon landing the forelimb muscles are actively stretched in order to dissipate mechanical energy and decelerate the body. Previous studies have examined muscle behavior during the aerial phase of jumping and have found that intensity of recruitment increases with jump distance suggesting that toads actively modulate the length and activation of forelimb muscles to match the anticipated impact. A potential candidate for the sensory modality that is used to modulate motor control strategies during landing is vision. In the present study, we determine how changes in visual cues may affect the timing and intensity of motor recruitment in the forelimb muscles. We change visual cues in the landing arena through video playback of black and white lines moving upward or downward at a constant speed. These visual perturbations were used to alter the animal's sense of acceleration or deceleration prior to landing. High−speed video of locomotion and electromyography in the anconeus, deltoid, and pectoralis muscles of *Bufo marinus* were simultaneously recorded to characterize the intensity and onset of activation. We predicted that if vision is the sensory modality used to modulate motor patterns the timing and activation of forelimb muscles will be altered based on perceived accelerations. This work will elucidate the role of vision in the predictive motor strategies used during landing in toads. Supported by NSF grant 1051691.

53.7 DEVICHE, P.*; BEOUCHE, B.; DAVIES, S.; GAO, S.; LANE, S.; VALLE, S.; Arizona St. Univ., Tempe, Univ. Poitiers, France; *deviche@asu.edu*

RELATIONSHIPS BETWEEN PLASMA TESTOSTERONE, CORTICOSTERONE, GLUCOSE, AND URIC ACID DURING ACUTE STRESS AND SOCIAL CHALLENGE IN MALE PASSERINES

Testosterone (**T**) and corticosterone (**CORT**) influence protein and carbohydrate metabolism, yet few studies on free−ranging birds have researched relationships between short−term changes in plasma levels of these hormones and metabolic parameters. We measured changes in plasma total T, total CORT, glucose (**GLU**), and uric acid (**UA**; product of amino acid breakdown and potent antioxidant) in free−ranging adult male Rufous−winged Sparrows, *Peucaea carpalis*, in breeding condition following acute stress (capture and restraint) or social challenge for 30 min. Stress decreased plasma T and increased plasma CORT, and decreased plasma UA by 49% and GLU by 15%. A social challenge did not affect plasma T or GLU, but increased plasma CORT and decreased plasma UA by 43%. Thus, elevated plasma CORT during acute stress or social challenge correlated with decreased plasma UA but was not associated with hyperglycemia. Supporting these observations, acute stress in free−ranging adult male House Sparrows, *Passer domesticus*, tested outside (January) or during (spring: March and May) their breeding season consistently increased plasma CORT and decreased plasma T and UA (31%), but affected plasma GLU variably (Jan.: no change; March: decrease by 12%; May: increase by 17%). The observed decrease in plasma UA may reflect decreased amino acid metabolism or increased excretion and/or tissue uptake of this metabolite, the latter perhaps enhancing protection against stress−induced oxidative damage. Additional research is needed to understand the regulation of glycemia during acute stress. Supported by NSF Award 1026620 to P.D.

P3.77 DEVOST, I; HALLOT, F; MILBERGUE, M; PETIT, M; VEZINA, F*; Univ. Quebec, Rimouski ; *francois_vezina@uqar.ca*

Triglycerides as markers of fattening rate in non−migratory passerines: effects of ambient temperature

In migratory birds, levels of blood triglyceride (TRIG) have been repeatedly shown to correlate with the rate of fat accumulation during stopover. Since fattening rate can be estimated from a single capture, this makes this marker a valuable tool for studying constraints on rate of migration. Similarly to birds fattening for migration, small non−migratory passerines wintering at northern latitudes also become hyperphagic during winter. They must accumulate fat on a daily basis to survive through the night fasts. The use of TRIG to infer fattening rate from single captures could therefore be used in the field as a tool to monitor individual performance in energy acquisition. However, daily fattening rate is likely to be affected by seasonal changes in ambient temperature, as the need for energy reserves will change with thermoregulation costs. Using captive black−capped chickadees (*Poecile atricapillus*) as our model species, we conducted an experiment to (1) validate the use of TRIG as a predictor of fattening rate in resident birds and (2) determine the effect of ambient temperature on the relationship between TRIG and fattening rate. We first measured daily mass gain and sampled blood for TRIG in birds maintained at 15°C. Then, birds were separated in two groups, one maintained at 0°C and the other maintained at 30°C (thermoneutrality) before repeating the sampling. As expected, we found significant positive correlations between daily fattening rate and plasma TRIG levels. However this effect was dependent on ambient temperature with the strongest relationship found at 0°C and a lack of correlation at thermoneutrality.

P3.158 DIAL, T.R.*; BRAINERD, E.L.; Brown University; *terry_dial@brown.edu*

Perinatal escape performance and morphological scaling of Trinidadian guppies (Poecilia reticulata)

One of the most vulnerable, and therefore critical, stages in life is that when a new generation first enters the outside world. Producing relatively mature neonates increases offspring survivorship, but at the reproductive cost of low fecundity. In environments with high predation, high fecundity, and thus small offspring size, is favored. The Trinidadian guppy (*Poecilia reticulata*) exhibits this paradoxical relationship between size at birth and exposure to predation: populations subject to high predation (HP) produce many, relatively small offspring, whereas populations exposed to few/no predators (low predation; LP) produce fewer, larger offspring. This study investigates escape performance at and around birth in several populations of Trinidadian guppy in an effort to illuminate tradeoffs between selection on life histories and selection on functional morphology. Escape performance was measured within a perinatal window of guppy development from ~1 week prenatal to 1 month postnatal in five different populations of Trinidadian guppy. Preliminary analysis suggests that in one of two major drainages studied, offspring performance at birth increases with size along a gradient of HP environments, but decreases in LP sites, possibly as a result of relaxed selective pressure on escape performance. Fastest escape starts were observed in a population of intermediate offspring size. The other major drainage produced less stark differences in both offspring size and performance. Perinatal performance and morphology will be presented to explore the scaling relationships of form and function through ontogeny between offspring of different populations. These data shed light on the conflicting selective action between life history evolution and morphological adaptation at this most critical neonatal stage.

P3.173 DIAMOND, K. M.*; GIFFORD, M. E.; POWELL, R.; Clemson Univ., Univ. of Arkansas, Little Rock, Avila Univ.; *kmdiamo@clemson.edu*

Individual variation in locomotor performance and behavior in Northern Curly−tailed Lizards (Leiocephalus carinatus)

Leiocephalus carinatus is a territorial sit−and−wait predatory lizard native to Cuba and the Bahamas that utilizes diverse display behaviors (e.g., head−bobs, pushups, and tail−curls). We explored patterns of variation in display patterns within and among individual lizards and tested whether laboratory measures of performance correlated with field measurements of behavior. We sampled 45 lizards along a 1060m stretch of beach that was isolated from other populations. We measured endurance capacity and maximal sprinting speed for each lizard and released them at sites of capture for subsequent behavioral observations. We used mixed−effects models to test for consistent individual differences in performance and behavior and for individual−level correlations between performance and field behaviors. Sprinting speed, field display intensity, and movement rates of lizards exhibited consistent individual differences (i.e., they were repeatable), but with considerable variation between the sexes and among traits. Sprinting speed was not correlated with either measure of field behavior. Unlike sprint speed, endurance was significantly correlated with field display intensity in the complete dataset and for males alone. Contrary to patterns observed among species, endurance did not correlate with movement rates at the individual−level. These may indicate that display intensity is an honest signal of endurance in male *Leiocephalus*. Our results are among the first demonstrating repeatability of behavioral traits of field−active lizards and intersexual variation in patterns of repeatability, and provide confirmation of correlations between laboratory measures of performance and behaviors of free−ranging lizards.

65.1 DICKENS, M. J. ; BENTLEY, G. E. *; Univ. of California, Berkeley; *m.dickens@berkeley.edu*
Stress and reproduction: What underlies reproductive suppression when birds are brought into captivity?
Intersecting research topics that John Wingfield pioneered, our study aimed to describe mechanisms underlying reproductive suppression in captive wild birds. Male and female European starlings were maintained in outdoor aviaries and sampled for baseline corticosterone (BS) and stress−induced (SI) CORT when birds began to build nests and pair. Half of the birds were then moved to an indoor aviary, while the rest remained outdoors. When outdoor females began to lay (10 days), the experiment concluded and CORT was measured again. Although most indoor females began to nest−build and pair, their ovaries did not progress beyond small white follicles; in contrast, outdoor females exhibited a range of ovarian development and two females laid. Males had no differences in gonad size; however, testosterone was significantly lower in indoor males (0.07+/−0.03ng/mL) compared to outdoor males (1.3+/−0.4ng/mL). Changes in CORT from initial to end samples were significantly different between groups for both BS and integrated SI. This difference appears to be a reduced or lack of change in CORT in the indoor group. BS differences were significantly driven by females (Δng/mL: indoor females=−3.6+/−1.3; outdoor females=9.0+/−2.9; indoor males=3.9+/−3.5; outdoor males=10.1+/−4.9); SI differences were not sex dependent (Δng/mL/min: indoor females=133+/−81.9; outdoor females=441+/−77.6; indoor males= 176.3+/−169.3; outdoor males=382+/−101.2). While higher BS and SI CORT has been demonstrated for breeding birds, our data suggest that this increase can occur within a short time frame (<10 days), associated with the transition to active breeding. In addition, this study suggests that captivity effects may act through suppression of this natural increase in BS and SI CORT.

73.3 DICKERSON, BH*; SANDERS, EJ; WOODS, JI; DANIEL, TL; Univ. of Washington, Roosevelt High School; *bdicker@uw.edu*
Multi−channel extracellular recording supports a gyroscopic function for wings.
Flying insects collect and process information from their environment to maintain stability using a host of sensory modalities including vision and mechanoreception. The precision, sensitivity, and rapid processing speeds of mechanoreceptors relative to vision make them critical components of locomotor control. Both dipteran (flies) and strepsipteran (twisted wing flies) insects possess gyroscopic organs known as halteres that allow these animals to detect and correct for any perturbations to the flight path. Moreover, halteres are derived from wings and are specific to only those two insect orders. The wings of all insects possess the same mechanosensory structures as the halteres, campaniform sensilla. Evolution, therefore, suggests that the wings of many insects could serve as gyroscopic sensors. Indeed, recent anatomical, electrophysiological, and behavioral evidence confirms that the wings of the hawkmoth *Manduca sexta* inform the animal of its body dynamics. However, linking the wings' bending dynamics to the encoding properties of these embedded mechanoreceptors is a critical challenge for understanding how the wing functions as a combined sensor and actuator. Until recently only single unit recording methods have been developed, limiting our ability to assess correlations among distributed strain sensing sensilla. Using a multi−channel electrode, we performed extracellular recordings from the forewing nerve while mechanically stimulating the wing with frequency and amplitude sweeps and band−limited (10−300 Hz) Gaussian white noise using a motorized lever arm. We extract stimulus features that drive multiple individual unit responses and show (a) response latencies of units are within 5 to 10 milliseconds following the stimulus and (b) a rapid rate of information transfer consistent with haltere function.

P3.141 DICKINSON, E.*; JOHNSON, A.S.; ELLERS, O.; DICKINSON, P.S.; Bowdoin College; *edickins@bowdoin.edu*
Cardiac muscle in Homarus americanus responds differently to loading in transverse and longitudinal directions
Central pattern generators (CPGs) are neural networks that generate stereotyped outputs, which drive rhythmic behaviors. CPGs can be modulated by neurotransmitters and feedback systems; in *Homarus americanus*, the neurogenic heart is controlled by a CPG: the cardiac ganglion, which generates bursts of action potentials that drive cardiac contractions. There are over 80 different identified neurotransmitters in the lobster; however, the effects of the stretch feedback system on CPG are less well understood. Since the heart is naturally loaded in three dimensions by pressure, uniaxial and biaxial (longitudinal and transverse) stretches of 2.5 mm were imposed on the heart muscle to understand the effects of stretch in cardiac modulation. The active force (force of contraction) increased in response to both transverse and longitudinal uniaxial stretching; however, the increase in force of contraction was greatest under transverse loading. The passive forces increased in response to both transverse and longitudinal uniaxial stretching, but longitudinal loading resulted in the greatest increase. Transverse but not longitudinal uniaxial loading had a state−dependent effect on frequency. Biaxial loading increased both the force of contraction and the passive forces during stretch and additionally had a state−dependent effect on frequency. These initial results suggest that the different muscle characteristics in the longitudinal and transverse direction, in conjunction with the stretch that occurs during normal cardiac function, is important in determining overall contraction parameters in the heart. Supported by NSF Grant IOS−1121973, and NIH Grants 5P20RR016463−12 and 8P20GM103423−12.

P2.103 DIMARCO−TEMKIN, M.P.*; TEMKIN, M.H.; State Univ. of New York, Canton, St. Lawrence University; *dimarcotemkinm@canton.edu*
Polyembryony and larval development in the stenolaemate bryozoan, Crisia pugeti
Polyembryony is a specialized mode of asexual reproduction that occurs between fertilization and the juvenile stage in the life cycles of some plants and animals. Among the Bryozoa, polyembryony occurs only in the Stenolaemata. In stenolaemates, all of the events of polyembryony occur within specialized individuals within stenolaemate colonies, called gonozooids. Here, we report on gonozooid ontogeny, primary embryogenesis, secondary embryogenesis, and larvagenesis in the stenolaemate bryozoan *Crisia pugeti*. In *C. pugeti*, the egg cleaves within the ovary to form the primary embryo. While it is still inside of the ovary, the primary embryo grows to become hundreds of microns in length and develops a lobate structure. During this growth period the ovary degenerates, and cytolysosomes and shrunken nuclei are numerous in ovarian tissue. Some of the lobes of the primary embryo, elongate to form bi−layered, finger−like processes or budding loci, which produce secondary embryos. Newly budded secondary embryos consist of 8 inner cells surrounded by an epithelium of about 32 outer cells. As the secondary embryos develop, the outer cell layer proliferates more rapidly than the inner cell layer. Larvae retain the two−layered structure of secondary embryos. During larvagenesis, the outer cell layer invaginates at the anterior end to form an apical sinus, which is lined by a cuticle. At the posterior end of the larva, the outer layer invaginates to form the adhesive sac. These observations indicate that the basic organization of the larva, and therefore, of the ancestrula (the first member of a new colony) is established very early in the primary embryo. The formation of secondary embryos from a pluripotent, bi−layered primary embryo may represent a heterochronic change in the onset of asexual reproduction in the life cycle of this group of bryozoans.

P2.82 DION, J.; GILMORE, E.*; FERREIRA, A.; MAGLIA, A.M.; SHEARMAN, R.M.; Framingham State Univ, MA, National Science Foundation, Arlington, VA; *lizzgilmore@gmail.com*

The effect of density on skeletal development in Xenopus laevis

Understanding how biodiversity evolves requires knowledge of environmental influences on phenotypic development. A species' developmental flexibility in response to the environment may dictate how much or little its morphology can vary. Until developmental variation is studied in an environmental context, predictions of phenotype from genotype will remain difficult, if not intractable. To investigate the role of environmental variation on skeletal development, we tested the influence of population density on the growth and ossification of *Xenopus laevis* (African clawed frog) tadpoles. Tadpoles were reared at two densities (1 tadpole/liter (1 t/L) and 3 tadpoles/liter (3 t/L)) under normal laboratory conditions, and developmental series were collected while maintaining densities. Consistent with previous studies, tadpoles in the higher density treatment group experienced an increased rate of mortality and were relatively smaller (snout−vent length by stage) than tadpoles in the lower density treatment group. The ossification sequence between treatment groups varied little, with the exception of delayed onset of ossification of some of the jaw elements, most notably the premaxilla, in the 3 t/L tadpoles. The overall lack of variation in ossification sequence between groups could be due to insufficient difference in the environmental conditions tested or may indicate developmental entrenchment of ossification sequence in *Xenopus laevis*.

4.4 DITSCHE−KURU, P.*; WAINWRIGHT, D./K.; SUMMERS, A./P.; University of Washington, Friday Harbor Labs, US, Havard, Cambridge, US; *pditsche@UW.edu*

Sticking to slippery surfaces − the impact of fouling on suction adhesion in Northern Clingfish

In aquatic environments solid substrates are fouled by bacteria, algae and invertebrates. A biofilm starts to form just a few hours after a surface is immersed, and the surface becomes more complex and diverse with time. This growth changes the elasticity and surface roughness of the primary substrate, and therefore the attachment conditions for benthic organisms. In this study, we investigate the influence of fouling on the adhesive strength of a small, suctorial intertidal fish, the Northern clingfish. We incubated surfaces of various roughness for six weeks in the Salish Sea, leading to a substantial biofilm and periphyton. We compared the adhesive force of the fish on unfouled and fouled substrates with four selected roughnesses. We tested additional unfouled substrates of increasing surface roughness to identify the upper threshold of surface roughness. Northern clingfish less than 10 cm in TL could not adhere to surfaces rougher than a 2−4 mm grain size. Clingfish were able to attach to both fouled and unfouled smooth substrates with equivalent tenacity. However, the tenacity on fouled, rough substrates was less than unfouled, rough substrates. This decrease may be because the biofilm acts like a lubricant, and lowers friction between the disk margin and the substrate. Nevertheless, even on smooth, fouled surfaces the fish generate impressive adhesive forces about 150 times higher than the body weight of the fish.

P3.167 DITSCHE−KURU, P.*; KOVALEV, A.; MICHELS, J.; KOOP, J.H.; GORB, S.N.; University of Washington, USA; University of Kiel, Germany, University of Kiel, Germany, Federal Inst. Hydrology, Koblenz, Germany; *pditsche@uw.edu*

More than just slippery − The impact of biofilm on the attachment of running water insect larvae

While terrestrial insects usually attach directly to the substrate, for aquatic insects the situation is more complex due to the presence of biofilms on primary substrates. In comparison with the primary substrates, these biofilms are usually softer and feature different surface structures and chemistries. Recent investigations indicate that the biofilm can strongly influence the ability of some mayfly larvae to attach to the substrate. The aim of this study was to test this assumption and prove the impact of biofilm on the attachment of mayfly larvae. We (1) performed attachment experiments in a flow channel, (2) measured attachment forces generated by the claws of dissected legs and (3) characterised mechanical properties of the biofilm. The experiments were performed on substrates of different surface roughness each with and without biofilm. Interestingly, on substrates with smooth or slightly rough surfaces, where the claws hardly find surface irregularities to grasp on, the presence of biofilm increased the attachment force of claws significantly. The larvae were able to endure higher flow velocities on these biofilm−covered smooth substrates in comparison to the biofilm−free smooth substrates. In contrast, on rough substrates the attachment force of claws decreased in the presence of biofilm. Nevertheless, on these rough substrates attachment forces were more than 10 times higher than on smoother substrates and larvae were able to endure the highest flow velocities in the flume on both biofilm−covered and biofilm−free substrates. Consequently, biofilm is of important ecological relevance for the larvae not only as food source, but also as a factor influencing their attachment ability in natural stream habitats.

72.6 DIVINO, J.N.*; MCCORMICK, S.D.; SCHULTZ, E.T.; Univ. of Connecticut, US Geological Survey; *jeffrey.divino@uconn.edu*

Examining Physiological Evolution in Derived Freshwater Threespine Sticklebacks

Marine taxa capable of invading freshwater habitats experience new ecological opportunities that have often resulted in species diversification and adaptive radiation. However, rates of trait change in the novel environment will depend on the intensity and mode of selection, e.g., positive or relaxed. The threespine stickleback (*Gasterosteus aculeatus*) system provides a unique glimpse into rapid evolutionary change following salinity transitions. In the Pacific Northwest there are numerous derived freshwater populations that range in age, including some recent introductions that are only a few generations old. We adopt a common garden approach to investigate potential evolutionary changes in this fish's osmoregulatory physiology and performance. Embryos from ancestral marine and derived freshwater populations were reared under identical laboratory conditions and then challenged at more extreme salinities representing both environments. We compared survival, sodium content, and various parameters associated with ion transporters in the gill. Although all populations exhibited euryhalinity, the ancestral stock and recent land−locked descendent each differed in survival, favoring their respective native salinities. Interestingly, the inter−population difference in survival rate between salinity treatments was asymmetric and suggests that a loss of seawater tolerance may occur at a slower pace than enhancement of freshwater tolerance. Molecular evidence suggests an osmoregulatory basis for these differences. We conclude that passage to an exclusively freshwater environment strongly selects for hyperosmoregulatory competency, but not necessarily against seawater tolerance, thus resulting in a halotolerance shift that involves both positive and relaxed selection.

P3.97 DIXON, G.*; MATZ, M.; Univ Texas, Austin;
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Gene body methylation and gene regulation the coral Acropora millepora

DNA methylation is an evolutionarily ancient epigenetic modification found in bacteria, plants, animals and fungi. In invertebrates, DNA methylation is primarily targeted to CpG dinucleotides within transcription units (gene bodies). Genome wide studies of a number of invertebrate species suggest that gene body methylation is involved in transcriptional regulation, chromatin modification, alternative splicing and environmentally induced phenotypes. However, the functional importance of gene body methylation in coral has yet to be thoroughly investigated. Here we present a genome wide study of gene body methylation in the coral species *Acropora millepora* and *Acropora digitifera* and its relationship with gene regulation. Because of the increased rate of substitution of methylated cytosines, genes that are targeted for methylation become depleted of CpG dinucleotides over evolutionary time. Using CpG depletion as a predictor for DNA methylation, we found that the genes of both species can be divided into distinct groups of hypermethylated and hypomethylated genes. These methylation groups showed significant enrichment for genes from unique functional categories. Hypermethylated genes were enriched for housekeeping functions such as RNA and DNA metabolism, and hypomethylated genes were enriched for inducible functions, such as cell signaling and developmental processes. Using RNA−seq, we found a clear underlying relationship between CpG depletion and transcription. CpG depletion (hypermethylation) correlated with higher transcription, and CpG enrichment (hypomethylation) correlated with lower transcription. Our results indicate that gene body methylation is common in coral genomes and are suggestive that gene body methylation is involved with gene regulation.

121.7 DLUGOSZ, E.M.*; DOWNS, C.J.; KRASNOV, B.R.; KHOKHLOVA, I.S.; Blaustein Institutes for Desert Research, Ben−Gurion University of the Negev, Israel, University of Nevada, Reno, USA; *dlugosz@post.bgu.ac.il*

Parasite reproduction: does host reproductive state matter?

Host reproduction is known to be energetically demanding which may shift allocation of resources away from an immune defense. Thus, parasites are expected to perform better on reproductively active hosts. We infested a desert rodent species (*Meriones crassus*) with its specific fleas (*Xenopsylla ramesis*). We measured the effect of several host reproductive stages on flea blood meal size, egg production, and offspring quality. We expected fleas to lay more eggs and produce higher offspring quality when feeding on pregnant and lactating females as compared to fleas exploiting non−reproducing females. Indeed, fleas performed best while feeding on lactating females. Surprisingly, when considering all reproductive and non−reproductive states, we found that fleas infesting late−term pregnant females showed the poorest performance. Quality of flea reproduction is likely to be dependent on the quality of host blood as well as host allocation of energetic resources toward immune function. The possible causes of this will be discussed.

P1.33 DODGIN, S/R*; LUNARDI, P/N; HRANITZ, J/M; Bloomsburg University of Pennsylvania;
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Vernal Pool Distribution on Assateague Island, Chincoteague National Wildlife Refuge, VA

Climate change poses a major threat to barrier islands and their communities through the consequences of sea level rise and erosion. Increased severity and frequency of coastal storms also make barrier islands vulnerable to flooding and salt water intrusion into the freshwater habitats important to mid−level consumers such as anurans. Four anurans (Fowlers Toad (*Anaxyrus (Bufo) fowleri*), American Green Tree Frog (*Hyla cinera*), Bull Frog (*Lithobates catesbeiana*) and Southern Leopard Frog (*Lithobates sphenocephalus*) occur on the island, all of which rely on freshwater pools to breed and forage. The goal of this study was to describe the distribution of vernal pools on Assateague Island (VA) in the Chincoteague National Wildlife Refuge. We found that many pools are created by one or multiple fallen trees after storms, creating a sometimes elaborate network of seasonal wetlands. Many of these pools are completely dry by late May to early August. During our study from May 26− August 2, 2013, we found salinities ranging from 0 to 25 ppt and areas from 2.7 to 4098 M2. Pools were found in habitats ranging from maritime forest, loblolly pine forest, loblolly/maritime forest, mixed coniferous forest and secondary dunes scrub. We found anurans in various larval and adult stages in or near 44 of 87 vernal pools. These results show that anurans rely on these unique habitats that are threatened by climate change.

P1.133 DOHENY, BM*; KOHNO, S; CLOY−MCCOY, JA; GUILLETTE JR, LJ; Medical University of South Carolina, MUSC;
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Receptor Isoform−specific Estrogen Signaling in Müllerian Duct Differentiation of the American Alligator

Perturbation of endocrine signaling during critical developmental windows has been implicated in adult reproductive disorders. This "developmental origins of disease" paradigm is the basis for our investigation of the role of estrogen signaling in embryonic differentiation of female reproductive tract in the American alligator. To this end, we first investigated pathways leading to sex reversal. Alligator eggs incubated at a temperature that produces 100% males (33.5 °C) were treated with estradiol−17^{2} (E2) or 4,4',4''−(4−Propyl−[1H]−pyrazole−1,3,5(−triyl)trisphenol (PPT), a specific agonist for estrogen receptor alpha (ER±), at a stage just prior to sex determination. E2 induced 100% sex reversal, indicated by Müllerian duct presence and gonadal histology. PPT treatment induced 100% gonadal sex reversal and abnormal enlargement of the Müllerian duct. Histological analysis indicated precocious glandular development in these tissues. Quantitative RT−PCR expression assays for steroid hormone receptors revealed significant downregulation of ESR1 and significant upregulation of progesterone receptor in oviductal tissue from PPT treated embryos. Receptor isoform−specific estrogen signaling was further studied by treating embryos incubated at a temperature that produces 100% females (30.5°C) with E2, PPT and ER^{2} specific agonist WAY 200070. Only PPT treatment induced the previously characterized oviductal phenotype. Further investigation via immunohistochemistry and RT−QPCR continues to reveal significant differences in PPT−treated oviductal tissue. The results of this study provide insight into the factors critical for healthy reproductive system formation in this sentinel species.

P1.16 DOMALIK, AD*; LENDVAI, AZ; OUYANG, JQ; DAKIN, R; MOORE, IT; BONIER, F; Queen's University, Kingston, ON, Virginia Tech, Blacksburg; *9add2@queensu.ca*

Does baseline corticosterone predict neophobia in tree swallows (Tachycineta bicolor)?

Individual differences in behavior are often attributed to different coping styles a set of behavioral responses that are consistent within individuals. For example, proactive individuals tend to be characterized by higher levels of aggression and boldness, while reactive individuals show the opposite behaviors. Moreover, an individual's response to novelty (neophobia fear of the new) is also an important component of coping style. However, the physiological mechanisms regulating neophobic behaviors in free−living animals remain to be clarified, but promising work in captive birds suggests that corticosterone (CORT) might be involved. In this study, we explored the relationship between neophobia and baseline CORT in free−living adult tree swallows (*Tachycineta bicolor*). Specifically, we investigated whether individuals exhibiting a high degree of neophobia would also have higher baseline CORT levels. From these data, we will provide further insight into the role of CORT in mediating an individual's behavioral response to novel stimuli.

P3.128 DONATELLI, CM*; SUMMERS, AP; PORTER, ME; University of Rochester, Friday Harbor Labs, Florida Atlantic University; *cdonatel@u.rochester.edu*

Bent out of shape: Bioinspired vertebral column morphology and mechanics

Vertebral centra are often characterized by the shape of the anterior and posterior faces, which can be flat, convex or concave. The platycoelus vertebrae of most mammals have flat faces, while the mono− and diphycoelus vertebrae of fishes, reptiles and amphibians have one or two concave faces. Some marine mammals even have slightly convex vertebral faces. There is a strong phylogenetic signal for centrum shape, and we are interested in the functional implications of the intervertebral cavity. We used a rapid prototyper and a viscoelastic molding technique to test the effects of centrum morphology and intervertebral joint length on mechanical outputs of the vertebral column. Five models, inspired by the vertebral morphology of fishes, humans, and marine mammals, were designed and printed. We constructed motion segments (centrum−joint−centrum) of varying joint length for each centrum morphology. Moment arms were added to motion segments to ensure loading in pure bending. From force outputs, we calculated moment (Nm), work (J), and bending stiffness (Nm^2). Increasing the bending angle during testing, doubled moment and increased work produced by an order of magnitude, while decreasing bending stiffness by an average of 0.15 Nm^2. Increasing joint length decreases each of these mechanical properties by three to four times. The slightly convex vertebral face of marine mammal models, regardless of joint length, produced the largest moment, work, and bending stiffness values while the intermediate concave fish model had the lowest. These data suggest that convex and flat models are consistently stiffer than concave models. Our data show the relation between centrum shape, joint length, and their associated mechanical outputs is not linear. This research was funded by NSF grant DBI 1262239.

P1.59 DONOVAN, M.W.*; TROWBRIDGE, R.L.; COSENZA, K.S.; MYKLES, D.L.; Colorado State University, Fort Collins , Colorado State University, Fort Collins; *matt_donovan@live.com*

Ecdysteroid regulation of the Gecarcinus laterals myostatin gene: a heterologous cell expression system to test the function of an ecdysteroid response element

Myostatin (Mstn) is a potent inhibitor of protein synthesis in mammalian skeletal muscle. In *G. laterals* claw muscle there is an inverse relationship between hemolymph ecdysteroid levels and *Gl−Mstn* expression. The promoter region of the Gl−Mstn gene contains a putative ecdysteroid response element (EcRE). These data suggest that ecdysteroid represses *Gl−Mstn* expression. As a ligand, ecdysteroids, such as 20−hydroxyecdysone (20E), bind to a heterodimeric nuclear receptor, consisting of the Ecdysone Receptor (EcR) and the Retinoid X Receptor (RXR). We hypothesize that this ligand/receptor complex directly inhibits transcription of the Gl−Mstn gene via the EcRE in the promoter region. A heterologous cell expression system was used to determine if the putative EcRE is functional. We cloned *Uca pugilator* EcR (Up−EcR) cDNA encoding the EcR open reading frame (ORF) into the pKH3−CMV and Up−RXR cDNA encoding the RXR ORF into the p3XFLAG−CMV plasmid vectors. The pKH3−CMV has a triple hemagglutinin (HA) tag and the p3XFLAG−CMV has a FLAG tag. Initial results indicate the fusion HA−EcR protein was expressed from the pKH3 vector in HeLa cells. The *Gl−Mstn* promoter sequence was cloned into the pGL3−Basic plasmid, which contains a luciferase reporter gene. HeLa cells will be transfected with the plasmid constructs encoding the HA−EcR and FLAG−RXR fusion proteins and the Mstn promoter−luciferase sequence. We hypothesize that 20E will suppress luciferase expression in cells expressing both EcR and RXR and not in cells expressing only EcR or RXR. This experiment will determine if ecdysteroids directly regulate Mstn expression in crustaceans. Supported by NSF (IBN−0618203).

P2.151 DONOVIEL, Z.S.*; SIRMAN, A.E.; HOOD, W.R.; Auburn University; *zsd0001@auburn.edu*

Maternal dietary effects and age at first reproduction in the House mouse

There is strong evidence that a mother's diet can have lasting impacts on the condition and physiology of her young. Yet, the adaptive significance of these effects remains poorly tested. Traits that result in early reproductive maturity should be selected for within a population, as early maturation over successive generations results in a rapid infusion of early maturating phenotypes. We tested the impact of maternal diet on offspring age at first reproduction in the house mouse, *Mus musculus*. Wild derived house mice were maintained in enclosures that mimic the environmental conditions and population sizes that wild mice often experience while living in barns. The F_0 generation was fed a high (20%, H) or low (10%, L) protein diet. At weaning, F_1 offspring were either placed on a diet that matched that of their parents (HH, or LL) a diet that is a mismatch to their parents diet (LH or HL). The reproductive performance of all F_1 mice were monitored daily and microsatellites were used to determine the parentage of the first litter that each parent gave birth to. The results of this study will be presented within the context of the environmental matching and silver spoon hypotheses.

33.2 DOUGHERTY, LF*; CALDWELL, RL; JOHNSEN, S; MARSHALL, J; University of California, Berkeley; *lindseydougherty@berkeley.edu*

Flashing in Ctenoides ales "disco clams": Structure and function in an ecological context

The disco or electric clam, *Ctenoides ales,* has a bright photic display that is the result of highly reflective tissue and localized mantle lip movement. It is the only known species of bivalve with a behaviorally controlled light display. The vividness of the display is noteworthy considering its habitat − deep water (10−50m) inside small crevices or caves, where there is limited ambient light available for reflection. Research utilizing spectrometry, particle modeling and energy dispersive X−ray spectroscopy for elemental analysis produced a model of how the reflective structures optimize scattering in this low−light habitat, resulting in extremely efficient reflection. The function of the flashing was reviewed from an ecological context, including habitat characteristics, water samples, interspecific associations and in situ video, time−lapse photography, and habitat spectral analysis. Hypotheses regarding the function of the light display being explored include that it acts in phototaxic prey luring, as a deimatic anti−predator display, and/or as a signal facilitating the recruitment of conspecifics.

21.1 DOWD, W.W.*; SEARS, R.; CARLONE, M.; HOYT, J.; OTANICAR, T.; Loyola Marymount University, University of Tulsa; *wdowd@lmu.edu*

Behavioral and biophysical contributors to variation in body temperatures of intertidal mussels and their role in micro−scale physiological variation

Organisms on wave−exposed, rocky intertidal shores inhabit a spatially complex and temporally dynamic environment. Much effort has been devoted to studying patterns of physiological and/or genetic variation within and between such species, over latitudinal, vertical, seasonal or other relatively large scales. Our recent attention has been focused on the factors that might regulate micro−scale, intra−population variation in body temperature and physiology, which by some measures can rival or exceed mean differences over much larger scales. Solar irradiance is probably the dominant source of heat for many intertidal organisms. Here, we examined the potential roles of behavior (modification of body orientation and shell area exposed to solar irradiance) and shell surface reflectance characteristics in setting body temperatures of intertidal mussels of the genus *Mytilus* . We also quantified inter−individual variation in physiology − specifically, the biochemical capacities for ATP production and antioxidant defense − from within a single mussel bed both before and after eliminating solar heating by shading mussels at low tide. Our results implicate a complex suite of interacting factors that influence the body temperatures and physiological state of intertidal mussels. Supported by NSF and Loyola Marymount University.

S4.3−2 DOWNS, C.J.*; DOCHTERMANN, N.A.; University of Nevada Reno, North Dakota State University; *cdowns@unr.edu*

Statistical approaches to uncovering ecological and evolutionary causes and consequences of behavioral and physiological differences among individuals.

Considerable work in ecoimmunology focuses on investigating individual variation in immune responses and linking this variation to physiological trade−offs, ecological traits, and environmental variation. Variation in immune responses, however, can be partitioned into differences between and within individuals, populations, and taxonomic groupings. Understanding how variation, and in particular how covariation across traits, is distributed among these levels is necessary for drawing appropriate ecological and evolutionary inferences. Moreover, variation at the between−individual level directly connects to underlying quantitative genetic parameters. In order to fully understand immune responses in evolutionary and ecological contexts and to reveal phylogenetic constraints on evolution, statistical approaches must allow (co)variance to be partitioned among levels of individual, population, and phylogenetic organization (e.g., population, species, genera, etc.). Here we describe how mixed−effects models allow variation in immune responses to be partitioned among different hierarchical levels. We detail the connection between these approaches and relevant ecological and evolutionary questions involving immune responses. For example, a between individual correlation (i.e., a correlation between mean responses of individuals) might pose evolutionary constraints or with−in lifetime constraints and trade−offs. We conclude by discussing the advantages of this approach when developing hypotheses about evolutionary constraints, investigating life history trade−offs, and developing predictions about ecological and evolutionary trajectories.

46.4 DRAKE, K*; BOWEN, L; MILES, K; ESQUE, T; NUSSEAR, K; LEWISON, R; US Geological Survey, San Diego State Univ., UC Davis, US Geological Survey, UC Davis, US Geological Survey, San Diego State Univ.; *kdrake@usgs.gov*

Using Genetics to Understand Physiological Responses to Environmental Stressors in the Desert Tortoise

As a Federally listed Threatened species, measuring and monitoring the health of desert tortoises *(Gopherus agassizii)* is a management priority. Identifying causal effects of population decline and assessing environmental impacts on animal health in this species has been difficult, as tortoises are exposed to a wide range of environmental stressors. Additionally, current health and disease screening methods are limited in their ability to diagnose clinical and physiological health conditions. In 2012, we initiated research to improve our understanding of how desert tortoises respond physiologically to stressors in the environment. To improve health diagnostics in the desert tortoise, we developed the first method of quantifying differential gene transcription levels in tortoises using a quantitative real time polymerase chain reaction (qPCR) assay. Genes screened included a combination of immune or detoxification response genes that have the potential to be modified by biological or physical conditions. Blood was collected from wild and captive tortoises in Nevada and California and evaluated for genes indicative of physiological health. As hypothesized, gene transcript profiles did not correlate with standard desert tortoise health assessments and with known animal condition, highlighting the need for the development of alternate assessment techniques, such as gene transcript profiling.

52.1 DREYER, AP*; SHINGLETON, AW; Michigan State University; *dreyerau@gmail.com*

Does Size Really Matter? The Effect of Genital Size on Reproductive Success

From flies to spiders and crabs to beetles, genital size remains near constant among individuals in a population despite considerable phenotypic plasticity in body size and the size of other organs. Several competing hypotheses have been proposed to explain the selective pressures underlying this commonly observed phenomenon, however, a lack of experimental data has made it difficult to distinguish between them. Any comprehensive test of these hypotheses requires high levels of variation in genital size alone, which does not exist in natural populations. We have designed a method to circumvent this problem and test the hypotheses experimentally. Our design uses targeted gene expression to up− or down−regulate insulin−signaling in the developing genitalia of *Drosophila melanogaster* and produce male flies with extreme genital morphologies. Male flies with proportionally small, wild−type or large genitalia are then paired with female flies in up to three contexts; (1) no male competition, (2) direct male−male competition, (3) indirect male−male competition. Specific aspects of male reproductive success are measured to compare across the three genital sizes: courtship and copulation latency, and duration; post−mating egg production, proportion of fertilized eggs and egg paternity. Our results suggest that females prefer males with wild−type size genitalia even though they are physically able to mate with, and fertilize eggs using sperm from, males that have proportionally small or large genitalia.

78.4 DRIESSENS, T*; VANHOOYDONCK, B; VAN DAMME, R; University of Antwerp, Belgium; *tess.driessens@uantwerpen.be*

A functional approach to the dewlap in Anolis sagrei

The dewlap of *Anolis* lizards, an extendable flap of skin attached to their throat, presents a classic example of a highly variable and complex signaling device. Even though the dewlap has been suggested to play a role in male−male competition, female mate choice, species recognition and/or predator defense, the exact function and evolutionary flexibility of this structure remain poorly understood. Our study incorporates a functional approach to the anoline dewlap, using *Anolis sagrei* as model species. Specifically, we examined whether certain dewlap components (i.e. size, colour and pattern) have a specific signaling function and if this implies certain costs or benefits. Therefore, a suite of physiological (body condition, immune response), behavioural (predator interactions, male−male and male−female interactions, female mate choice) and performance traits (bite force, clinging capacity, sprinting speed, jumping capacity) were obtained from the same individuals under fully−controlled laboratory conditions, and linked to the individual dewlap components. We focused on both sexes of *A. sagrei*, as selective pressures on signaling traits often differ between sexes and previous studies on anoles are strongly biased towards the male dewlap only.

52.6 DROGE−YOUNG, E.*; BELOTE, J.; PEREZ, G.; PITNICK, S.; Syracuse University, New York; *emdroge@syr.edu*

Mechanisms underlying variance in competitive fertilization success in the highly promiscuous beetle Tribolium castaneum

Investigating mechanisms that influence competitive fertilization success is critical to our understanding how postcopulatory sexual selection drives the evolution of reproductive characters. Our knowledge of postcopulatory processes, particularly when females mate with more than two competing males, remains limited in part due to the difficulty of discriminating among the sperm of different males within a female's reproductive tract. Here, we used transgenic lines of the flour beetle, *Tribolium castaneum* that have males that produce sperm with green or red fluorescent protein tagged heads to identify sources of variance in fertilization success after females are mated to two or more competing males. We then associated patterns of sperm storage to patterns of paternity across the multiple matings. Our results indicate that sperm relevance to fertilization as well as displacement in subsequent matings depends on sperm location in the female reproductive tract. Additionally, we found that male size predicts success in transferring sperm during copulation, in addition to other variables influencing the proportion of focal male sperm in the female reproductive tract.

117.2 DRURY, J.P.*; GRETHER, G.F.; Univ. of California, Los Angeles; *druryj@ucla.edu*

Agonistic character displacement, not reproductive character displacement, explains variation in male wing patterns in rubyspot damselflies (Hetaerina spp.)

Agonistic character displacement (ACD), a process wherein natural selection acts on traits that mediate the occurrence or outcome of interspecific aggression, is an understudied evolutionary phenomenon. Previous research suggests that patterns of geographic variation in wing coloration and competitor recognition of male rubyspot damselflies (*Hetaerina* spp.) have resulted from ACD. However, reproductive character displacement (RCD) may also have acted to produce the same geographic patterns, and recent theoretical work has shown that RCD dominates ACD when mate recognition and competitor recognition are based on the same traits. To determine whether female mate recognition in *Hetaerina* is based, in part, on male wing coloration, we carried out a phenotype manipulation experiment in the field. Compared to control males, male *H. americana* that we manipulated to have wing coloration resembling a sympatric congener (*H. titia*) suffered no reduction in attractiveness to conspecific females. Thus, at least in *H. americana*, female mate recognition is not based on male wing coloration. These results strengthen the case for ACD as the process responsible for the character displacement pattern in *Hetaerina* wing coloration.

20.1 DUBAY, SG*; WITT, CC; Univ. of Chicago, Univ. of New Mexico; *dubaysg@uchicago.edu*

Differential high−altitude adaptation and limited gene flow across a mid−elevation hybrid zone in birds

The Andes are a global hotspot of biological diversity that is characterized by dramatic elevational shifts in community composition and a preponderance of recently evolved species. Animal habitats in the Andes span a ~5000 m elevational gradient, encompassing a tremendous range of atmospheric conditions that pose challenges for respiration, thermoregulation, and water balance. Few studies address the extent to which this elevational gradient influences speciation or facilitates high rates of species turnover. We report a previously unknown hybrid zone between recently diverged flycatchers (Aves: Tyrannidae) with partially overlapping elevational ranges. The southern *Anairetes reguloides* has a broad elevational distribution from 0−4200 m, while the northern *Anairetes nigrocristatus* is restricted to elevations above 3000 m. Where the two species overlap in central Peru we found hybrids at elevations between ~3100−3800 m, with *A. nigrocristatus* above this elevation and *A. reguloides* below. We analyzed variation in hematological parameters, morphology, and unlinked genetic markers across an elevational transect encompassing the hybrid zone. The hybrid zone was structured as a steep cline, with little evidence of gene flow away from the two central, mid−elevation localities of the transect. Relative heart mass and hemoglobin concentration increased strikingly with elevation and the proportion of genetic input from *A. reguloides*, suggesting that the latter species is not genetically adapted to high altitudes. *A. nigrocristatus* did not show evidence of respiratory stress at high altitudes. These results suggest a physiological basis for elevational replacement and species turnover across elevational gradients, whereby differential adaptation to altitude maintains the distinctness of incipient species by stable parapatry along an elevational contour.

P3.79 DUBOIS, K.*; HALLOT, F.; MILBERGUE, M.; VEZINA, F.; Université du Québec à Rimouski; *karinedubois777@yahoo.ca*

Rate of change in metabolic performance in response to thermal variations in three North American passerine species

Thermal acclimatization in birds is associated with adjustments in metabolic performance. Basal metabolic rate (BMR) and maximal thermogenic capacity (Msum, an indicator of cold tolerance) are known to be flexible and studies have reported various amplitudes of adjustments in response to changes in ambient temperature (Ta). However, little is known on the rate of change in metabolic performance in birds subjected to rapid temperature changes and evidences suggest that it may differ between species. We compared three North American passerines species contrasted in their seasonal thermal environment, therefore likely to respond distinctively to the same thermal treatments. Snow buntings (*Plectrophenax nivalis*, migratory birds found exclusively at northern latitudes), White−throated Sparrows (*Zonotrichia albicollis*, migratory birds found from southern Canada to southern USA) and Black−capped Chickadees (*Poecile atricapillus*, resident species experiencing seasonal Ta fluctuations) were first acclimated to 10°C and had their metabolic performance measured (BMR, Msum and MMR, induced by exercise and reflecting stamina). Birds were then separated into "cold" (−5°C) and "warm" (28°C) temperature treatments and performance was measured again on the 4th and 8th day of acclimation (in progress at time of submission). As the extent of temperature fluctuations increases with latitude, we expect Snow buntings and Black−capped Chickadees to express a higher relative rate of acclimation than White−throated Sparrows.

P2.93 DUELL, M*; CIARLARIELLO, J; KLOK, CJ; VANDENBROOKS, J; HARRISON, JF; Arizona State University; *meduell@asu.edu*

Is there a price of being a giant? Body systems scaling in Scarabaeid beetles illustrated by high resolution micro−CT

Today's insects are small in comparison to the giants of the Paleozoic Era when atmospheric oxygen levels were higher than current levels. If tracheal oxygen delivery limits insect size, then larger insects might require larger tracheal systems with respect to body size (hypermetrically scaled) to meet their oxygen demands; this pattern has been found in grasshoppers during ontogeny and across tenebrionid beetle species. Hypermetric scaling of the tracheal system could mean that the price of being giant may be reduced investment in other body systems. We tested these possibilities in the clade of insects including the most massive extant species, scarab beetles ranging in size from 1 mg to 30 g. The beetles were killed using ethyl acetate fumes and scanned within two days to maintain the integrity of internal structures. Using micro−CT scanners at Virginia Tech, Argonne National Laboratory, and UT Austin, beetles were scanned at high resolution. Raw X−rays were reconstructed in 3−D so we could estimates volumes of muscles, airsacs, gut, genitalia, and brain tissue using Avizo Fire software. We measured cuticle volumes after a NaOH digestion of soft tissues. Based on analysis of about a third of the species, air sac contents scaled hypermetrically, as found in prior studies. Gut and genitalia were difficult to distinguish using x−ray density thresholding so they were combined and represent approximately 3−20% of the body volume. Brains were consistently less than 1% of body volume and were proportionally larger in smaller beetles (Haller's rule). Flight muscle scaled isometrically and was approximately 15−20% of the body. Larger beetles have lower densities due to investing a greater percentage of body volume in airsacs, apparently without trade−offs in other tissues. This work was funded by NSF 1122157.

130.2 DUELL, M*; ROUBIK, D; WCISLO, W; HARRISON, JF; SMITH, BH; Arizona State University, Smithsonian Tropical Research Institute; *meduell@asu.edu*

Correlates of miniaturization: Scaling of morphology and behavioral repertoires of Neotropical stingless bees

When a species evolves extremely small body size with respect to close relatives, is said to be miniaturized. This condition is pervasive throughout the Animal kingdom but we do not understand the physiological mechanisms responsible or their effects on behavioral repertoires. Stingless bees, the Meliponini, are a tropical group in which miniaturization has evolved in 11 separate genera with species ranging in size over three orders of magnitude. We observed foraging behaviors of over 15 species of Neotropical stingless bees in the Panama and Colon provinces of the Republic of Panama before collecting them and removing their brains to determine if major differences in foraging regimes correlate with body size, head size, and brain structure. Tiny bees had relatively larger heads but smaller thoraxes and abdomens relative to larger bees. One interpretation of these data is that miniaturized bees may over−invest in the brain to maintain behavioral capacity, at the expense of flight and transport capacities. We found that tiny bees and large bees each have some unique behaviors but that general foraging strategies were similar, suggesting that miniaturized stingless bees might not be behaviorally limited by the physiology of small size in terms of general foraging behavior. This research was funded through Arizona State University and the Smithsonian Tropical Research Institute.

13.3 DUFFY, TA*; MCCORMICK, SD; Conte Anadromous Fish Research Center, Turners Falls, MA and Louisiana Universities Marine Consortium, Chauvin, LA, Conte Anadromous Fish Research Center, Turners Falls, MA; *tduffy@lumcon.edu*

Differential life−stage response to common endocrine disruptors in Atlantic salmon, Atlantic sturgeon and shortnose sturgeon

Atlantic salmon (*Salmo salar*), Atlantic sturgeon (*Acipenser oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*) are endangered anadromous fish that may be exposed to feminizing endocrine disrupting compounds (EDCs) during early development, potentially reducing fitness and survival. To assess differential life−stage sensitivity to common EDCs, we carried out acute (96 hour) exposures using three doses each of nonylphenol (NP), 17 ²−estradiol (E2) and ±−ethinylestradiol (EE2) on four life−stages; embryos, yolk−sac larvae, feeding fry and 1+ year−old juveniles of Atlantic salmon and shortnose sturgeon. Additionally, chronic (21−day) exposures were carried out in Atlantic salmon and Atlantic sturgeon. Differential response was compared using vitellogenin (Vtg, a precursor egg protein) gene transcription. Additionally, we validated enzyme−immunoassay (EIA) measurements of plasma Vtg in 1+ age individuals. No EDC−related mortality occurred, but Vtg mRNA was elevated in a dose−dependent manner in salmon across all life stages except embryos and patterns were similar between acute and chronic exposures. Both species of sturgeon showed little Vtg response in early stages but did respond as 2 year old juveniles, indicating that sturgeon may be less sensitive to EDCs during early development than other species.

P1.84 DUFFY, TD*; MCCORMICK, SD; Conte Anadromous Fish Research Center, Turners Falls, MA and LUMCON, Chauvin, LA, Conte Anadromous Fish Research Center, Turners Falls, MA; *tduffy@lumcon.edu*

DNA methylation in brook trout (Salvelinus fontinalis) following acclimation to thermally stressful environments

Brook trout (*Salvelinus fontinalis*) is a cold water salmonid that is threatened in the southern portion of its range by increasing summer temperatures. Brook trout may routinely experience temperatures near their thermal limit (~26 °C) and survival under these conditions may be driven in part by thermal acclimation. We wished to examine whether DNA methylation plays a role in thermal acclimation and performance of brook trout. We measured markers of cellular and physiological stress and assessed DNA methylation of gill, liver and muscle tissue in juvenile trout. Fish were acclimated to 12 °C, 20 °C and 22 °C for two weeks then moved to 12 °C for one month. Tissues were collected for physiological measures of stress and DNA methylation at multiple timepoints. After acclimation to 12 °C for one month, fish were exposed to a stair−step increase in temperature over 24 hours and periodically sampled for differential responses in heat shock protein−70 (HSP70) mRNA and protein, plasma lactate, and hemoglobin. Gill total DNA methylation increased significantly following initial acclimation to the high temperatures, but no differences in methylation were observed in liver or muscle. Acclimation temperature predicted survival time when fish were exposed to their thermal maximum. Physiological measures of thermal stress did not differ among fish that were acclimated to different temperatures, but did display predicted changes with increasing temperature. Our results suggest that DNA methylation may be involved in temperature acclimation in brook trout, but the genes involved in differential responses to temperature are still unknown.

15.3 DUMONT, E.*; PINEDA, W.; BAIRD, B.; WARSI, O.; SMITH, A.; SWARTZ, S.; DÁVALOS, L.; University of Massachusetts at Amherst, MA, Instituto Tecnológico de Costa Rica, Cartago, Stony Brook University, NY, Stony Brook University, NY, Brown University, Providence, RI ; *bdumont@bio.umass.edu*

Rates of Evolution in the Crania and Wings of Phyllostomid Bats

The movement of lineages into new adaptive zones and subsequent differentiation are often accompanied by changes in morphology. Vertebrate morphologists typically turn to feeding systems for evidence of adaptation to new ecological niches. Previous analyses of phyllostomid bats found significantly lower rates of cranial evolution among the morphologically distinct subfamily Stenodermatinae than in other subfamilies, suggesting stabilizing selection following the early filling of multiple feeding niches for which the family Phyllostomidae is well known. In contrast, the evolution of the locomotor system within phyllostomids and its relationship to the feeding system has received little attention. We analyzed the links between the locomotor and cranial traits, as well as their relative rates of evolution by combining new phylogenies with functionally meaningful measurements from species representing all phyllostomid subfamilies. We found that variation in the locomotor and feeding systems was uncorrelated, and the systems experienced significantly different overall rates of evolution. Rates of evolution in locomotor and feeding characters peak in different regions of the phylogeny, but there is no evidence that rapid evolution in one system preceded rapid evolution in the other. Taken together, these results suggest that the evolution of the locomotor and feeding systems of phyllostomid bats is decoupled, which may have contributed to the evolution of extreme trophic and habitat diversity within the group.

3.8 DUNHAM, LA*; WILCZYNSKI, W; Georgia State Univ, Atlanta; *ldunham2@student.gsu.edu*

Arginine vasotocin and social behavior in Anolis carolinensis

Arginine vasotocin (AVT) is a potent regulator of social behavior in a variety of species but little is known about its role in reptilian behavior. Our goal was to examine the effect of exogenous AVT on aggressive responding and courtship behavior in the green anole lizard. Aggressive behavior was examined in two ways: 1) stimulated by the animal's own mirrored reflection (no status formed) and 2) within the context of a size−matched pair (where a social status is formed). To elicit courtship behavior, a novel female was introduced into the home cage of a male. Regardless of the behavior condition, male anoles were injected IP with either reptile ringer's solution (VEH) or AVT 30 minutes prior to testing. Behavior tests were taped for 30 minutes and scored for latency to first display and number of display bouts. Treatment with AVT significantly reduced the number of aggressive displays performed toward a mirror ($t=4.511$, $p<0.001$). Administration of AVT did not, however, significantly affect the status outcome of paired interactions (dominant vs. subordinate; $p=1.000$) nor did it significantly affect the overall number of aggressive display bouts to a conspecific male ($F=0.397$, $p=0.541$). A significant interaction between injection type and status was observed in which AVT injected males that became dominant had a longer latency to first display than those that became subordinate ($q=3.603$, $p=0.027$). AVT injection did not significantly affect the number of courtship displays toward a novel female ($t=-0.349$, $p=0.732$). Overall, we found that AVT reduced aggressive behavior as has been reported for other territorial species. The effect was not observed in a paired aggression condition, suggesting that AVT is not a critical factor in determining social status. Unlike data from many other species, AVT does not affect courtship behavior in the green anole.

53.3 DUNLAP, KD; Trinity College; *kent.dunlap@trincoll.edu*
Glucocorticoids and complex natural stimuli enhance adult neurogenesis in weakly electric fish.
Neurogenesis in the adult brain responds to both internal neuroendocrine signals and external sensory stimuli. In most species, glucocorticoids and external stimuli that elevate glucocorticoids inhibit neurogenesis. Here I present research showing that, in electric fish, social interaction simultaneously elevates glucocorticoids, increases aggressive electric signaling (chirping) and stimulates neurogenesis in brain regions associated with chirping. Blocking glucocorticoid action pharmacologically abolishes chirping and reduces socially elevated neurogenesis. These studies indicate that elevated glucocorticoid activation is required for increasing aggressive signaling and contributes to social enhancement of neurogenesis. In field studies, I demonstrate that fish facing complex natural stimuli, particularly during the breeding season, show much greater neurogenic rates throughout the brain (compared to laboratory housed fish). This global enhancement of neurogenesis in the breeding season is likely due to seasonal changes in temperature or daylength, but regionally−specific enhancement of neurogenesis in brain areas associated with electrocommunication is likely due to elevated social interaction during the breeding season. Both these sets of studies illustrate the value of a Wingfieldian approach to 1) understanding species diversity in hormone, brain and behavior relationships and 2) examining these relationships in free−living animals.

S10.3−1 DUPRAT, Camille; Ecole Polytechnique; *camille.duprat@espci.fr*
Wetting of flexible fibers
Fibrous media, and in particular fiber arrays, are ubiquitous in natural systems (hair, adhesive pads, feathers or plants), which take advantage of their qualities of filtration, water collection and retention, hydrophobicity or coloring. The fibers composing these arrays, often flexible, can undergo deformation under capillary forces. Such elastocapillary deformations may have a negative impact, for example the matting of feather barbules in birds exposed to oil spills. Conversely, these deformations can be used to control liquid capture or evaporation. To understand these phenomena, we study the model system of a drop sitting on two fibers, which is a first step toward understanding the wetting of larger fibrous networks. On rigid fibers, the liquid can adopt two distinct equilibrium shapes: a compact, approximately hemispherical, drop shape or a long liquid column of constant cross−section. On flexible fibers, the transition from drops to columns can be induced by the deformation of the fibers.The morphology adopted by the liquid then depends on the elasticity of the fibers as well as the drop volume. We find that there is a maximum volume above which spreading does not occur, and identify a critical volume that maximizes liquid capture. When the fibers are clamped, the liquid morphology can be controlled by adjusting the tension within the fibers. Finally, we study the drying dynamics of these systems and show that the evaporation rate is strongly related to the fibers elasticity: a flexible material, in which fibers are allowed to bend, evaporates faster than a rigid material. We present quantitative arguments from which we deduce universal rules governing the spreading and drying of liquid drops on flexible fiber arrays, which we apply to various natural or man−made fibrous materials.

P2.42 DUQUETTE, AM*; MCCLINTOCK, JB; AMSLER, CD; HALL−SPENCER, JM; MILAZZO, M; University of Alabama at Birmingham, Birmingham, AL, University of Plymouth, England, University of Palermo, Italy; *amd82886@gmail.com*
Effects of reduced pH on shell integrity of a common whelk from a natural undersea CO2 vent community off Vulcano Island, Italy
Hexaplex trunculus is a widespread Mediterranean gastropod mollusc that plays a crucial role in benthic ecosystem dynamics. Individuals occur in shallow, sublittoral habitats near Vulcano Island, Italy, where an undersea CO_2 vent provides a gradient of seawater acidification mimicing future predicted levels of ocean acidification. Individuals were collected from three sites with declining pH [ambient (pH 8.18), medium (pH 8.05) and low (pH 7.49)]. Dissolution of shells was clearly evident at the medium (smoothing of outer shell) and low (pitting and holes) pH sites. Scanning electron microcroscopy will provide a qualitative comparative assessment of micro−scale impacts of shell dissolution of individuals from the three sites. X−ray diffraction will provide a quantitative comparative assessment of carbonate composition in shells of individuals from the three pH sites. This study indicates that end of century anticipated levels of ocean acidification are capable of causing severe shell damage that may render individuals more susceptible to infection and predation. Supported by Abercrombie and Kent Philanthropy and an Endowed Professorship to JBM.

P3.24 DURANT, SE*; DE BRUIJN, R; TRAN, M; ROMERO, LM; Oklahoma State Univ, Tufts Univ; *sarah.durant@okstate.edu*
Neither chronic stress nor a costly−life history stage affect wound−healing in European Starlings (Sturnus vulgaris)
Chronic stress, potentially through the actions of corticosterone, is thought to have negative consequences for immune function in birds. However, chronic stress may also influence allocation of energy, ultimately shifting resources away from the immune system. If so, then the effects of chronic stress on immune responses may be greater during costly life history stages like molt. To test whether the effects of chronic stress on immune responses differ during life history stages, we exposed both molting and non−molting starlings to 28 d of chronic stress. We minimized disturbance experienced by control birds. Prior to the start of chronic stress we collected baseline, stress−induced, Dex−induced, and ACTH−induced blood samples to determine whether corticosterone correlated with wound healing rates. After 8 days of exposure to chronic stress, we wounded both control and chronically stressed birds and monitored healing daily. We also monitored body mass of birds every two days. Contrary to work on lizards and small mammals, all birds, regardless of stress or molt status, fully−healed wounds at similar rates. Body mass data suggest that chronically stressed birds initially lost weight after wounding, whereas control birds did not. However, about 6 d post wounding both control and chronic stress birds continually gained weight throughout the rest of the study. Increased body mass could suggest compensatory feeding to offset energetic or resource (e.g., proteins) demands of wound healing. Interestingly, pre stress baseline corticosterone concentrations positively correlated with healing rates. Although chronic stress did not inhibit healing, our data suggest that corticosterone may play an important role in mediating healing processes.

70.4 DURSO, AM*; SMITH, GD; NEUMAN−LEE, LA; FRENCH, SS; Utah State University; *amdurso@gmail.com*

Using labeled nutrient tracers to reveal resource allocation in lizards with competing needs

Animals must allocate limited resources to competing needs, necessitating trade−offs. Evidence for a fundamental trade−off between self−maintenance and reproduction is widespread but mostly indirect. We used a stable isotope label to measure how resource availability and handling stress interact to mediate decisions in energy allocation between immunity and reproduction in a reptile with a high degree of plasticity in life history traits. Fifty−six gravid female Side−blotched Lizards (*Uta stansburiana*) were wounded and injected with ^{15}N−labeled leucine at the start of the experiment. They were then subjected to one week of frequent handling stress and/or food restriction in a 2x2 design. The proportion of ^{15}N in healed wound scabs was used to evaluate energy allocation to self−maintenance, whereas ^{15}N in eggs was used as a measure of allocation to reproduction. We also measured wound healing rate, immune function, oxidative stress, and corticosterone as indirect performance measurements of the trade−off. We found significant effects of both types of stress treatments on both direct and indirect endpoints of energy allocation. Although these lizards live only 1−2 years, individuals in stress treatments allocated more energy to self−maintenance than controls, perhaps because all lizards were in a relatively early stage of their lifetime reproductive output. Regardless, this design illustrates that both stress and energy affect allocation decisions among important life history variables.

118.3 DURYEA, MC*; CALSBEEK, R; KERN, AD; Dartmouth College, Rutgers University; *duryea@dartmouth.edu*

Females bite back: Sexual conflict and the evolution of venom proteins in the reproductive tract of female anole lizards

Reproductive proteins evolve rapidly in many species, yet the ecological significance of these proteins remains largely unknown. In this study, we investigate reproductive proteins in *Anolis* lizards, a system in which the ecological basis for a fertilization bias has been established. When female *A. sagrei* mate with multiple males, they preferentially use the sperm from larger sires to produce sons. Field experiments reveal that this bias may be adaptive, based on patterns of offspring survival. Using Next Generation Sequencing, we investigate genes that are expressed in the reproductive tract of female anoles. Comparisons with *Drosophila*, the system in which female reproductive gene expression has been best studied, reveal broad similarities in the genetic response to mating across these distantly related taxa. Additionally, we investigated the molecular evolution of a group of serine proteases that are differentially expressed after mating in the reproductive tract of female anoles. Of these serine proteases, some appear closely related to snake venom proteins. Due to the deep origin of venom toxin in squamates and the hypothesized origin of *Drosophila* reproductive serine proteases from digestive proteases, our results suggest that Anolis reproductive serine proteases and venom serine proteases could share a common phylogenetic origin. This would imply that digestive enzymes have been involved in the evolution of cryptic aspects of female choice in multiple mating systems.

73.1 DYHR, JP*; SPONBERG, S; HALL, R; COLMENARES, DJ; CHAUHAN, NS; DANIEL, TL; Univ of Washington, Carnegie Mellon Univ., Univ Prep HS; *jdyhr@u.washington.edu*

Closing the loop on abdominal control with free flight pitch perturbations

Flying animals use multiple motor outputs for flight control. While the aerodynamic force generation by wings has been of primary interest, changes in body shape have also been shown to contribute to flight stabilization in the hawkmoth *Manduca sexta*. This inertial control mechanism acts to both modulate the center of mass relative to the centers of lift and thrust and to redirect the vectored forces produced by the wings. However, the extent to which inertial control is used to stabilize flight has been inferred from experiments in tethered flight preparations, greatly altering the body dynamics of the animal. Here, we ask whether moths use abdominal movements for control in free flight and compare our results to those from open−loop tethered flight experiments. To accomplish this we used high−speed videos of moths feeding from a robotically actuated flower. The flower was rotated about the pitch axis, forcing the moth to track that motion to continue feeding. By varying the pitch angle using a broadband sum of sines trajectory, we were able to determine the sensorimotor transfer function between flower motion and abdominal−thoracic angle. We show that movements of the abdominal−thoracic joint are strongly coupled to the visual stimulus and that the shape of the response is consistent with a high−pass filter with a 3 dB cutoff frequency at approximately 2 Hz with a fixed time delay of 200 ms. These free flight responses are similar to those responses observed in tethered open−loop studies.

74.2 DZIALOWSKI, E.M.*; SOTHERLAND, P.R.; GOY SIRSAT, S.K.; SIRSAT, T.S.; Univ. of North Texas, Kalamazoo College; *edzial@unt.edu*

Metabolic and cardiac correlates of hatching in an ectothermic archosaur

Though metabolic capacity is augmented in birds when endothermy develops, non−avian archosaurs remain ectothermic throughout their lives and lack metabolic augmentation. We have shown in the Pekin duck (*Anas pekin*) that mitochondrial respiration increases in the left ventricle of the heart upon hatching and in association with attainment of endothermic capacity. In the present study, and largely as a foil to our experiment conducted in Pekin duck, we examined whole animal metabolism and cardiac mitochondrial respiration of right and left ventricles in prehatch and neonate American alligators (*Alligator mississippiensis*). Animals were examined at 80% development (stage 25), 90% development (stage 27), day 0, day 1, and day 7 days post hatch (dph). Oxygen consumption was measured at 32°C and 25°C and was significantly lower at 25°C, typical of an ectothermic phenotype. No significant differences between mitochondrial respiration of the right and left ventricles at the LEAK and OXPHOS (CI and CI+CII) were seen. There was also no significant difference in mitochondrial respiration as the animals aged. Contrary to duck hatchlings, heart mass as a fraction of body mass did not change with hatching. These results in alligator suggest that the increase of mitochondrial activity in the left ventricle seen previously in ducks is not merely a facet of the hatching and aging process, but is a physiological change necessary for metabolic maturation of endothermic species.

S2.3−2 D'ALBA, L.*; SPENCER, K.A.; VAN HEMERT, C.; HEIDINGER, B.J.; GILL, L.; EVANS, N.P.; MONAGHAN, P.; HANDEL, C.M.; SHAWKEY, M.D.; University of Akron, University of St. Andrews, USGS Alaska Science Center, University of Glasgow, Max Planck Institute for Ornithology, USGS Alaska Science Center; *liliana@uakron.edu*

The mechanisms of condition−dependent variation in melanin−based plumage color.

Carotenoid−based plumage color is clearly condition−dependent, fulfilling a key prediction of honest advertisement models of sexual selection, but whether the same holds true in melanin−based colors is still unclear. Here we first provide direct experimental evidence of condition−dependence in a eumelanic (black bib of black−capped chickadees, *Poecile atricapillus*) and pheomelanic (cheek feathers of zebra finches, *Taeniopygia guttata*) ornament. However, to provide a direct link between condition and trait expression, it is necessary to understand the proximate mechanisms underlying variation. Therefore, we use transmission and scanning electron microscopy and light microscopy to investigate how feather micro and nano−structure affect reflected color and is in turn affected by stress (either from disease or food unpredictability). We show that reflected color is a product both of melanin density and the larger−scale spacing and density of feather barbs and barbules. Thus, stress affects both pigment deposition and feather structure, leading to variation that honestly reflects underlying condition.

84.5 EBERLE, AL*; DICKERSON, BH; REINHALL, P; DANIEL, TL; Univ. of Washington; *eberle10@uw.edu*

Wings wobble when waggled: detecting Coriolis forces from bending dynamics

Insect wings are flexible structures that are subject to Coriolis forces when they experience rotational motions in an axis orthogonal to their flapping axis. Since insect wings are richly imbued with mechanosensors, they can potentially act as detectors of body dynamics like the halteres of dipteran flies. Indeed, recent behavioral, electrophysiological and anatomical evidence suggests that the wings serve a gyroscopic function, mediating reflexes to body rotations. But, can Coriolis forces be detected using only changes in the structural dynamics of a flapping flexible wing? To address this question we built a robotic actuator that rotates a flapping model wing about an axis orthogonal to the axis of wing flapping. Using a wing with a flexural stiffness of similar to *Manduca sexta* wing, we took high−speed video of the model wing flapping at a frequency similar to that of *Manduca* (25 Hz). We compared the 3D structural dynamics of flapping wings with and without a 3 Hz, 20 degree, rotation about the yaw axis. We observed a large difference in tip displacement induced by the body rotation, with a maximum of approximately a 30% decrement in the amplitude of tip displacement at both wingbeat frequency and twice wingbeat frequency (systematic error of measured position is approximately 1 mm). These results are consistent with the influence of Coriolis forces. In addition, our observed changes in tip displacement indicate similar changes in strain over the surface of the entire wing. Moreover, in the context of a *Manduca* wing, the strains could stimulate embedded mechanoreceptors at the wing base and over the surface of the wing that could trigger reflexive responses to body rotations.

17.4 ECKWRIGHT, MJ*; MCGOWAN, CP; SHELLOOE, L; University of Idaho, Gonzaga University; *eckw7684@vandals.uidaho.edu*

The Effects of Substrate on the Bipedal Hopping of Kangaroo Rats

In the wild, animals live on a wide variety of substrates including sand, snow, leaf−litter, and so on. These various substrates exhibit a wide range of physical properties that can affect locomotion, and many animals have evolved specialized forms of locomotion to better navigate their native substrate. Despite the large role that substrate plays, most studies done on human and animal locomotion have used solely rigid substrates. The few studies that have involved varied substrates have focused mostly on humans on elastic surfaces, though natural substrates are more likely to be dampers. There have also been numerous studies done with desert lizards on sand, but this is only one particular case. For our study, we focused on the desert kangaroo rat, which is a sand−native bipedal hopper. We recorded the kangaroo rats hopping over a rigid substrate with 0, 1, 2, and 3 cm of sand overlain. We used video and force data to calculate the leg stiffness and vertical stiffness for each trial. The results were vertical stiffness values that increased with the addition of sand, but not between sand levels. Leg stiffness values were independent of sand level. These results suggest that desert kangaroo rats increase their vertical stiffness on sand, possibly to make up for the energy lost to the substrate.

P2.65 EDELSTEIN, LW*; JONES, AG; Texas A&M University; *ledelstein@bio.tamu.edu*

An evo−devo study of evolutionary novelties: the origin of the seahorse tail

Studies investigating evolutionary novelties shed light on the developmental and evolutionary origins of intriguing morphological innovations. Most bony fish rely on their muscular tail as a source of power for locomotion, but seahorses have a novel prehensile tail that lacks a caudal fin and allows for grasping the substrate. This morphological innovation is not present in most other syngnathids (e.g. pipefish and seadragons), raising evolutionary questions as to how the unique seahorse tail arose from a common ancestor lacking a prehensile tail. Moreover, the development of the prehensile tail during embryonic gestation within the father's pouch makes it an ideal trait to study in order to answer questions as to how novel traits arise. My research investigates the development of syngnathid tails, both the prehensile tail in seahorses and the more typical teleost tail of the pipefish. I am conducting a morphological developmental time series throughout the duration of male pregnancies in both a seahorse species, *Hippocampus zosterae*, and a pipefish species *Syngnathus scovelli*. I will also use next−generation RNA sequencing technology to investigate differential gene expression and identify candidate genes involved in syngnathid tail development at the same developmental stages as the morphology series. This will identify both the intraspecific and interspecific changes in gene expression during syngnathid tail development, thereby shedding light on how the evolutionary novelty of the seahorse prehensile tail evolved.

59.5 EDWARDS, D/D*; MOORE, P/A; Bowling Green State University; *davide@bgsu.edu*

The Field Measurement of Chemical Plumes in Headwater Streams: Implications for Ecological Interactions

Aquatic organisms use chemoreception in lotic systems for a broad spectrum of ecologically relevant decisions. In order to appreciate behavioral responses to chemical stimuli, one needs an understanding of the physics of chemical transmission within moving fluids (i.e., turbulence). Because of the chaotic nature of turbulence, chemical plumes have a spatial microstructure with fluxes in chemical concentrations. An organism that needs to extract ecological information from these fluxes does so on temporal scales of seconds and spatial scales of millimeters. The purpose of this study was to quantify chemical signal distribution within the field. A section of Carp Creek, Emmett Co., MI was selected to examine the relationship between hydrodynamics and interflow odor plume characteristics. In order to imitate a pollution plume influx 72 hours post heavy rainfall, a chemical tracer was introduced in a way to mimic groundwater flow. Stream velocity and chemical fluxes were measured using an ADV and electrochemical microelectrode simultaneously. Thirty six different downstream locations in grid fashion were chosen for measurements. Measurements of the microscale structure of the chemical plume showed an intermittent signal that consistently changed with distance from the odor source, height above the substrate, and distance from the center line of the plume. Animals exposed to chemical fluctuations would either perceive or be impacted by periods where concentrations were significantly higher than the overall average concentration. These measurements show that standards for pollution exposure need to consider the turbulent dispersion of chemical signals rather than time−averaged models. The relationship between fluid dynamics, pollution exposure and organism physiology are complex and need to be evaluated in natural systems.

124.4 EERNISSE, D.J.*; PILGRIM, E.M.; MARKO, P.B.; Cal State Fullerton, U.S. EPA, Cincinnati, OH, Univ. of Hawaii at Manoa; *deernisse@fullerton.edu*

Trans−Pacific invasion drives North Pacific limpet (Lottiidae) species diversification

Limpets were collected from the intertidal of cooler high latitude portions of the northwest Pacific (NWP) and sequenced for two mitochondrial gene regions, 16S and COI, and nuclear cytosolic malate dehydrogenase (cMDH). We resolved about eight limpet species based on combined gene analysis, and these also differ in their morphology, but matching these to nominal species remains a challenge. The species differed on protected vs. exposed coasts of Hokkaido Island, Japan, and Vostok Bay, Sakhalin Island, and the Pacific coast of Kamchatka Peninsula all in Russia. Pacific and Sea of Japan coasts mostly differed in their limpet fauna. Further south, the species likely differ again. We found no overlap with three other "tsunami debris" species washed up on beaches in Oregon and Washington but originating just south of Hokkaido on northeastern Honshu Island, a different faunal province, and the site of the devastating 2011 tsunami. The striking pattern of regional differences in NWP limpets observed could be due to factors such as differences in temperature tolerance or barriers to larval dispersal. Combined analysis with available sequences and our various unpublished data sets representing most northeastern Pacific (NEP) Lottiidae species reveals that NWP species do not group with each other but are scattered across this NEP−dominated phylogeny. The results imply there have been at least seven separate trans−Pacific invasions over geological time. Collectively, the NWP/NEP species comprise a monophyletic endemic North Pacific radiation. Only one species, the shield limpet or *Lottia pelta* (Eschscholtz 1833), was distributed on both sides of the Pacific, but with greater mitochondrial haplotype diversity on the NWP side. This intriguing result could indicate a geologically recent invasion of the NEP by *L. pelta* vagabonds, now widespread.

11.6 EGGE, AR*; ELLER, OC; MORGAN, TJ; Kansas State University; *aegge@ksu.edu*

Genotype−by−environment interactions of demographic values in fluctuating thermal environments using Drosophila melanogaster

Organisms often experience a wide range of temperatures in nature, exhibited by daily and seasonal fluctuations. Ectotherms are particularly susceptible to these fluctuations and must alter their physiology in order to survive and reproduce in potentially stressful conditions. Assessment of egg laying and survivorship at different temperature regimes provides significant information on how different genotypes are affected by thermal fluctuations. *Drosophila melanogaster* have adapted to a range of thermal regimes and inhabit much of the world. They also provide us with a large base of genetic resources including the *Drosophila melanogaster* Genetic Reference Panel (DGRP). We chose forty genotypes from the DGRP to assess absolute lifetime fitness measures at two different fluctuating environments: 18° ± 6° C and 25°± 6° C (average 18.3° C and 25.3° C, respectively). Preliminary results indicate significant variation in survival and egg laying rates among these forty genotypes, which may lead to significant differences in demographic parameters such as lambda, net reproductive rate, and generation time. These parameters are important in assessing long−term population−wide, genotype−specific survival under natural conditions. Association mapping of these 40 genotypes will provide candidate genes involved in these thermally sensitive reproductive values.

35.4 EITING, TP*; PEROT, JB; DUMONT, ER; UMass Amherst; *tpeiting@bio.umass.edu*

Smelling the difference: How do the size and shape of the olfactory recess relate to olfactory airflow?

Many mammals house a blind recess in the back of their nasal fossa, the olfactory recess. Histological examinations and airflow modeling of the nasal fossa have been based on only a handful of fairly distantly related mammalian species. However, histological work that has investigated groups of closely related species has shown substantial variation in the morphology of the nasal fossa, including the olfactory recess. One such group is the New World leaf−nosed bats (Phyllostomidae). Within this family some species have less than 10% of the olfactory epithelium located within the olfactory recess, while in others it is more than a third. These different percentages stem from differences in morphology of the olfactory recess; those species that have low percentages have reduced and fairly simple olfactory recesses, while those with higher percentages have enlarged and more complex olfactory recesses. Based on previous modeling studies, we expect species with enlarged olfactory recesses to have lower rates of flow over their olfactory epithelium during inhalation, and to sequester more newly−inhaled air from the air currents during exhalation. Initial results from airflow models of four species of phyllostomid bats show little variation in patterns of airflow during inhalation and exhalation. Instead we find that changing flow rate within a species produces different patterns of flow throughout the nasal fossa, including the olfactory recess. These findings suggest that the size and morphology of the olfactory recess alone do not explain differences in olfactory airflow.

23.4 EKDALE, E.G.; San Diego State Univ; *eekdale@projects.sdsu.edu*

Implications for the origin of baleen as revealed by palatal vascularization of a gray whale calf (Cetacea, Mysticeti)

The origin of baleen in Mysticeti was a major transition during cetacean evolution. All extant baleen whales are edentulous in adulthood, but teeth develop in utero within open alveolar grooves. The teeth are resorbed prenatally and the alveolar grooves close as dermal papillae associated with baleen differentiate on the palate. Lateral nutrient foramina in place of the maxillary alveolar groove transmit arteries to the highly vascularized epithelium from which baleen develops. The vessels through the foramina are hypothesized to be branches of the superior alveolar artery given the position of the foramina in relation to the embryonic alveolar groove, and presence of the foramina often is used to reconstruct baleen in extinct taxa. However, branches of the greater palatine arteries that supply blood to the hard palate also may play a role in baleen vascularization. Baleen has epidermal and dermal origins, and medially positioned sulci radiating from the greater palatine canal towards developing baleen are observed in some fetal mysticetes. In order to identify the blood source to the baleen, the hard palate of a gray whale neonate was injected with latex and CT scanned. Vessels that supply blood to the baleen and surrounding tissues are in fact those within the superior alveolar canal. The greater palatine artery is restricted to its own passage that diverges within the maxilla posterior to the superior alveolar canal and opens onto the hard palate medial to the baleen. No direct connections between the palatine artery and vessels passing through the lateral foramina of the palate were observed. The results indicate that the presence of lateral nutrient foramina in mysticete fossils can be used as bony correlates for the presence of baleen in extinct taxa.

P1.36 EL−BIBANY, A.H.*; ZYLBERBERG, M.; DUMBACHER, J.P.; Univ. of California, Davis, California Academy of Sciences; *ahelbibany@ucdavis.edu*

Comparison of gut microbiota diversity among avian species from Papua New Guinea

Recent studies have highlighted the importance of the microbiome in determining the metabolism, physiology, and susceptibility to disease of a macroorganism. Despite recent advances in our understanding of the impact of microbiomes, relatively little remains known about the microbiomes of wild animals. In this study, we describe patterns of gut microbiota diversity among the bird families Alcedinidae, Apodidae, Colluricinclidae, Columbidae, Dicruridae, Hirundinidae, Laridae, Megapodiidae, Melanocharitidae, Meliphagidae, Monarchidae, Nectariniidae, Pachycephalidae, Rhipiduridae, Sturnidae, and Zosteropidae. In the fall of 2011, buccal and cloacal swabs were collected from 96 birds from the Milne Bay Province of Papua New Guinea. Samples were sequenced using Illumina next−generation technology and bacterial genomes were identified to the family level using BLASTn and BLASTx. Enterobacteriaceae, family to *Escherichia coli* and *Salmonella*, comprised the majority (>90%) of bacterial hits among all individuals. Other common bacterial families included Staphylococcaceae, Corneybacteriaceae, and Pasteurellaceae. We then used Shannon indices to quantify the gut microbiota diversity of each individual and examined variation of microbiota diversity by diet type and, within species, by sex. Our analyses show no significant difference in microbiota diversity among species with different diet types or between sexes. However, after accounting for the high proportion of Enterobacteriaceae, qualitative differences in bacterial composition appear to exist both by diet type and by sex. We discuss the possible implications of this variation to further elucidate the complex roles of diet type and sex in the structure of the gut microbiota of wild birds.

79.2 ELDER, L.E.*; SCHNEIDER, J. L.; HANCOCK, L.P.; SEIBEL, B.A.; University of Rhode Island, Univeristy of Rhode Island, Brown University; *leab83@my.uri.edu*

Metabolic depression as a common strategy for diel migrating zooplankton survival in oxygen minimum zones

Oxygen minimum zones (OMZs) are predicted to expand as global temperatures and CO_2 levels increase, and oceanic oxygen levels decrease. OMZs occur at intermediate depths in productive regions of the world's oceans where oxygen consumption is greater than oxygen supply. In such regions, the biomass of permanent deepwater species is limited. However, diel vertical migration is still prevalent, with many species that spend daytime at oxygen levels less than 10µM (1% oxygen). Here we assess the respiratory physiology of some abundant zooplankton that perform diel vertical migrations into OMZs. Oxygen consumption, and lactate production were measured to estimate the aerobic and anaerobic contributions, respectively, to total metabolism under conditions that mimic its day− (1% oxygen, 10 C) and night−time (21% oxygen, 20 C) conditions. In all species tested, oxygen consumption was lower in the hypoxic treatment. Anaerobic metabolism was elevated but did not compensate entirely for the reduced rate of aerobic metabolism. This work demonstrates that the vertically migrating zooplankton are employing metabolic depression to survive day time forays into OMZs. Retreat to shallow waters at night is required for foraging and to burn off the accumulated oxygen debt. As global warming continues, OMZs are expected to expand vertically, compressing the nighttime habitat of diel migrating zooplankton, which has implications for the ecology and biogeochemical cycling in the region.

3.2 ELDERBROCK, E.K.*; SMALL, T.W.; SCHOECH, S.J.; University of Memphis; *kldrbrck@memphis.edu*

Nestling begging rate predicts adult physiological stress response in Florida scrub−jays (Aphelocoma coerulescens)

The young of altricial bird species communicate nutritional need to adults by begging. Begging is hypothesized to be an honest signal and is regulated in part by corticosterone (CORT), the avian glucocorticoid secreted in response to stressful stimuli. Increased CORT exposure during development may have programming effects that shape an individual's adult phenotype. If begging rate represents nutritional state and is being regulated by CORT, then begging rate may be a useful indicator of the conditions that the nestling is developing under and thus may be predictive of the individual's future phenotype. We investigated the effects of increased CORT levels on nestling begging, as well as the relationship between begging rates and an individual's adult CORT response. We manipulated CORT levels of Florida scrub−jay *(Aphelocoma coerulescens)* nestlings by administering exogenous CORT on days 8−11 post−hatch to a single nestling within each treatment nest. On days 5, 8, 11, and 13 post−hatch we monitored nestling behavior at treatment and control nests using high−def video cameras. We subsequently caught the birds at either nutritional independence (~70 days of age) or 1−year of age and determined stress responsiveness with a standard capture and restraint protocol. To date, our results suggest that administration of CORT does not alter begging rate in CORT−treated nestlings although sibling competition may be masking the effect of CORT. In addition, we found a strong positive relationship between begging rate as a nestling and stress−induced CORT secretion as an adult, suggesting that early life experiences influence the development of the adult phenotype.

P3.90 ELLER, OC*; EGGE, AR; MORGAN, TJ; Kansas State University; *oceller@ksu.edu*
Effect of Cooling Rate on the Rapid Cold Hardening Response in Drosophila melanogaster
Climate is a significant environmental factor that influences the distribution and abundance of most organisms on Earth. One constantly changing component of climate is temperature and we are interested in how organisms respond to stress brought on by temperature fluctuations coupled with cold stress. *Drosophila melanogaster* is a cosmopolitan species that inhabits many different environments throughout the world and exhibits a wide−range of physiological thermal adaptations. Rapid cold hardening (RCH) is a short−term acclimation response in which an organism is exposed to a non−lethal cold temperature before being exposed to an extreme cold temperature. This non−lethal pretreatment improves cold survival for individuals that have the ability to acclimate over a short period of time. Previous experiments investigating the RCH response have directly transferred flies from rearing temperature to pretreatment to extreme cold exposure. These direct shifts do not translate to natural conditions where organisms are gradually exposed to new temperatures. Our goal was to compare experimental environments of a more natural context to see if or how the RCH response changed in relation to direct transfer experiments. We used thermal ramping to cool the experimental environment at two ecologically natural but different rates and then compared survivorship after an extreme cold shock between flies that received a ramping pretreatment and flies that received a direct transfer pretreatment. Our results indicate that neither the speed of cooling nor direct transfer pretreatment have a significant effect on an individual's ability to acclimate and survive extreme cold temperatures. These results are significant as they demonstrate that direct and ramping RCH pretreatments are both ecologically relevant measures of thermal performance.

110.6 ELLERBY, DJ*; HITCHCOCK, AC; Wellesley College; *dellerby@wellesley.edu*
Quo vadis? Mechanical constraints on fish escape behavior
Successful predator evasion is essential to the fitness of many animals. Flexibility in escape behavior may be adaptive, as it reduces predictability and allows for behavioral modulation. High escape velocities and accelerations increase escape success, but biomechanical factors may constrain the behavioral range over which performance can be maximized. There may therefore be a trade−off between behavioral flexibility and mechanical performance. We have used fish escape responses to examine this trade−off, determining the full repertoire of escape behavior for individual bluegill sunfish and linking this to performance. Fish escapes involve an initial C−bend of the body axis, followed by variable steering movements. These generate thrust and establish the escape direction. Direction changes during the C−bend are relatively constrained, and the most frequent directions are associated with high performance. Individuals differ in escape behavior, magnifying overall variability. Steering in the subsequent stages of the escape also affects performance, with turns away from the stimulus reducing velocity. Our observations suggest that escape behavior is mechanically constrained, and that this imposes a performance cost for behavioral variation. This has important implications for understanding the scope and control of intra− and inter−individual variation in escape behavior and the associated costs and benefits.

25.3 ELLERS, O.; JOHNSON, A.S.*; GUTTENPLAN, K.; MOTOKAWA, T.; Bowdoin College, Tokyo Institute of Technology; *ajohnson@bowdoin.edu*
The bounce in a seastar's step: classifying gaits in underwater legged locomotion
We describe a novel mode of underwater legged locomotion in which a seastar, *Protoreaster nodosus*, uses the coordinated action of podia to develop a bouncing gait when moving relatively quickly. This mode of locomotion can be provoked by poking, especially after a righting reaction; so perhaps this behavior is part of an escape response. Fastest average speeds are about 2 mm s^{-1} and the periodicities of the bounces range from 5 to 12 seconds per step with larger seastars having longer periods. This mode of locomotion is similar to terrestrial walking in that the seastar maintains contact with the ground at all times, but it is dissimilar to classic inverted pendular walking in several ways. In the classic inverted pendulum, potential energy gained on each rise of the center of mass is converted to kinetic energy as the center of mass falls, with kinetic and potential energy being of similar magnitudes. But in this seastar, kinetic energy is three orders of magnitude less than potential energy. Potential energy is, however, converted to kinetic energy with each bounce but most of the kinetic energy is lost with each step, making each step more of a thud than a bounce. Greater average horizontal speed is correlated with greater fluctuations in vertical speed, and horizontal speed develops as bounces form during an accelerative phase at the start of movement. Once the bounces have developed, the temporal relationship of vertical and horizontal velocity most resembles that of terrestrial running, despite the lack of an aerial phase. This novel mode of locomotion explores some limits and characteristics of underwater legged locomotion.

P3.115 EMERICK, A/R; University of South Florida; *aemerick@mail.usf.edu*
Status of a Translocated Florida Sand Skink Plestiodon reynoldsi Population: Criteria for Success
The translocation of organisms is becoming a frequently used tool in conservation biology. Translocation efforts involving small reptiles are replete with failed attempts to establish viable populations, owing to a paucity of data on life history or the ecological conditions that the organisms require. Logistical and temporal limits of monitoring, combined with ambiguous metrics concerning "success", has led to few advances regarding reptile translocation. Successful populations display fitness through the survival and reproduction of both the founding population, and the survival and reproduction of at least one subsequent generation at consistent or increasing levels. A small population of the Florida Sand Skink *Plestiodon reynoldsi* was relocated to a conservation site in 2007 to investigate the environmental associations and demography of a translocated population. The current study used mark−recapture data of individuals collected during two separate sampling events during the sixth year after the translocation occurred. Trends in population size, survival, reproduction, and generation structure were found by combining data from all years post−translocation. Novel individuals captured in the sixth year exceeded captures during every prior sampling event since monitoring began, with founding individuals representing only 10% of total captures. Despite this reduction, juvenile captures also increased from previous years, indicating successful reproduction by first and possibly second filial generations. These results are significant in the light of the history of reptile translocations, and the methods applied here will contribute to developing more effective management strategies for reptile translocations.

P3.149 ENG, CM*; ARNOLD, AS; LIEBERMAN, DE; BIEWENER, AA; Harvard University; *cmeng@fas.harvard.edu*

Length changes of the human iliotibial band in relation to hip motion

The human iliotibial band (ITB) is a complex fascial structure crossing the hip and knee and its role in locomotion is poorly understood. A role for the ITB in lateral hip stabilization has been previously proposed. We suggest that the ITB may also function to store and recover elastic energy. The ITB's ability to perform these functions during locomotion depends on its length changes and stresses, which are influenced by the ITB's moment arms (MAs), its material properties, and forces generated by in−series muscles. To test hypotheses about ITB function, MAs and muscle force estimates were obtained from 5 fresh human limbs. MAs of gluteus maximus (GMax) and tensor fascia lata (TFL) muscles inserting on the ITB (i.e., ITB muscle−tendon units) for hip flex/extension and ab/adduction were obtained by the tendon excursion method. Portions of GMax and TFL inserting on the ITB were weighed to estimate the force that these muscles potentially transmit to the ITB. Because muscles that insert on the ITB are located superficially on the thigh, these MTUs have large hip MAs. While all GMax regions have MAs that extend the hip, proximal GMax has a hip abduction MA while distal GMax has a hip adduction MA. The antagonistic hip ab/adduction MAs of GMax may keep the ITB taut during the stance phase to laterally stabilize the limb. The large hip extension MAs of GMax may stretch the ITB during hip flexion and store elastic energy, suggesting the human ITB may play dual roles during locomotion. We estimated that all of TFL and as much as 50% of GMax fibers insert on the ITB. Overall, these data indicate that due to large hip MAs and the potential for substantial muscle loading, ITB undergoes large length changes during locomotion. These data will be integrated with a musculoskeletal model to further explore ITB function.

P1.141 ENSMINGER, D.C.*; SHARICK, J.T.; SOMO, D.A.; HOUSER, D.S.; CROCKER, D.E.; Sonoma State University, California, Rohnert Park; *ensminge@seawolf.sonoma.edu*

Effects of an acute stimulation of the HPA axis on sexual and stress hormones in male Northern Elephant Seals

Little is known about variations in hypothalamic−pituitary−axis (HPA) responsiveness and its impacts on metabolism in wild pinnipeds. To characterize changes due to acute stress, 18 free living adult male northern elephant seals were challenged with an intramuscular injection of slow release adrenocorticotropic hormone (ACTH) over 3 sample periods: early in the breeding season, after 70+ days of the breeding fast and during peak molt. Subjects were blood sampled every 30 minutes for 2 hrs post−injection. Breeding animals were recaptured and sampled at 48 hrs. This was not possible in molting subjects due to animal density and mobility. In response to ACTH, cortisol increased two−three fold in all groups, and remained elevated at 48 hrs in early breeding subjects. ACTH was a stronger secretagogue for aldosterone, causing a three−eight fold increase. Cortisol and aldosterone responses did not vary between groups but were significantly correlated among individuals. Endogenous ACTH was suppressed by the challenge in late breeding males, particularly at 48 hrs. Cortisol increases resulted in elevations in plasma glucose only during molting. ACTH challenge caused suppression of testosterone and thyroid hormone (T3) at 48 hrs in early breeding males. ACTH challenge increased plasma non−esterified fatty acids and blood urea nitrogen in all study groups. These data suggest that sensitivity of the HPA axis is maintained but the metabolic impacts of cortisol and feedback inhibition of the axis varies with life history stage. Strong impacts of the challenge on testosterone, thyroid hormone and protein sparing suggest the importance of maintaining low cortisol levels during breeding.

48.3 ENSMINGER, A.L.*; ELMORE, A.G; PITA, D.L.; FERNANDEZ−JURICIC, E.; Purdue University, West Lafayette, IN; *amanda.ensminger@gmail.com*

In the Eye of the Beholder: Intraspecific Variation in Retinal Physiology and Modeled Visual Perception in Two Species of Passerines

Many theoretical models on anti−predator behavior, foraging behavior, and mate−choice assume that there is no intraspecific variation in visual perception. We tested whether individual house finches differ in the absorbance of their oil droplets (which influences the ability to distinguish between different colors), and whether house sparrows vary in the absolute density of cones (which affects spatial resolving power), and in the relative density of single and double cones (which affects chromatic/achromatic contrasts). We found that, for all types of photoreceptors, individual house finches differed significantly in oil droplet absorbances, and that these translated into differences in modeled estimates of chromatic contrast. For house sparrows, we found significant individual differences in the density of cones, overall and for each type, as well as relative densities and ratios of types. These translated into significant individual differences in modeled estimates of perception (both chromatic contrast and anatomical spatial resolving power). Further, we found that cone densities of each type were positively correlated, and that individual estimates of chromatic contrast did not correlate, either positively or negatively, with estimates of spatial resolving power. These results have relevant implications for intraspecific variation in behaviors of fitness consequence.

21.5 ENZOR, L.A.*; PLACE, S.P.; University of South Carolina; *enzorl@email.sc.edu*

Energy trade−offs and cellular damage: The physiological response of the Antarctic fish Trematomus bernacchii to global climate change

Studies have projected future changes in sea surface temperature and *p*CO_2 levels will impact higher latitudes to a greater extent than temperate regions. For notothenioid fishes of the Southern Ocean, evolution in extremely stable, cold waters have resulted in several adaptations which have left these fishes more susceptible to oxidative stress, and poorly prepared for global climate change. We have analyzed the metabolic and cellular response of *Trematomus bernacchii* to a long−term, multi−stressor scenario relevant to the predicted changes in the Southern Ocean. By combining whole animal respirometry with cellular level analysis of energy allocation, osmoregulatory mechanisms and cellular damage, we aimed to determine if acclimation to increased sea surface temperature (4°C), increased seawater *p*CO_2 levels (1000 µatm), or a combination of these two parameters result in energetic trade−offs and exacerbated cellular damage. Our data suggest a synergistic relationship exists between elevated temperature and *p*CO_2, as the combination of these variables further elevates metabolic rates and delays the acclimatory response. Overall, long−term acclimation to experimental treatments resulted in an increased capacity for acid base regulation as well as moderate increases in antioxidant capacity. In response to the added energetic demands of these pathways, *T. bernacchii* also displayed a significant increase in metabolic capacity. However, our data indicate this increase in capacity is insufficient to fully compensate for the added energetic demands of environmental change and that cellular homeostasis is ultimately achieved through energy trade−offs.

P1.127 ERNST, DFK*; LYNN, SE; BENTLEY, GE; Univ. of California, Berkeley, College of Wooster; *dfkernst@berkeley.edu*
Acute Restraint Stress Decreases Gonadotropin−Inhibitory Hormone Immunoreactivity in the Zebra Finch Hypothalamus
Gonadotropin−inhibitory hormone (GnIH) acts to inhibit reproduction at all levels of the hypothalamo−pituitary−gonad (HPG) axis. GnIH in the hypothalamus increases with acute stress in some birds and mammals, thus representing a mechanism by which stress can inhibit reproduction. The zebra finch is an opportunistic breeder for which timing of breeding is closely associated with unpredictable environmental cues. Thus, the zebra finch GnIH system may be more sensitive to stress than that of seasonal and/or continuous breeders. To test this, we collected tissues from males and females in mixed−sex aviaries immediately after capture or following 60 min of restraint. As expected, restraint significantly increased plasma corticosterone in males and females. Contrary to studies on other species, immunocytochemistry for GnIH revealed significantly fewer GnIH immunoreactive (−ir) cell bodies in the stressed birds. There was no sex difference in GnIH cell number in either treatment or control animals. Our data indicate that the GnIH system of zebra finches responds strongly to acute stress, but by a reduction of GnIH peptide, rather than the predicted increase. Further research will determine whether the stress−induced reduction of GnIH−ir cell bodies is a consequence of increased GnIH release or decreased gene expression in response to restraint. Regardless, our data suggest that although GnIH responsiveness to stress appears to be conserved, the directionality of response does not. Variation in the GnIH response to stress among species might be the result of ecological adaptations or species differences in GnIH function, though additional research is necessary to draw firm conclusions.

48.6 ERNST, D.A.*; GENTRY, K.; LOHMANN, K.J.; University of North Carolina at Chapel Hill; *dernst@live.unc.edu*
Finger on the Pulse: Evidence for Magnetite−Based Magnetoreceptors in the Caribbean Spiny Lobster
The Earth's magnetic field plays an important role in guiding diverse species by providing both directional (compass) and positional (map) information. However, the transduction mechanisms that underlie magnetic field detection have not been clearly established in any animal. One hypothesis proposes that crystals of the mineral magnetite function as receptors for the magnetic sense. By twisting into alignment with the geomagnetic field, single−domain magnetite crystals may activate secondary receptors or open ion channels. Magnetic material thought to be magnetite has been detected in the Caribbean spiny lobster (*Panulirus argus*), the only invertebrate known to possess both a magnetic compass and a magnetic map. To determine if these magnetic particles are associated with magnetoreception, lobsters were subjected to strong, pulsed magnetic fields capable of re−aligning the magnetic moment of biogenic magnetite crystals. Lobsters were subjected to a pulsed field directed from posterior to anterior and either parallel to the geomagnetic horizontal component (North pulse) or antiparallel to it (South pulse). An additional group of control lobsters was handled but not pulsed. The following morning, lobsters were tethered within a water−filled arena and allowed to walk for 30 minutes at the capture location. Control lobsters were not significantly oriented as a group. In contrast, lobsters subjected to the North pulse oriented approximately west (mean angle = 259°). The South pulse group oriented approximately northeast (mean angle = 47°). The distributions of the two pulsed groups were significantly different. These results strongly suggest that spiny lobsters possess magnetoreceptors based on magnetite.

23.2 EVANS, N*; PAULAY, G; Univ. of Florida; *evansnat@ufl.edu*
Symbionts are couch potatoes: rounded bodies and loss of swimming in symbiotic "swimming" crabs.
Most members of the brachyuran family Portunidae swim with an efficiency unmatched by any other clade of crabs. This has been attributed to a number of morphological adaptations typical of the group including having a broader, more laterally streamlined carapace and highly modified posterior legs shaped like paddles. Yet some portunids exhibit a divergent ecology and morphology that suggests they have abandoned a natatory lifestyle. Among these, members of the subfamily Caphyrinae (28 spp.) have evolved commensal associations with a number of organisms including algae, sea cucumbers and soft corals. Relative to most portunids, these crabs are smaller, less streamlined and many have nearly or completely lost the paddle shape of their posterior legs. Phylogenetic analyses presented here reveal significant phylogenetic support for Caphyrinae being derived within the portunid genus *Thalamita* (91 spp.). This surprising result suggests that while *Thalamita*'s significant diversification may have involved limited morphological change in which carapace shape and allometric growth trajectories remained highly conserved, morphological diversification was significant and rapid during the ecological diversification of Caphyrinae, and resulted in the evolution of two (or more) novel allometric growth trajectories corresponding to the genera *Caphyra* and *Lissocarcinus*. To investigate these hypotheses I am using geometric morphometric methods, collecting data on shape, size, and allometric growth of the carapace. Final datasets will be analyzed using an approach that combines fossil calibrated molecular dating with phylogenetic, model−based tests capable of inferring patterns and rates of morphological evolution. Progress on this research will be discussed.

P3.89 EVERMAN, ER*; MORGAN, TJ; Kansas State University; *evermane@ksu.edu*
Age−related change in cold stress tolerance in Drosophila melanogaster
Organisms occur in environments that vary spatially and temporally throughout their lifespans. Resistance to cold stress is one important fitness trait that is expected to decline through ontogeny; however this general expectation is based on the response of a small number of genotypes of *Drosophila melanogaster*. To further characterize this change in cold stress resistance, we performed Rapid−Cold Hardening (RCH) screens on 49 genetically distinct lines of the *Drosophila melanogaster* Genetic Reference Panel (DGRP) at early (5−7 days) and late (20−22 days) age. Consistent with previous investigations of RCH and the DGRP lines, we observed a wide range of variation between lines at each age point. In addition, cold stress resistance differs significantly ($p < 0.05$) between early and late aged flies. However, we observed that the direction of the change in expression of cold stress resistance varies among lines as well, with several lines increasing in cold stress resistance as they age. The difference in cold resistance between ages combined with the difference in direction of the change between lines suggests that cold stress resistance as characterized by RCH screens is influenced by a number of complex genetic interactions. To fully characterize these interactions, we will continue screening the remaining 143 lines in the DGRP and use association mapping to isolate regions of the genome that are likely tied to the age−related change in cold stress tolerance.

P3.75 FABER III, A.R.*; GOY SIRSAT, S.K.; SIRSAT, T.S.; DZIALOWSKI, E.M.; SOTHERLAND, P.R.; Kalamazoo College, Univ. of North Texas; *Alan.Faber10@kzoo.edu*

Development of endothermy: getting to the heart of the problem

Precocial birds develop from ectothermy to endothermy during the final days of incubation and the first 24 hours after hatching. Onset of endothermy and an ability to thermoregulate are coupled with ductus arteriosus closure and a noteworthy upregulation of metabolic activity. The present study examined changes in whole animal oxygen consumption as an indicator of endothermic capacity in precocial Pekin ducklings (*Anas pekin*). Parameters of heart mass, hemoglobin, and hematocrit were measured to elucidate changes in blood oxygen carrying capacity. Mitochondrial respiration in permeabilized cardiac fibers from left and right ventricles was measured to examine cellular level metabolic capacity. Measurements were made on day 24 of incubation, at internal and external pipping stages, and at 12 to 24 hours after hatching. When exposed to cold temperature, ducklings were able to maintain an elevated body temperature and metabolic rate only after hatching. There was a significant increase in body mass, coupled with a decrease in yolk sac mass, as ducks aged. No significant differences were documented in hemoglobin or hematocrit between age groups. Associated with the onset of endothermy, hatchlings had a significantly larger relative ventricle than earlier stages of development. Increased heart mass was associated with an increase in cardiac oxidative phosphorylation (OXPHOS) through Complex I in the left, but not right ventricle. In hatchlings, there was a significant increase in OXPHOS through Complex I + II within the left ventricle compared with the right. These results suggest that increased ventricle size and mitochondrial respiration within the left ventricle of hatchlings occurs in response to increased energy demand brought about by acquisition of endothermy and the closing of the ductus arteriosus.

5.1 FABRE, A.−C.*; GOSWAMI, A.; PEIGNé, S.; CORNETTE, R.; MNHN/UCL, UCL, MNHN, MNHN; *fabreac@gmail.com*

Morphological integration in the forelimb of musteloid carnivorans

The forelimb forms a functional unit that allows a variety of behaviours and needs to be mobile, yet at the same time stable. Both mobility and stability are controlled at the level of the elbow joint. Here, we study the morphological integration between each long bone of the forelimb at the level of the entire arm, as well as at the elbow joint, in musteloid carnivorans. To do so, we test shape co−variation and the degree of morphological integration using two block partial least square approaches performed on surface 3D geometric morphometric data. Our results show that morphological integration is stronger for bones that form functional units and whose function is crucial in the life−history of these animals. Different results are obtained depending on the level of investigation: for the entire arm, results show a greater degree of shape co−variation between long bones of the lower arm than between the humerus and either bone of the lower arm. Thus, at this level the functional unit of the lower arm is comprised of the entire radius and ulna, permitting rotational movements of the lower arm. At the level of the elbow, results display a stronger shape co−variation between bones allowing stability (humerus and ulna) than between bones allowing mobility (ulna and radius and humerus and radius). Thus, the critical functional unit appears to be the articulation between humerus and ulna providing the stability of the joint.

P3.199 FAHEY, N.M.*; STUDNICKA, B.T.; KROHMER, R.W.; Saint Xavier University, Chicago, IL; *krohmer@sxu.edu*

Effect of Sex Steroid Hormones on Neurogenesis in the Injured Red−Sided Garter Snake Brain

Injury to the homeotherm brain results in the upregulation of the estrogen−synthesizing enzyme aromatase. While peripheral estrogens have been shown to be neurogenic in birds and mammals, the possible effect of sex steroid hormones on the injured reptilian brain has not been examined. To determine whether or not injury−induced aromatization and or, local estrogen provision can affect neurogenesis following mechanical brain damage, adult male red−sided garter snakes (*Thamnophis sirtalis parietalis*) were castrated and implanted with either an empty silastic tube (control) or an individual or combination of tubes containing testosterone, estradiol or the anti−aromatase 1, 4, 6−androstatriene−3, 17−dione (ATD). Fourteen days after implantation, animals were given a unilateral penetrating brain injury. All animals were then injected with the thymidine analog 5−Bromo−2'−deoxyuridine (BrdU) on the following schedule: immediately following surgery, 24 hours after surgery and 24 hours prior to perfusion. Animals were perfused 96 hours after lesions were administered, cryoprotected overnight, snap frozen on dry ice and sectioned on a cryostat in the coronal plane. Tissues were visualized using an antibody against BrdU. Sections containing the injury site and surrounding areas (III ventricle and preoptic area (POA) were examined for neurogenesis. The relative density of BrdU positive cells for each of the treatment groups was assessed and their locations recorded.

88.4 FAHLMAN, A*; BRODSKY, M; ROCHO−LEVIN, J; LEVINE, G; LORING, S/H; KLEINHENZ, D; AUSTIN, T; Texas A&M Univ. Corpus Christi, V.M.D. Consulting, Dolphin Quest Oahu, Dolphin Quest Oahu, Beth Israel Deaconess Medical Center, Paxarms Inc.; *andreas.fahlman@tamucc.edu*

Lung mechanics in live cetaceans

For breath−hold diving mammals time underwater needs to be maximized to enhance foraging efficiency. However, O_2 stores are finite, so the animal eventually must return to the surface to renew this resource. Functional anatomic adaptations, like compliant lungs and stiff conducting airways in comparison to their terrestrial counterparts is a major principal in our current understanding of their respiratory physiology. Recent work indicates that there is great variability in the structural properties of the respiratory system between marine mammal species. Our objective was to measure the pulmonary compliance, respiratory flow−rates, and end−tidal gases in six bottlenose dolphins (body mass range: 167−250 kg), under a variety of circumstances. A custom made pneumotachometer allowed measurement of respiratory flow rates, an esophageal balloon catheter measured the pressure over the lung, and a fast response O_2 and CO_2 analyzer measured expiratory gas composition. A total of 128 spontaneous and 41 forced breaths (trained "chuffs") were collected. The average (± SD) expiratory duration was significantly longer (spontaneous: 0.31 ± 0.04 sec; chuff: 0.26 ± 0.04 sec) and the inspiratory duration shorter (spontaneous: 0.43 ± 0.05 sec; chuffs: 0.66 ± 0.11 sec) during spontaneous breaths as compared with chuffs. Maximum expiratory flow rates exceeded 120 l sec^{-1}, while maximum inspiratory flow rates ranged between 12 to 30 l sec^{-1}. The esophageal pressure suggests that dolphins exhale passively during spontaneous respiration, but actively during chuffs. Our results provide data that confirm an amazing respiratory capacity in cetaceans, and provide new data on chest compliance in dolphins.

103.2 FAIRHURST, G.D.*; MARCHANT, T.A.; SOOS, C.; MACHIN, K.L.; CLARK, R.G.; Univ. of Saskatchewan | Environment Canada, Saskatoon, Univ. of Saskatchewan, Saskatoon, Environment Canada | Univ. of Saskatchewan, Saskatoon, Environment Canada | Univ. of Saskatchewan, Saskatoon; *graham.fairhurst@usask.ca*

Experimental relationships between plasma− and feather−levels of corticosterone in a free−living bird

Integrated measures of corticosterone (CORT), such as from feathers ($CORT_f$), have intuitive appeal because they incorporate the duration, as well as the amplitude, of glucocorticoid secretion. However, $CORT_f$ is a fundamentally different measure of physiology than an instantaneous sample of CORT from plasma, so it is unclear as to when and if these measures should be correlated. We hypothesized that $CORT_f$ should correlate with instantaneous measurements of plasma CORT when the latter reflect sustained changes in the activity of the hypothalamic−pituitary−adrenal axis. To test this, we experimentally manipulated levels of plasma CORT in wild nestling tree swallows (*Tachycineta bicolor*) using 5−day time−release CORT pellets, and measured plasma CORT and before, during, and at the end of hormone manipulation (days 7, 9, and 11 post−hatch, respectively). $CORT_f$ and plasma CORT were significantly positively related only when the latter was at its highest and most variable (day 9). Our results demonstrate that $CORT_f$ from free−living birds reflects plasma CORT, but correlations may not always be expected, especially if elevations in plasma CORT are relatively modest and of short duration. Future studies aiming to better understand $CORT_f$ from nestlings will benefit from manipulating the nest environment.

67.6 FALKINGHAM, P L *; GATESY, S M ; Royal Veterinary College, Brown University; *pfalkingham@rvc.ac.uk*

Using experimental and simulated footprints to interpret dinosaur limb motion

Dinosaur tracks offer a primary source of evidence for understanding not only the behaviours of individual taxa, but also the broader view of locomotor evolution through time. Track morphology emerges from the dynamic, coupled interaction between moving feet and substrate. Deep tracks, in which the foot has penetrated far into the sediment, record the most kinematic data. However, traditional methods of analysis (2D surface outlines) fail to capture the fundamentally volumetric nature of deep track morphology and formation essential to their interpretation. In order to fully extract these data, we must visualize sub−surface foot movements and sediment responses within opaque substrates. To this end, we analysed guineafowl traversing a bed of poppy seeds, using X−ray Reconstruction of Moving Morphology (XROMM) to reconstruct the 3D kinematics of the distal limb both above and below the surface for the first time. Guineafowl limb morphology and motion were incorporated into a discrete element simulation to produce virtual tracks in which the motion of individual particles could be dynamically observed. By combining experimental data with simulations, we were able to reconstruct foot motion paths and the reaction forces in the sediment of a 200 million year old fossil dinosaur track.

P2.162 FALSO, P.G*; NOBLE, C.A.; HAYES, T.B.; Slippery Rock University, University of California, Berkeley; *paul.falso@sru.edu*

Corticosterone Treatment Alters Blood Cell Differentials and Function for Long−term Periods in Laboratory and Wild−caught Amphibian Models.

Amphibians may experience stressful habitat conditions as a result of human habitat alteration. Interrenal dysfunction and increased plasma glucocorticoids (corticosterone) have been observed in amphibians in altered habitats. The effect of long−term stress on amphibian immunity is not well understood, however. We modeled a long−term endocrine stress scenario by elevating plasma corticosterone in two species of adult amphibians and examined effects on white blood cell differentials and innate immune activity. Plasma corticosterone was elevated in adult American bullfrogs (*Lithobates catesbeianus*) by surgically implanting corticosterone capsules and in adult African clawed frogs (*Xenopus laevis*) by immersion in corticosterone−treated water. Elevated plasma corticosterone levels increased the ratio of peripheral neutrophils to lymphocytes in both *L. catesbeianus* and *X. laevis*, and decreased blood eosinophil concentrations in *L. catesbeianus* over a long−term period. Whole blood oxidative burst activity generally correlated with blood neutrophil concentrations, and thus was increased with CORT treatment, significantly in *L. catesbeianus*. In *L. catesbeianus*, an endogenous response of eosinophils and lymphocytes to implanted capsules was generally attenuated by corticosterone treatment, suggesting an alteration of immune response to large particles or macroparasites. Blood monocyte concentrations and blood basophil concentrations were not significantly altered by corticosterone treatment in either *L. catesbeianus* or *X. laevis*. Our results show that long−term stress can alter amphibian immune parameters for extended periods of time and may play a crucial role in disease.

132.7 FALSO, P.G.*; GALLIPEAU, S.; HAYES, T.B.; Slippery Rock University, University of California, Berkeley; *paul.falso@sru.edu*

Amphibians Stressed By Agricultural Land Use Have Altered Immunity and Increased Parasitic Infections

Changing environmental conditions have dramatically decreased global amphibian populations. Increases in susceptibility to pathogens may result from stressful habitat conditions and subsequent disruption of immune response. Amphibian populations in agricultural regions are subject to diverse environmental stressors resulting from human habitat manipulation. In the current study we examined the connection between land use, physiology, and disease ecology of amphibian populations in three agricultural watersheds in California, USA. The invasive American bullfrog (*Lithobates catesbeianus*) was used as a surrogate model to examine possible effects of agricultural contaminants and habitat disruption on sensitive native amphibian populations in the Salinas, San Joaquin, and Sacramento River systems. We analyzed the endocrine and immune function of bullfrogs collected at sites along a gradient of agricultural land use within the three river systems. Elevated plasma stress hormone levels (corticosterone) and altered white blood cells (differentials and activity) were observed in bullfrogs collected from agricultural sites compared to sites upstream of agriculture. Additionally, bullfrogs collected in an agricultural site had increased infections with *Echinonstoma spp* parasites in comparison to a reference site upstream. Our study indicates that altered environmental conditions in agricultural regions may lead to endocrine and immune disruption of amphibians, and result in increased disease and further population declines.

99.3 FAMIGLIETTI, A.*; SEGADE, F. ; DAVIDSON, B.; Swarthmore College, Swarthmore College ; *afamigl1@gmail.com*

Investigating the emergence of the matrix protein fibronectin in the urochordate Ciona intestinalis

The glycoprotein fibronectin (FN) is a major instructive molecule in the extracellular matrix (ECM) of vertebrates that contains three domains: fibronectin type 1 (FN1), type 2 (FN2), and type 3 (FN3). FN performs many cellular functions including mediation of cell movement, proliferation, and differentiation by binding to receptors on the cell surface (Tucker and Chiquet−Ehrismann, 2008). A recent analysis of the fully sequenced FN gene in the urochordate *Ciona intestinalis* shows a characteristic "vertebrate−like" arrangement of FN domains that is not found in other invertebrates. In order to investigate the expression pattern of this gene, we fused the intergenic region upstream of Fn to a GFP reporter. The reporter construct was electroporated into *Ciona* embryos and expression was evaluated at various developmental stages. Our findings indicate that the FN enhancer drives expression predominantly in the notochord lineage, beginning at early tailbud stage (~9.5H after fertilization). Further studies of the *Ciona* FN protein may provide insight into the ancestral role of FN in the shared tunicate/vertebrate ancestor. We plan to next knockdown *Fn* expression through RNAi interference in order to determine any potential effect on *Ciona* development.

37.6 FARHADIFAR, R.*; BAER, C.F.; ANDERSEN, E.; FABIG, G.; MüLLER−REICHERT, T.; DELATTRE, M.; NEEDLEMAN, D.J.; Harvard, Cambridge, UFL, Gainesville, NW, Evanston, TUD, Germany, LBMC−ENS, France; *rfarhadifar@cgr.harvard.edu*

Scaling of Subcellular Structures in C. elegans by Internal Selection

The size of Eukaryotic cells varies nearly billion fold range in volume. Core biological processes, such as cell division, vary in cells of different size, but little is known about its evolutionary or mechanistic basis. We are using the first embryonic division in *C. elegans* to study the evolution of the mitotic spindle, the subcellular structure that segregates chromosomes during division. Examining intraspecies variation can provide valuable evolutionary insights because the short evolutionary distances involved allow process to be dissected in detail, but the extent of intraspecific variation of sub−cellular traits is unknown. We developed a high−throughput microscopy platform that allows us to obtain quantitative information on spindles from thousands of embryos in hundreds *C. elegans* lines. We found extensive standing genetic variation among natural isolates of *C. elegans* for all traits we studied. Mutations are the ultimate source of variation between individuals. We studied how spontaneous mutations modify the spindle by characterizing cell division in a panel of mutation accumulation (MA) lines. Comparing the spectrum of variations in MA lines to those we observe among natural isolates allows us to draw inferences about how selection and population dynamics combine with raw mutational inputs to shape the spindle. Taken together, our results indicate that selection continuously acts to scale the structure and dynamics of the spindle to match cell size. The presence of this internal selection implies that the long term evolutionary dynamics of cell−division traits are dominated by the evolution of cell size, which we confirm by studying how these traits vary across ~40 species of nematodes of known phylogeny.

P3.38 FARIA, S.C.; THURMAN, C.L.*; MCNAMARA, J.C.; Universidade de São Paulo, Ribeirão Preto, University of Northern Iowa, Cedar Falls; *thurman@uni.edu*

Variation in Osmoregulatory Ability among Ten Species of Fiddler Crabs (Crustacea, Brachyura) from the Atlantic Coast of Brazil

Osmoregulatory ability was assessed in ~70 populations of 10 species of semiterrestrial crabs (genus *Uca*) distributed along the Atlantic coast of Brazil between Amapá and Santa Catarina. In the laboratory, crabs were exposed for 5 days to media ranging in osmolality from 15 to 3550 mOsm kg H_2O^{-1}; hemolymph osmolality was then measured in 10−¼L aliquots using a Wescor 5520 osmometer. Survivorship, lower− and upper median−effective osmolality (UC_{50}) and isosmotic concentration [ISO] were estimated in populations for which habitat osmolality was also measured. All species were excellent hypo−/ hyperosmoregulators. Mean [ISO] was <600 mOsm kg H_2O^{-1} in the lone oligosaline species, between 650 and 770 mOsm kg H_2O^{-1} in the seven mesosaline species, and >800 mOsm kg H_2O^{-1} in the two eusaline species. Intraspecific variation in [ISO] was significant only in *U. rapax*, emphasizing its importance as a physiological set−point. Although UC_{50} varied intraspecifically in six species, habitat osmolality varied significantly for *U. rapax* and *U. victoriana* alone. Thus, intraspecific variation in UC_{50} likely results from local osmotic acclimation. Since genetic variation appears to be minor in most *Uca* species and unstructured across populations, the lack of physiological variation in [ISO] reflects the ecophenotypic nature of UC_{50}. Financial support provided by Fulbright Foundation, Univ. Iowa GRERC, FAPESP, and CNPq.

100.4 FARINA, S.C.*; SUMMERS, A.P.; Cornell University, University of Washington; Friday Harbor Labs; *scf59@cornell.edu*

Robotic modeling of fish ventilation supports the addition of a third pump to the traditional two−pump model

The current model of aquatic gill ventilation in actinopterygian fishes, proposed by GM Hughes in the 1950's, solved a fundamental problem in fish physiology: how do fishes maintain a continuous and unidirectional flow over the gills? The answer is they use two pumps − one is the buccal pump and the other is the opercular pump − alternating between generating suction and positive pressure, to drive water across the gills. However, ventilatory morphology and behavior is highly variable and more complicated than the two−pump model can explain. The addition of a third pump, working in parallel with the operculum, is a useful framework for understanding this variation. This "third pump" is the branchiostegal apparatus. Branchiostegal rays are long dermal bones that articulate with ventral elements of the hyoid arch and form the floor of the gill chamber. While these structures have long been understood to contribute to driving ventilatory current, the relative size of the pump formed by the branchiostegals is a better predictor of variation in ventilatory function than the morphology of the other pumps. To further explore this, we constructed an Arduino−controlled robotic fish head to manipulate the morphology and behavior of each of the three pumps (mouth, operculum, and branchiostegals). We will present pressure data recorded in the mouth and gill chambers of this model that show simple changes in kinematics of the pumps allow us to mimic pressure data from living fishes. For example, shifting the amplitude of the branchiostegal pump turns the pressure wave of a benthic lifestyle into that seen in pelagic fishes.

P1.130 FASANELLO, VJ*; VASSALLO, BG; FISCHER, CP; REED, WL; HAUSSMANN, MF; Bucknell Univ, Lewisburg, North Dakota State Univ, Fargo; *mfh008@bucknell.edu*

Glucocorticoid−induced Oxidative Stress (GiOS): cellular consequences to elevated glucocorticoids?

During a stress response, elevated glucocorticoids alter the physiology and behavior of individuals, promoting survival in an unpredictable environment. Recent evidence, from our laboratory, suggests that glucocorticoid exposure during acute stress causes a shift into oxidative stress; a phenomenon we term Glucocorticoid−induced Oxidative Stress (GiOS). During oxidative stress, reactive oxygen species are produced which cause oxidative damage to macromolecules throughout the body, resulting in a decline in organismal performance and survival. We sought to characterize and explore GiOS through two experiments. First, we characterize GiOS in both domestic and feral breeds of Japanese quail (*Coturnix japonica*) during an acute stress response. Second, we explore how the pattern of stress affects GiOS in domestic quail. We found that, regardless of breed, plasma oxidative damage increased and plasma antioxidants decreased during an acute stress response. In our second experiment, we exposed groups of domestic quail to different patterns of the same acute stress protocol: high stress (8 stressors in 3 wk) and low stress (2 stressors in 3 wk). We found that plasma oxidative damage decreased in the low stress birds, but increased in the high stress birds, while plasma antioxidants increased in the low stress birds, but decreased in the high stress birds. Our results show that GiOS appears to be a conserved phenomenon in feral and domestic quail. Furthermore, we show that the pattern of stress is important. Low frequency of repeated stress appears to prime the system, protecting against oxidative damage, while high frequency of repeated stress increases oxidative damage.

S4.2−1 FASSBINDER−ORTH, C; Creighton University; *carolfassbinder−orth@creighton.edu*

Using molecular techniques to measure immune responses and infectious disease dynamics in non−model species

Historically, the use of cutting−edge molecular techniques to study immunological gene expression and related cellular pathways has been largely limited to model organisms. Few studies have been performed that quantify the molecular immunological responses of non−model species, especially in response to infectious diseases. This dearth of information has largely occurred due to the lack of available non−model species−specific gene sequences and immunological reagents and also due to prohibitively expensive technology. However, with the rapid development of various sequencing and transcriptomic technologies, gene expression profiling of non−model organisms has become possible. Technologies and concepts explored here include an overview of digital vs. analog transcriptomics, next−generation sequencing (NGS), NGS−based gene−expression profiling (RNA−Seq), bead−based gene expression assays, microarrays, and qRT−PCR. Examples of the advancement of these technologies in non−model systems are discussed. Additionally, applications, limitations and feasibility of the use of these methodologies in non−model systems to address questions in ecological immunology and disease ecology are specifically addressed.

S7.3−4 FAULKES, Z; The University of Texas−Pan American; *zfaulkes@utpa.edu*

First, do no harm: Challenges to controlling another organism's nervous system

Parasites, particularly those with complex life cycles requiring multiple hosts, often manipulate the behaviour of their hosts to ensure infection by subsequent hosts. Parasites attempting to manipulate the behaviour of their hosts face a series of trade−offs. For example, where parasites ultimately live in a host may be a trade−off between access and damage to the host's "control centers" (usually the central nervous system). Presumably, an ideal place for parasites to manipulate their host's behaviour would be from inside the host's nervous system, but penetrating the nervous system may cause unwanted damage by disrupting synaptic connections or killing neurons. Similarly, hosts with fewer neurons in their nervous systems may be easier to manipulate, but accidental damage of neurons is more likely to have unwanted effects. If the ability of an individual parasite to change host behaviour is small, the number of parasites infecting a host may represent another trade−off between effective control and damage to the host. The infection of white shrimp (*Litopenaeus setiferus*) by larval tapeworms (*Polypocephalus* sp.) will be used as a case study. The tapeworms live inside the nervous systems of their host by the hundreds. This would seem to post great risk of damaging synaptic connections between neural circuits, but tapeworm infections do not appear to cause any severe behavioural abnormalities in the shrimp, but do change the shrimp's activity in more subtle ways.

109.5 FAY, S; AHMAD, M; SWINEY, K; FOY, R; STILLMAN, JH*; Univ. of California, Berkeley, National Marine Fisheries Service, National Marine Fisheries Service; *stillmaj@sfsu.edu*

Transcriptomic response of juvenile red king crab, Paralithodes camtschaticus, to the interactive effects of ocean acidification and warming

Impacts of elevated carbon dioxide on marine ecosystems depend on physiological responses to consequential decreased pH and increased temperature. Responses to these environmental factors vary among species and life stages, and interactive effects can be significant. To study effects of decreased pH and increased temperature on juvenile red king crab (RKC, *Paralithodes camtschaticus*) we exposed individuals to three levels of temperature: 11ºC (ambient), 13ºC, and 14°C, crossed with three levels of pH: 8.0, 7.8 and 7.5, for a total of nine treatments. To better understand the effect of these environmental changes at the level of genome regulation, we analyzed total RNA of whole crabs using Illumina−based RNA−seq: massively parallel, quantitative, whole−transcriptome sequencing. After quality filtering the data and joining overlapping read pairs, we de−novo assembled a RKC transcriptome using Trinity. We annotated the RKC transcriptome by best BLAST hit, gene ontology, and Pfam transmembrane and signal peptide domains using a Trinotate pipeline. Rfam was used to search for non−coding RNA family homologies. To estimate gene−wise expression levels, sequence reads were mapped to the de−novo transcriptome as a reference using bowtie2, samtools and eXpress. Significantly differentially expressed genes were found using EdgeR. Genes were clustered by similar change in expression over treatments and grouped within by functional category. Interactive effects were determined by comparing sets of differentially expressed genes using three statistical models to examine the effect of temperature, the effect of pH, and the interaction between temperature and pH in EdgeR.

5.3 FEILICH, K.L.; Harvard University, Cambridge, MA; *kfeilich@fas.harvard.edu*
Body and fin shape evolution in cichlid fishes
Cichlid fishes (Acanthomorpha: Cichlidae) are some of the most morphologically and behaviorally diverse fishes in the world. Their morphological disparity, especially of feeding structures, is well−documented. Despite this, comparatively little is known about how swimming morphology has evolved. I am using cichlid fishes as a model system, bringing together morphometrics, robotics, and biomechanics to determine the effects of post−cranial morphology on fish swimming performance. In this study, I examined body, caudal, pectoral and dorsal fin shape in cichlid fishes spanning the group's phylogeny. Using a combination of traditional and geometric morphometrics, I analyzed 29 body landmarks from digital x−rays, and the lengths of fin bases, fin spines, and fin rays to examine patterns of variation and co−variation in cichlid body shape evolution. Principle components analysis separated cichlid body shapes by aspect ratio, with rounded fishes like *Symphysodon* and tapered fishes like *Benthochromis* appearing at opposite ends of PC1. More than 80% of variation in caudal fin shape was explained by a single principle component, reflecting a caudal fin's degree of "forkiness". By incorporating information from the cichlid evolutionary tree into morphometric comparisons, I revealed patterns in the evolution of body and fin shape, and how they may be constrained by phylogenetic history. For instance, African cichlids fail to invade parts of morphospace occupied by Neotropical cichlids. Patterns in the evolution of locomotor structures may be related to ecology and contribute to differences in swimming performance. Future studies linking morphology to swimming performance may reveal adaptive trends in patterns of morphological evolution.

26.1 FELICE, RN*; O'CONNOR, PM; Ohio University; *ryanfelice@gmail.com*
Examining the relationship among foraging style, rectricial morphology, and the caudal skeleton in birds
The tail represents an important locomotor module in modern birds, complementing the role of the wings during flight. The shape of the tail fan determines its aerodynamic properties and thus varies among birds that utilize different flight behaviors. This study tests two hypotheses: that tail skeletal morphology, like tail feather shape, is correlated with flight behavior and that tail skeletal and feather morphology are in turn linked. Skeletal and integumentary anatomy was quantified using linear metrics and geometric morphometrics in 51 species of birds. The relationship between caudal skeletal morphology and flight behavior was tested in a phylogenetic comparative context using phylogenetic MANOVA, regression, and flexible discriminant analysis. Pygostyle shape accurately predicts foraging behavior but not flight mode. Plunge− and pursuit−diving birds exhibit an elongate pygostyle, with aerial and terrestrial foragers possessing a short, dorsally deflected pygostyle. Convergent evolution of a common pygostyle shape in diving lineages (Alcidae, Phaethontidae, Phalacrocoracidae, Spheniscidae, Sulidae) strongly suggests that this morphology is related to the functional demands of using the tail as a rudder underwater (e.g., dissipating the increased mechanical loads experienced in the aquatic environment). Moreover, pygostyle shape is significantly correlated with and accurately predicts tail−fan shape. A forked tail fan is correlated with a dorsally deflected, hourglass−shaped pygostyle, whereas a graduated tail fan is linked with an elongate, tapered pygostyle. Taken together, these results indicate that avian caudal skeletal morphology is influenced not only by its function as part of the locomotor apparatus, but also as part of an integrated tail apparatus and fanning mechanism.

38.6 FELLER, KD*; COHEN, JH; CRONIN, TW; University of Maryland Baltimore County; *kfeller1@umbc.edu*
Seeing double: the ontogeny of light sensitivity in stomatopod crustaceans
In addition to having unique adult visual systems, stomatopod crustaceans also undergo a unique process of eye development. Just prior to metamorphosis, an adult retina and associated neuropils emerge adjacent to the existing structures within each larval compound eye. The duration of this double−retina eye can range from as little as a few hours up to several days. The extent to which each retina contributes to the animal's visual sensitivity is currently unknown. Each eye has the potential to gather visual information simultaneously from two retinas, or the larval retina could dominate the visual sensitivity until the adult structures are more completely developed in the postlarva, at which point the adult retina becomes the prevailing sensor. Previous findings using microspectrophotometry led us to hypothesize the latter scenario. To test this, we used electroretinography to simultaneously measure light sensitivity in both retinas throughout ontogeny in a Western Atlantic stomatopod species, Squilla empusa, which undergoes complete eye metamorphosis within a 24 hour period. We rejected our hypothesis by the finding of robust electroretinogram responses in both the larval retina and the adult retina from the very onset of its emergence in the terminal stage larva. These data show significant decreases in dynamic range and response latency as well as an increased sensitivity to light as the eyes shift from the single−retina, larval type to the double retina adult dominant eye. This sensitivity shift was likely due in part to a clear circadian rhythm in visual sensitivity where photoreceptors were more sensitive when tested during the night phase. These are the first data regarding the physiology of the unique eye development in stomatopods and are important for directing further physiological investigations of the system.

127.4 FELTON, S.K.*; MERTE, C.E.; SCHULTE, B.A.; Western Kentucky University, Bowling Green, Georgia Southern University, Statesboro; *shilo.felton749@topper.wku.edu*
Exploration of the Behaviors Defining Personality in African Elephants
In sub−Saharan Africa, crop−raiding by African elephants is a major component of human−elephant conflict (HEC) which impedes conservation efforts. Understanding elephant behavioral patterns may provide insights for reducing HEC. Elephants have a capacity for learning; thus, they may alter their behavioral patterns over time. This behavioral plasticity in itself might be a way of measuring consistent behavioral differences among individuals. We approached elephant personality as a multivariate problem. We ran ordination methods on all behaviors gathered from 156 female African elephants to determine which behavior correlations were important in defining personality. Ordinations were performed on the data set and subsets for each age class (calf, juvenile, pubescent, adult). We calculated the angular differences among major axes of covariation from the subset ordinations to determine if the behaviors that defined personalities differed by age class. We compared measurements of dispersion (plasticity) among ordination scores for age classes and for individuals to assess if plasticity differed for age classes and individuals. Behavioral plasticity and the behaviors defining behavior remained consistent among age classes. Individuals varied in some measurements of dispersion, though dispersion was not a function of other factors measured (family group, age, etc.), indicating that it may be a valid measurement of personality. Our approach lends more flexibility in defining behavioral trends in individuals. Characterizing elephant behavior in this manner could allow predictability to which individual elephants create conflicts and under what conditions HEC might occur.

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Not all asymmetric feathers are created equal; a survey of flight feathers reveals several morphological strategies for achieving vane asymmetry

Feathers come in a wide diversity of shapes and sizes which birds use to accomplish a variety of functions from sound production to fight. Each feather is a complex branched structure with an equally complex tubular development. Due to this complexity, there is generally more than one way to modify development and morphology to achieve a particular shape. The flight feathers of all extant flying birds are characterized by a strong asymmetry in vane width, which is known to have an aerodynamic function. Each feather vane is a composite series of branches called barbs, and barb angle and barb length determine the width of a feather vane. Previous research on a small number of flight feathers has found that either barb angle, barb length, or both can vary between the vanes of an asymmetric feather suggesting that a feather can employ one of several morphological strategies to achieve vane asymmetry. We surveyed wing and tail feathers across the extant avian clade to characterize the relative importance of each morphological character in generating asymmetry. We found that differences in barb length between the two vanes of a flight feather generally increase with increasing vane asymmetry, whereas differences in barb angle do not show the same trend. Instead, large differences in barb angle between vanes are found only in certain types of flight feathers, suggesting that the different morphological strategies for achieving vane asymmetry may be associated with different functions.

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Ontogenic Correlation Between Muscle and Nervous System Novelties in a Neritimorph Gastropod

The visceral loop of the gastropod nervous system has been exceptionally significant in providing a foundation for pioneering work on the evolution of development and the neuronal basis of behaviour. Neritimorphs show greater anatomical modification of the visceral loop than any other gastropod group. In the early twentieth century, morphological work done by Bourne suggested that although neritimorphs retain a supra−intestinal connective with a trajectory typical of streptoneurans, they have lost the conventional sub−intestinal connective. Instead the sub−intestinal ganglion has inconspicuously fused to the right pleural ganglion and there is a direct connection between the two pleural ganglia creating a novel neuroanatomical shortcut in the visceral loop. Bourne hypothesized that this shortcut could function in coordinating the two pedal muscles present in adult neritimorphs. Although the presence of two similar−sized pedal muscles is unusual among gastropods, it is not unique. Why then is this shortcut not present in other gastropods with two−pedal muscles? We propose that development may provide the answer. Sections for light and electron microscopy through larvae of Nerita melanotragus and 3D reconstructions of the central nervous system have shown that the shortcut is present in the youngest larval stage, which is astonishing because derived features of neuroanatomy usually develop gradually in other gastropods. We also discovered that the larvae hatch with two relatively equal sized larval retractor muscles as well as two equal sized pedal retractor muscles, both of which are unprecedented among the earliest larval stages of gastropods. Based on these results we extend Bourne's hypothesis by suggesting that the shortcut may function in coordinating the two sets of muscles within the larvae as well.

114.6 FERGUSON, S.M.*; SMALL, T.W.; SCHOECH, S.J;
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We gotta get out of this place: Relationships between corticosterone and dispersal distance in the Florida scrub−jay (Aphelocoma coerulescens)

Dispersal from the natal territory prior to breeding is a mechanism that serves to reduce the chances of inbreeding and reduce competition among closely related individuals. The glucocorticoid, corticosterone (CORT) in birds, is important for energy mobilization and can influence activity levels, both important factors in dispersal. Indeed, glucocorticoid levels are correlated with dispersal activity in multiple taxa, including birds. Recent research by our group has found that early developmental exposure to CORT can have profound long−term effects and shape both an individual's behavioral phenotype and hypothalamic−pituitary−adrenal (HPA) axis responsiveness (i.e., CORT response to a stressor). Thus, an individual's early life experiences may play an important role in influencing dispersal behavior. To explore relationships between CORT and dispersal distance in Florida scrub−jays (FSJ), we recorded the distance from an individual's natal nest to the nest of their first breeding territory over a 7 year period. FSJs exhibit sex−biased dispersal patterns, with females dispersing further than males regardless of habitat quality. Preliminary analysis suggests males and females show no difference in either baseline or corrected integrated CORT. We will explore connections between baseline and corrected integrated CORT on dispersal distance and discuss causes of and implications for sex−based differences and the effects of early development on behavior at maturity.

P3.28 FERREIRA, A.*; GILMORE, E.; DION, J.; DAVIS, A.M.; MAGLIA, A.M.; SHEARMAN, R.M.; Framingham State Univ, MA, National Science Foundation, Arlington, VA;
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The effect of thyroid hormone on skeletal development in Xenopus laevis

Thyroid hormone plays a key role in growth and development, including the initiation of ossification. Tri−iodothyronine (T3) is the active form of thyroid hormone in vertebrates. In frogs, T3 is responsible for the initiation and regulation of the dramatic metamorphic changes involved in the transition from the tadpole to the adult frog. Exposure to exogenous T3 has been shown to cause accelerated metamorphic change in *Xenopus laevis* (African clawed frog) tadpoles, including precocious tail resorption and progression of cartilage development. In addition, Hanken and Hall (1988) indicated that thyroid hormone increased the rate of ossification of the parashpenoid, frontoparietal, and exoccipital bones in *Bombina orientalis* (Oriental fire−bellied toad). Herein, we exposed *X. laevis* tadpoles to two different concentrations of exogenous T3 for 48 hours during early pre−metamorphic development (Nieuwkoop and Faber Stage 50). Tadpoles were then reared without further T3 exposure, developmental series were collected, and specimens were cleared and double stained for cartilage and bone. Tadpoles in the T3 treated groups were relatively smaller (snout−vent length) and reached NF stages faster than those in the untreated group. Similar to Hanken and Hall's (1988) findings, onset of ossification of the parasphenoid, frotoparietal, and exoccipital occurred earlier (relative days) in T3 treated tadpoles than in untreated tadpoles. In addition, some bones of the upper and lower jaw began ossification at earlier NF stages in T3 treated tadpoles. In light of our findings, we revisit Hanken and Hall's (1988) hypothesis that interspecific differences in ossification sequence may be the result of variation in sensitivity of osteogenic centers to T3.

4.2 FERRY, LA*; GIBB, AC; KONOW, N; Arizona State University, Northern Arizona University, Brown University; *lara.ferry@asu.edu*

Determining the mechanism behind intramandibular bending in Helostoma temmincki

The kissing gourami, *Helostoma temmincki*, is a monotypic, enigmatic tropical freshwater fish, which displays a kissing behavior where the upper and lower jaws protrude and rotate such that the mouth resembles pursed lips poised for kissing. This extreme rotation of the tooth−bearing jaw elements is facilitated by an intramandibular joint (IMJ) located within the lower jaw. During feeding, the IMJ enables the jaws to produce gape angles of ~180 degrees, placing the teeth in direct contact with the substrate for scraping. Here, we clarify the mechanism of jaw rotation, and evaluate a model for rotation based upon the 4−bar mechanism previously proposed for other herbivores carrying the IMJ. Karel Liem originally described the input forces for the kissing behavior as dorsal rotation of the neurocranium and contraction of the sternohyoideus, which depresses the lower jaw. During lower jaw depression, force is transferred from the anguloarticular bone of the posterior lower jaw to the upper jaw via the maxilla. This force transfer rotates the maxilla and places tension on the maxilla−premaxilla connection, causing the premaxilla to protrude. The orientation of the anterior lower jaw (dentary) is such that it is rotated into a dorsoventral orientation via flexion of the IMJ, when the anguloarticular is depressed. Additionally, adduction of the suspensorium, which separates the right and left anguloarticular bones, causes the maxilla to rotate laterally, forcing the upper and lower jaw elements to expand laterally like an umbrella. These movements produce the kissing posture, and also the scraping posture used during food procurement.

2.1 FIDLER, RY*; TURINGAN, RG; Florida Institute of Technology, Melbourne; *rfidler2011@my.fit.edu*

Marine protected areas (MPAs) potentially reverse the development of fishing−induced traits in exploited populations of coral−reef fishes

Size−selective fishing pressure causes directional shifts in body size toward the predominance of smaller and early maturing individuals in exploited fish populations. Small, early−maturing fish exhibit significantly reduced reproductive output, and therefore, reduced fitness. Although previous studies have shown significantly higher fish density and biomass within MPAs compared to adjacent fished reefs, the evolutionary implications of MPAs have been largely ignored in contemporary research. This study determined the variation in body−size frequency distribution, fish length, length−at−age, and Gonadosomatic Index (GSI) between MPAs and adjacent fished reefs to advance our understanding of the evolutionary implications of MPAs. Results revealed that: (1) about half of the MPAs surveyed had significant shifts in size−frequency distribution, skewed towards larger−bodied fishes compared to adjacent fished reefs; (2) the occurrence of significant shifts in size−frequency distribution was not affected by MPA age and size; (3) large−bodied fish were younger inside MPAs than same−size conspecifics in adjacent fished reefs; and (4) fish inside MPAs matured at an older age and larger body size than conspecifics in adjacent fished reefs. These results indicate that by eliminating fishing pressure within their boundaries, MPAs may ameliorate the adverse evolutionary effects of fishing on exploited fish populations.

32.6 FIELD, D.J.*; KING, B.L.; GAUTHIER, J.A.; PETERSON, K.J.; Yale University, Mount Desert Island Biological Laboratory, Dartmouth College; *daniel.field@yale.edu*

Reanalysis of microRNAs reveals an archosaur rather than a lepidosaur affinity for turtles

The phylogenetic interrelationships of the major amniote clades have received considerable attention in the last decade. Specifically, the topological placement of turtles (Testudines) within Amniota has been source of contention, with most morphological cladistic analyses suggesting that turtles are the sister taxon to the rest of Diapsida, and most molecular analyses advocating a position of turtles sister to, or within, Archosauria. Previously, a phylogenetic study investigating micro−RNAs (miRNAs) indicated that, contrary to most morphological and molecular datasets, turtles actually represent the sister taxon to Lepidosauria. Here, we reanalyze these data, employing stricter limits on the criteria for miRNA annotation, as well as an expanded taxonomic sample of expressed miRNAs and genomic sequences. We recover no support for the previously espoused turtle−lepidosaur sister−relationship, and rather recover strong support for turtles sharing a more recent common ancestor with archosaurs than with any other amniote clade. These results are in accordance with most recent molecular studies, providing strong, consilient evidence from independent datasets for the phylogenetic position of turtles.

P3.11 FIELD, K.E.*; PRAJAPATI, A.S.; MARUSKA, K.P.; Louisiana State Univ, Univ of Louisiana Monroe; *kfield3@tigers.lsu.edu*

Social Status Influences Different Modulatory Receptors in the Olfactory Bulb of an African Cichlid Fish

Neuromodulators such as peptides and biogenic amines can influence processing of behaviorally relevant sensory information, helping an animal integrate the external environment with its internal physiological state. In fishes, olfaction is crucial for behaviors such as feeding, predator avoidance, and reproduction, and olfactory processing may be influenced by modulators. The first−order processing center in the fish brain, the olfactory bulb, receives information from the olfactory epithelium, then sends it to higher brain centers involved in mediating behavioral decisions. Little is known, however, about which modulators might function in the fish olfactory bulb, and whether the relative sensitivity to modulators might differ between animals motivated towards different tasks. We used the highly social African cichlid fish, *Astatotilapia burtoni*, to test the hypothesis that mRNA levels of several modulatory receptors in the olfactory bulb differed between dominant and subordinate males. Dominant males are territorial and reproductively active, while subordinate males are non−territorial and reproductively suppressed. Using qPCR we demonstrate that dominant males have higher mRNA levels of kisspeptin receptor, dopamine receptors, arginine vasotocin receptor, and neuronal nitric oxide synthase in the olfactory bulbs compared to subordinate males. Modulatory receptors were also positively correlated with gonadosomatic index, suggesting a link between olfactory modulation and reproduction. These results suggest that the olfactory bulbs of dominant males are more sensitive to neuromodulators, which may facilitate detection and fine tune their perception of olfactory signals vital for social assessment during reproductive and territorial interactions.

P1.169 FINK, A. A.*; JOHNSON, M. A.; RIBBLE, D. O.; Trinity University; *afink@trinity.edu*

Do corridors maintain genetic diversity? A study of urban Texas Spiny Lizard populations

Habitat fragmentation results in small, isolated populations that may experience higher extinction risks. One possible solution for the conservation of fragmented populations is the creation of dispersal corridors, or habitat connections, to allow movement and gene flow between areas. In theory, corridors allow genetic diversity to be maintained, increasing the overall fitness of otherwise isolated populations. The city of San Antonio, Texas, has recently set aside natural areas and connection corridors (i.e., green−belts) between natural areas for conservation purposes. These corridors provide an excellent opportunity to assess the effectiveness of corridors for maintenance of genetic diversity. Here, we study the population genetics of the Texas Spiny Lizard (*Sceloporus olivaceus*), to determine if lizards from populations in isolated urban natural areas are genetically less variable than those in areas connected by corridors and those in rural natural areas. We have collected tissue samples from 146 lizards from two isolated city parks, two systems of parks connected by corridors, and two rural natural populations. Seven highly−variable microsatellite markers will be analyzed with F−statistics to assess population isolation. We will also determine the number of independently evolving populations represented in our sample with the program STRUCTURE. This study will contribute toward our understanding of the effectiveness of corridors in preserving genetic variation for vertebrate conservation.

P3.165 FINKLER, M.S.*; HOLDA, J.; CATT, B.; Indiana University, Kokomo; *mfinkler@iuk.edu*

Nest soil moisture and incubation temperature influences on visceral organ mass in snapping turtle (Chelydra serpentina) neonates

We investigated whether variation in moisture availability and temperature during incubation influenced the relative size of visceral organs of hatchling snapping turtles. Snapping turtle eggs were incubated at three different temperatures (25, 27.5, and 30 °C) in natural soil collected from original nest sites with water contents adjusted to either 5% or 7% water by mass. Hatchlings were sacrificed at Day 5 post−hatching, their yolk sacs, hearts, livers, lungs, stomachs small intestines and kidneys were removed, and the organs and remainder of the carcass were dried to a constant mass. Hatchlings from eggs incubated in the wetter soil were larger than those from eggs incubated in the drier soil, but had relatively smaller hearts and livers based on dry mass. The relative dry masses of the yolk sac, lungs, and kidneys did not differ among the two soil moisture treatments. Dry carcass mass and the relative sizes of the heart, liver, lungs, and yolk sac were similar among incubation temperature treatments. However, the relative dry mass of the kidneys were larger in hatchlings incubated at 25 °C than at hatchlings from the two higher temperatures. The relative dry masses of the stomach and small intestine were greater in hatchlings from the drier soil treatment incubated than in those from the wet treatment at 30 °C, but were similar between the two moisture treatments at the other two temperatures. The findings suggest that for eggs incubated in natural soils variation in water availability in particular may influence relative organ size, perhaps through alterations in circulation and mobilization of nutrients, whereas incubation temperature appears to induce little difference in the relative size of visceral organs.

37.1 FISCHER, AHL*; PANG, K; HENRY, JQ; MARTINDALE, MQ; MBL, Woods Hole, SARS Bergen, Norway, University of Illinois, Urbana, Whitney Lab for Marine Bioscience, Univ. Florida; *afischer@mbl.edu*

Cell differentiation in cleavage arrested embryos of the comb jelly Mnemiopsis − Do they have a cleavage clock?

Ctenophores, an early branching group of gelatinous marine invertebrates, have a highly stereotyped cleavage pattern and a precocious specification of blastomere fates. We investigated the role of cell autonomous specification and developmental timing of two distinct cell types in the lobate ctenophore *Mnemiopsis leidyi*. Light emitting photocytes and comb cells with motile compound cilia form around 9 hours after spawning. Most comb plate cilia normally appear in derivates of the E lineage, while photoprotein is formed in derivatives of the M lineage. Using Cytochalasin B, we found that even if cytokinesis is blocked at the 8−cell, 16−cell −and later stages comb plate cilia and photoprotein still form. Our work supports and extends previous studies demonstrating that the cleavage program is causally involved in the spatial segregation and/or activation of factors giving rise to photocytes and comb cells. These factors are segregated independently to the appropriate lineage at the 8− and the 16−cell stage and have features of a clock' since the comb plate−like cilia appear at roughly the same developmental time in cleavage arrested embryos as they do in controls. Timed treatment with the DNA−synthesis inhibitor Aphidicolin suggests that nuclear division, possibly affecting DNA−cytoplasmic ratios, appears to be important in the timing of differentiation markers. Evidence suggests that the 60−cell stage, just prior to gastrulation, represents the time of zygotic gene activation. Such cleavage clock regulated phenomena appear to be widespread amongst the Metazoa and these cellular and molecular developmental mechanisms probably evolved early in metazoan evolution.

41.2 FISH, F.E.*; DINENNO, N.K.; West Chester University; *ffish@wcupa.edu*

The dog paddle': Stereotypic swimming gait pattern in different dog breeds

The term dog paddle' has been applied to the swimming behavior of a number of terrestrial and aquatic species. Dog paddling refers to a form of drag−based, paddle propulsion in which the limbs are oriented underneath the body and moved through an arc. Despite the ubiquity of the term, particularly in association with unrefined and inefficient swimming capabilities, there has been no analysis of the swimming kinematics of dogs. Underwater video was recorded (30 fr/s) of surface swimming dogs for eight individuals from six breeds, ranging in size from terrier to Newfoundland dog. The quadrupedal paddling stroke was analyzed to determine the kinematics and coordination of the fore and hind limbs. The paddling stroke represented a modified terrestrial gait similar to a fast diagonal sequence single footfall, which was outside the kinematic space for terrestrial locomotion by dogs. Stroke frequency decreased with increasing body size. The stroke cycle was divided into power (propulsive) and recovery (non−propulsive) phases. During the power phase, digits of the paw were abducted and the front limb was retracted posteriorly until perpendicular to the body. In the recovery phase, digits were adducted while the brachium was retracted anteriorly and the antebrachium was supinated. The power phase of the stroke cycle was shorter than the recovery phase for both fore and hind limbs. Maximum velocity during the power phase was greater for the hind limb compared to the forelimb. The modified terrestrial gait used for swimming in the dog paddle appears to be stereotypic among breeds, whereas terrestrial locomotion in dogs shows substantial variation in gait. Without constraints imposed by gravity and substrate contact, swimming dogs can utilize new gait profiles.

P3.127 FISH, F.E.*; FONTANELLA, J.E.; GABLER, M.K.; SAADAT, M.; West Chester University, University of Virginia; *ffish@wcupa.edu*

Body density of batoids in relation to ecology: Morphological control of buoyancy

Control of buoyancy is a major factor in the ecology of aquatic animals. Buoyancy is determined by the density of an organism relative to the density of the medium in which it is immersed. Fish that occupy benthic habitats should have body densities large enough for them to sink and remain in contact with the bottom, whereas, pelagic species should maintain a relatively lower density. The body densities were determined from four genera of batoid fishes (*Dasyatis*, *Gymnura*, *Potamotrygon*, *Rhinoptera*) that were from freshwater and marine habitats and were either benthic or pelagic. Body density was measured from the weight of the rays when suspended underwater and from water displacement. All rays were denser than their respective aquatic media. Marine benthic rays had body densities that were higher than the marine pelagic ray (*Rhinoptera*). The freshwater rays (*Potamotrygon*) had the lowest densities of the rays measured. When the density of the water medium was taken into account, the density differential was lowest for the marine pelagic ray. A low relative density would be advantageous for a pelagic ray to reduce costs associated with maintaining a given depth, although the ray is still denser than medium. Computational fluid dynamic analysis indicated that the small density difference can be passively compensated for by the hydrodynamic shape of the body. The pelagic marine ray has a body profile that provides increased lift and hydrodynamic efficiency compared to benthic species.

P2.80 FISH, JF*; STAYTON, CT; Bucknell University; *jff008@bucknell.edu*

Morphological and mechanical changes in red−eared slider turtle (Trachemys scripta elegans) shells during growth

Turtles experience numerous changes as they develop, specifically modifications in their morphological, physiological, and mechanical characteristics. Growth changes in turtles are associated with different abilities to defend against predators. Specific aspects of changes in the turtle shell's size, shape, strength, and rigidity have not been quantitatively studied prior to our research. This study investigates the morphological and mechanical changes that juvenile *Trachemys scripta elegans* undergo as they increase in size. Turtles undergo notable changes in shell morphology and ossification as they grow, but these changes are rarely quantified and have never been related to the mechanical behavior of the shells. Morphology and shell rigidity were quantified in a sample of 36 alcohol−preserved juvenile *Trachemys scripta elegans*. Morphometric information was then used to create finite element models of all specimens. These models were used to assess the mechanical behavior of the shells under various loading conditions. Overall, we find that turtles experience complementary changes in size, shape, and relative strength as they grow. As turtles age their shells become larger, more elongate, relatively flatter, and more rigid. In an absolute sense, their shells become stronger but relatively weaker in shape, compared with younger turtles. We suggest that the mechanical implications of shell size, shape, and deformability may have a large impact on survivorship and development in these turtle species as they mature.

115.4 FLAMMANG, BE*; KENALEY, CP; Harvard University; *bflammang@post.harvard.edu*

Comparative morphology of cobia and remoras

Remoras (family Echeneidae), cobia (*Rachycentron canadum*), and dolphinfish (*Coryphaena* sp.), members of the percomorph superfamily Echeneoidea, are closely related fishes that bear a striking resemblance to one another. The most notable difference between these taxa is that the first dorsal fin of their most common recent ancestor was replaced by a suction disk in the family Echeneidae. While there has been limited research focused on the development, skeletal morphology, and adhesive performance of the suction disk in remoras, there has been no study of the anatomical modifications in the remora as compared to its echeneoid sister group . We used dissection, computed microtomography staining (with and without contrast augmentation of soft tissue), and composite histology to examine the comparative morphology of cobia and two species of remora (*Echeneis naucrates* and *Remora osteochir*). In addition to previously reported modifications of the first dorsal−fin skeletal elements and associated erector and depressor musculature, we also found modifications of the epaxial muscle morphology of the remoras. Remoras also possess a modified cranial structure with vascular morphology not seen in cobia. Furthermore, pectoral fins of the two remora species had a thicker membrane surrounding stiff fin rays, suggesting functional differences in hydrodynamics of these fins as compared to the cobia. The morphological modifications of remoras likely contribute to their ability to attach to a host and maintain a low−drag profile.

96.3 FLANAGAN, S.P.*; JONES, A.G.; Texas A and M University; *sflanagan@bio.tamu.edu*

Identifying the genomic signature of selection using a simulation model

Selection on phenotypic traits is a major driver of evolutionary change, but evolution will only occur if there is a heritable component of selected traits. Understanding the effects of selection on the genome is an important topic in evolutionary biology. However, this can be difficult because selected traits are often the result of many loci and because other processes, such as genetic drift, can obscure the signature of selection. Thus, we are using simulation modeling to generate predictions about the conditions that allow selection to be detected. We have developed an individual−based simulation model, which consists of a population that experiences polygynous mating (sexual selection), mutation, recombination, viability selection, and random survivorship. After the population has reached an equilibrium (after running the model for about 5000 generations), a random sample of the population for several generations is collected, differentiating between adults and offspring. Comparisons of allele frequencies between adults and offspring allow the signature of selection to be detected. The conditions under which this signature is detectable will be discussed, as well as the consequences of these findings for empirical research in natural populations.

P3.179 FLEUREN, M.*; QUICAZAN−RUBIO, E.M.; VOESENEK, C.J.; VAN LEEUWEN, J.L.; POLLUX, B.J.A.; Experimental Zoology Chair Group, Wageningen University; *mike.fleuren@wur.nl*

Reconstructing changes in 3D body shape during the pregnancy of three species of viviparous fish (Poeciliidae): effects of placentation and superfetation

Viviparity confers a high reproductive burden to females, because they carry their offspring for a long period of time and often undergo a large change in mass and volume. Viviparous organisms have evolved a number of different reproductive adaptations that help reduce the burden during gestation. We recently proposed that placentation and superfetation are two such reproductive adaptations. Placentotrophic fish produce small egg cells with relative low amounts of yolk that are supplied with nutrients over the course of development, resulting in large differences in body volume between the early and last days of gestation. Superfetation, having multiple broods of different developmental stages, reduces the amount of simultaneously present late−stage embryos and thus the volume and mass changes associated with this stage. We illustrate this using three species that differ in the level of post−fertilization maternal provisioning and superfetation: *Poeciliopsis gracilis* (Matrotrophy Index: 0.7; Superfetation Index: 2), *Poeciliopsis turneri* (MI: 41; SI: 2) and *Phalloptychus januarius* (MI: 23, SI: 14). At multiple time points during their pregnancy, females are photographed from 3 orthogonal directions. The multiple images are analysed using semi−automated in−house software, yielding highly accurate three−dimensional body models. Shape parameters derived from the body models are then used to assess changes in the 3D body shape of females during gestation. Ultimately, we are interested in comparing the pregnancy−related changes in 3D body shape between viviparous species that differ in their level of placentation and/or superfetation.

60.2 FLORES, V.R.*; WEISBLAT, D.A.; Univ. of California, Berkeley; *vrf2@berkeley.edu*

Wnt signaling in the leech posterior growth zone

Segmented groups (vertebrates, arthropods, annelids) are very successful taxa within the three bilaterian super−phyla (Deuterostomia, Ecdysozoa, Lophotrochozoa, respectively). Each of these also contains unsegmented taxa, raising the question of whether segmentation evolved once or multiple times. We study segmentation in a leech (*Helobdella austinensis*) because it represents the understudied super−phylum Lophotrochozoa, and because its lineage−driven segmentation is not seen in model systems. In leech, segments arise from a posterior growth zone (PGZ) comprising five pairs of lineage−restricted stem cells (teloblasts) and their progeny (segmental founder cells called blast cells). Wnt signaling is a conserved pathway that affects transcription, cell polarity, stem cell maintenance and/or cell adhesion. Wnt signaling is involved in segmentation of vertebrates and arthropods; and Wnt components are expressed in the *Helobdella* PGZ. Thus, we hypothesized that Wnt signaling also operates in leech segmentation. To test this, we microinject select blastomeres with a translation−blocking antisense morpholino oligomer (ASMO) to knock down Disheveled (Dsh), a key scaffolding protein that transduces divergent Wnt signals. Injecting Dsh−ASMO into a left or right precursor of the ipsilateral ectodermal teloblasts yields morphant embryos with teloblasts that vary in number, size and position relative to controls. Often, teloblasts arising from injected cells form an adherent cluster, in contrast to their normal disposition as discrete spheres wrapped by macromere processes. Time−lapse video and confocal microscopy will be used to further characterize these defects. We will also identify localization of other Wnt pathway proteins. Together, these results can give insight into how Wnt signaling regulates the formation of lineage−restricted stem cells.

132.3 FLYNN, RW*; LANCE, SL; University of Georgia, Savannah River Ecology Laboratory; *wflynn@srel.uga.edu*

Copper tolerance in the southern toad, Anaxyrus terrestris: a quantitative genetic approach

Amphibian population declines have been extensively studied, and environmental contaminants have been implicated as co−factors in many of the declines. Copper is an environmental contaminant that is common in aquatic habitats worldwide due to anthropogenic activities. Copper is acutely toxic to virtually all aquatic plants and animals, including amphibians. In environments with elevated Cu, organisms can be differentially selected based on tolerance to Cu, as well as other fitness−related traits. Southern toads (Anaxyrus terrestris) exhibit considerable variation in their response to Cu, both among individuals and populations. We used a quantitative genetics approach (four female, four male full−sib crosses) to quantify the parental contributions to embryonic and larval responses to Cu. Embryo survival was affected by Cu concentration and parentage, with a significant Cu x sire interaction. Larval growth and development also differed among Cu levels and parents, with a significant dam x Cu interaction. Overall heritabilities were higher for developmental stage reached than growth rate. Environmental exposure to elevated Cu could have evolutionary consequences for this population of southern toads. The differential parental contributions to Cu tolerance could have further implications if tolerance constrains other fitness−related traits. Populations may adapt to tolerate Cu, but may cope poorly with other environmental stressors thought to be affecting amphibian populations, such as shortened hydroperiods and increased drought frequency.

3.1 FOKIDIS, HB*; PRIOR, NH; MA, CC; GRADANDOS−SAMAYOA, J; TAVES, MD; ADOMAT, HA; GUNS, ES; SALDANHA, CJ; SOMA , KK; Rollins College, Univ. of British Columbia, Vancouver Prostate Centre, American Univ.; *hfokidis@rollins.edu*

Aggressive responses to food insecurity: the search for novel steroid−peptide interactions

Aggression enables individuals to access limited resources. Most research has focused on the regulation of male breeding aggression where circulating testosterone (T) is converted to estradiol (E_2) by aromatase (AROM) within the brain to act on receptors in behavioral circuits. Food insecurity is common in nature and can promote aggression, but is percieved as a stressor, stimulating corticosterone (CORT) secretion in birds. Higher CORT lowers circulating T, thus suggesting aggression during food insecurity is mediated by another, as yet unknown, mechanism. Using novel behavioral tests we explored how food insecurity impacts aggression in both gregarious and territorial birds. In zebra finches, fasting increased aggressive interactions between individuals competing for a food source, while both decreasing T and elevating levels of CORT and the prohormone, dehydroepiandrosterone (DHEA). Circulating DHEA can be metabolized to E_2 within the brain to maintain aggression. In microdissected brain tissue, fasting increased E_2 content within the vertebrate social behavior network. In territorial song sparrows, fasting increased aggression in a resident−intruder test and altered steroid profiles as determined using liquid chromatography − mass spectrometry. To identify neuroendocrine links between energy and behavior pathways within the social behavior network, we investigated immunoreactivity for neuropeptide−Y (NPY) and orexin (two central regulators of food intake) and AROM in response to fasting and aggressive encounters over food. We propose fasting may promote DHEA secretion and its neural conversion to E_2 where it may interact to promote aggression during food insecurity.

34.6 FOLTZ, S.L.*; DAVIS, J.E.; BATTLE, K.E.; ROSS, A.E.; MOORE, I.T.; Virginia Tech, Radford University; *sarahf8@vt.edu*

Urbanization in relation to reproductive success, parental care, aggression, and corticosterone in song sparrows (Melospiza melodia)

As urban areas continue to grow, animals must adapt to the challenges and opportunities presented by these novel habitats or retreat to shrinking and fragmented rural areas. Responses to urbanization could include changes to behavior and physiology that may determine whether individuals succeed or fail at urban colonization. We compared urban and rural song sparrows *(Melospiza melodia)*, a songbird common in both urban and rural areas, at 4 field sites (2 urban, 2 rural) in southwestern Virginia during the 2013 breeding season. We focused on relationships between nest success, parental care, male territorial aggression, and corticosterone, a hormone associated with energy balance and stress. In previous years, urban males from these populations have been more aggressive than rural males. We measured aggression via simulated territorial intrusions with recorded male song. We also measured plasma corticosterone before and after a handling stressor, nest visits by each parent during two 45min observations per nest between days 4 and 8 of the nestling period, and whether nestlings reached fledging age. Preliminary analyses suggest that urban nests were more likely to fledge and that likelihood of nest success changes during the breeding season. Urban males were significantly more aggressive than rural males, and there was a trend toward higher stressed corticosterone in rural birds, though baseline levels did not differ between the two groups. Males' corticosterone and aggression were not related to their proportion of nest visits or to nest success, and nest visits did not differ between groups. These initial results suggest that urban areas may benefit some species via increased reproductive success.

P1.135 FONTANILLA, T.F.*; RONCALLI, V.; CIESLAK, M.C.; LENZ, P.H.; CHRISTIE, A.E.; Békésy Laboratory of Neurobiology, Pacific Biosciences Research Center, University of Hawaii at Manoa, Honolulu, HI 96822; *tianamf@hawaii.edu*

Identification and developmental expression of amine biosynthetic enzymes in the copepod crustacean Calanus finmarchicus

Chemical signaling is a key component of physiological/behavioral control systems in the copepod crustacean *Calanus finmarchicus*, a major contributor to the zooplanktonic biomass in the North Atlantic Ocean. While many molecules can be used for chemical signaling, one well−known class is the amines. Here, we have used a *de novo* assembled transcriptome composed of 206,041 unique sequences to identify *Calanus* transcripts encoding amine biosynthetic enzymes; known *Drosophila melanogaster* proteins were used for all query sequences. To help vet the proteins deduced from the identified *Calanus* transcripts, each was subjected to reverse BLAST and protein structural analyses. Via this workflow, putative *Calanus* homologs of DOPA decarboxylase (dopamine and serotonin biosynthesis), histidine decarboxylase (histamine biosynthesis), tryptophan hydroxylase (serotonin biosynthesis), tryptophan−phenylalanine hydroxylase (dopamine, octopamine and serotonin biosynthesis), tyramine beta−hydroxylase (octopamine biosymthesis), tyrosine decarboxylase (octopamine biosynthesis), and tyrosine hydroxylase (dopamine synthesis) were identified. In addition, RNA−Seq profiling was used to map transcript expression across the developmental stages of the *Calanus*. For each of the enzyme−encoding transcripts, high levels of expression were seen in the early nauplius and early copepodite stages, suggesting that amines may play key roles in controlling the metamorphic transitions between embryo/nauplius and nauplius/copepodite in this species.

122.3 FOSTER, AD; University of Arizona; *adfoster@email.arizona.edu*

Developmental plasticity of locomotor morphology in an animal model for the quadrupedal−to−bipedal transition

The evolution of bipedalism in the human lineage involved significant changes in musculoskeletal morphology to accommodate the locomotor shift from quadrupedalism to upright walking. However, the evolutionary mechanisms that underpin this shift remain unclear. This study seeks to better understand how this transition might have occurred by taking advantage of the inherent plasticity of musculoskeletal tissues. Because bone adapts to the predominant forces placed upon it, this study explores the relationship between bipedal loading patterns and skeletal morphology during growth and development. A novel method was used to experimentally induce a locomotor shift during ontogeny in an animal model for the quadrupedal−to−bipedal transition. Rats (n=10) were placed in a custom harness system mounted on a treadmill which allowed for bipedal locomotion over 60 minute periods, 5 days a week, for three months. The harness imparts an adjustable upward force on the torso which alters the load experienced by the hindlimbs. A quadrupedal control group (n=10) was exercised for the same period. Micro−CT scans were taken every third week to track skeletal changes. At the end of the experiment, bipedal rats had significantly greater growth in relative hindlimb length ($p<0.05$) and significantly larger distal and proximal joint dimensions ($p<0.05$). These findings suggest that initial changes consistent with the evolution of bipedal traits in the human lineage can occur through developmental plasticity in response to bipedal walking and may provide a blueprint for which traits may have occurred first in the earliest hominins. Funding was provided by: NSF (BCS−1153863), Force & Motion Foundation, and the University of Arizona.

P1.1 FOURNET, ME*; SZABO, A; Oregon State University, Alaska Whale Foundation; *mbellalady@gmail.com*

Vocal behavior of Southeast Alaskan humpback whales (Megaptera novaeangliae): classification and context

Humpback whales (*Megaptera novaeangliae*) are vocal baleen whales that exhibit complex social interactions across broad spatial and temporal scales. On low latitude breeding grounds, humpback whales produce complex and highly stereotyped "songs" as well as a range of "social sounds" associated with breeding behaviors. While on their Southeast Alaskan foraging grounds, humpback whales produce vocalizations during cooperative foraging events as well as a range of unclassified vocalizations for which the social context remains unknown. This study investigates the vocal repertoire of Southeast Alaskan humpback whales from a sample of 299 vocalizations collected over a three−month period on foraging grounds in Frederick Sound, Southeast Alaska. We used a two−part classification system, which included aural−spectrogram and statistical cluster analyses, to describe and classify vocalizations. Vocalizations were classified into sixteen individual call types nested within four discrete call classes. The vocal repertoire of Southeast Alaskan humpbacks shows moderate overlap with vocalizations recorded in Atlantic foraging grounds and along the Australian migratory corridor.

44.2 FOWLER, MA*; WILLIAMS, TD; Simon Fraser University; *melinda.a.f@gmail.com*

Individual variation in provisioning effort does not result in larger offspring at fledging

Parents that work harder at raising young should obtain fitness benefits but, theoretically, these benefits should come at some cost of reproduction'. However, the predicted positive relationship between workload and fitness, in terms of chick quality, appears to be surprisingly poorly supported in the literature. We analyzed 7 years of provisioning (nest visit rate) and breeding success data in European starlings *(Sturnus vulgaris)* to investigate the causes and consequences of individual variation in parental care. Provisioning rate was extremely variable among individuals; when controlling for brood size, it varied up to 16 fold. Provisioning rate was negatively related to daily temperature, but was not impacted by rainfall. Mean fledgling mass was equal across brood sizes and independent of the presence of male provisioning effort. Total provisioning rate (at day 6−8) predicted fledging mass at day 17, but when assessed as provisioning per chick there was no effect on fledging mass. Individual birds appear to adjust workload to the number of chicks in the brood. However, there is large residual variation in provisioning which is independent of offspring quality (17 day mass) i.e. variation in provisioning per chick does not provide a payoff in the form of heavier chicks. This disconnect suggests either that : a) provisioning rate is not a good proxy for work' effort; or b) working harder to provision chicks does not have an immediate cost; or c) individuals do not bear the costs of work equally. Increased provisioning rate may not be reflective of increased work load in individuals that forage more efficiently. Alternatively, individual quality in exercise ability may explain some of the variation in provisioning rate.

P1.118 FOWLER, L.A*; PAUL, L.T; WATTS, S.A; University of Alabama, Birmingham; *fowlela@uab.edu*

Evaluation of Moringa oleifera leaves as a short−term nutrient source for animal health

Consumption of *Moringa oleifera* leaves can provide a significant source of protein, vitamins and minerals for human consumption in developing countries. We evaluated the effectiveness of the *Moringa* leaf as a dietary supplement in a formulated zebrafish diet. While the *Moringa* leaf was found to be a suitable dietary micronutrient supplement, it was not acceptable as a long term sole source ingredient. Zebrafish fed a diet of *Moringa* leaf exhibited poor growth performance and no reproductive success, but showed reasonable survivorship. In the present study we evaluated the recovery of growth rate and body condition index (K) following a period of feeding *M. oleifera* as a sole source ingredient. Juveniles were raised on live feed until 30 days of age, and then separated into three treatments to be fed over an 8 week period. Treatments were fed either a control diet (formulated feed C), dried, ground *Moringa* leaves for the first four weeks, followed by the control diet for the last four weeks (M−C), or a diet of dried *Moringa* leaves during the entire trial (M). Weights and lengths were recorded weekly. The M treatment had the least growth performance and smallest K value. The C treatment group exhibited the highest growth performance and an increased K value. The M−C treatment had significant recovery in weight gain and body condition index after changing to the control diet, with notable increases in weight gain occurring within a week. These results suggest that *M. oleifera* can provide sufficient nutrients for maintenance short term, and that recovery is possible when nutrient complete diets become available. In human populations, we hypothesize that *M. oleifera* can serve as a short−term nutrient source when food is limited.

P2.153 FRAKER, T.L.*; WALLACE , J.A.S.; NAVARRO, A.; DEATON HAYNES, R.; SCOBELL , S.K.; St. Edward's University, Brooklyn College ; *tamfraker@gmail.com*

Morphology as a predictor of female reproductive investment in the sex role reversed Gulf pipefish, Syngnathus scovelli

Gulf pipefish (Family Syngnathidae) exhibit a phenomenon known as sex role reversal, where polyandrous females compete intensely for males and place eggs into a male brood pouch, resulting in male pregnancy. Because males are the limiting sex, females show elaborate courtship and display behaviors, and possess ornaments such as iridescent lateral bars to attract mates. It is known that males prefer larger females with higher bar numbers and a larger total bar area, but it remains unknown whether other female characters influence male mate choice, female−female competitive interactions, and female reproduction. Using a multivariate approach, this study will characterize several additional, but less explored, morphological characters of female pipefish as potential predictors of female reproductive investment. To date, 150 mature female Gulf pipefish have been dissected, measured, photographed and weighed. In addition, ovaries have been removed and weighed to obtain gonodosomatic index (as a measure of reproductive investment). ImageJ will be used to assess several phenotypic characters that may be indicators of reproductive investment (e.g. number and area of bars, size of the dorsal fin, body depth and length, and others). Using these data, we will determine what characters (or combinations of characters) are most predictive of female fecundity. This study represents the first step in a series of studies investigating potential population−level morphological and reproductive life history differences in Gulf pipefish.

120.1 FRANKINO, W. A.*; STILLWELL, R. C.; DWORKIN, I. M.; SHINGLETON, A. W.; University of Houston, Michigan State University, Michigan State University; *frankino@uh.edu*

Tipping the scales: Evolution of the allometric slope independently of average trait size

The scaling of body parts is central to the expression of morphology across body sizes and to the generation of morphological diversity within and among species. Although patterns of scaling relationship evolution have been documented for over one hundred years, little is known regarding how selection acts to alter these patterns. In part, this is because the degree to which the elements of scaling relationships, mean trait size and the slope, can evolve independently is not known. Here, using the wing:body size scaling relationship in Drosophila as an empirical model, we demonstrate that the slope of a morphological scaling relationship can evolve independently of mean trait size. Our success is likely due to in part to our employment of a developmentally−timed diet manipulation to isolate the nutritional static allometry from the genetic static allometry and to our application of selection over many (17) generations. We discuss our findings in the context of how selection likely operates on scaling in nature, the developmental basis of the integration of mean trait size and the scaling relationship slope, and the general approach of using individual−based selection experiments to study the expression and evolution of morphological scaling.

S7.2−3 FREDENSBORG, Brian L; Univ. of Copenhagen; *blf@life.ku.dk*

Jack−of−all−trades or Master of one? Does location of infection predict host specificity in behavior−manipulating parasites?

Parasite modification of host behavior leading to increased trophic transmission is widespread across parasite and host taxa. The exact mechanisms causing altered host behavior, and relationship to host specificity, remain unclear in most cases. Sophisticated mechanisms such as tissue−specific migration and alteration of host neuromodulation may indicate a narrow ecological niche where parasites are fine−tuned to the physiology of a small group of closely related hosts. Similarly, parasites remaining in close proximity to the point of entry to the host, e.g. body cavity or muscle tissue, may display a broader host range. However, other factors related to host−parasite interaction (host immune response, host−parasite body size ratio, parasite−induced pathology) may override those predictions. Here, I investigated if location of larval helminths in intermediate hosts could predict host specificity. Data on intermediate host use of known parasite manipulators, taxonomic grouping, and location in the host, were derived from published records. Host specificity was measured according to Poulin & Mouillot (2003) where phylogenetic relationship among hosts rather than just the number of host species is considered. As expected, parasites located on the CNS demonstrate a more taxonomically distinct host range compared to parasites in muscle. However, some helminths in the body cavity were more host specific than predicted by location, and eye flukes in the lens of fishes display low host specificity despite tissue−specific migration. In sum, the location of parasites inside intermediate hosts seems to be a good indicator of host specificity, but other factors are also important to the observed specificity in some parasite groups.

36.3 FRENCH, J.D.*; YOUNG, J.E.; CHUMCHALL, M.M.; BRINKMAN, E.L.; MOORE, B.C.; Louisiana Tech University, Texas Christian University, Arkansas Game and Fish Commission; *jdf040@latech.edu*

Hepatic Melanomacrophage Aggregates and Metal Bioaccumulation in Spotted Gar (Lepisosteus oculatus)

Toxic metal contamination of aquatic environments can pose serious health threats to fish, especially those in higher trophic levels due to tissue buildup through biomagnification. Elevated mercury concentrations can jeopardize overall fish health in various ways including liver damage resulting in robust immune response. Hepatic mercury accumulation has been demonstrated to increase the formation of melanomacrophages in spotted gar, putatively as a consequence of chronic mercury−mediated tissue damage and resulting inflammation. Additionally, melanomacrophage aggregates scavenge iron after tissue damage. We investigated the relationship between hepatic mercury and iron concentrations and the frequency of liver melanomacrophages in spotted gar from two southern Arkansas lakes (Calion Lake and Felsenthal National Wildlife Refuge) with varying levels of mercury contamination. We quantified the number, size, and frequency of melanomacrophages and the concentrations of total mercury and iron in the liver tissues. Lower liver mercury concentrations were found in the fish from the control site, Calion Lake, compared to those from Felsenthal NWR. Both collections of fish from Felsenthal NWR also exhibited increased hepatic melanomacrophage aggregates with higher mercury concentrations. These associations, along with variations in iron concentrations, will be discussed in light of possible detriments to spotted gar health and potentially other fish in similar environmental conditions.

P1.149 FRIEDMAN, ST*; ROCHA, LA; University of Washington, California Academy of Sciences; *Sarahsea@prodigy.net*

A great divide: Allopatric speciation of the yellowtail damselfish, Microspathodon chrysurus

Globally, there are numerous biogeographic barriers that physically restrict the dispersal and distributions of marine ichthyofauna. These barriers range from obtrusive land masses, such as the Isthmus of Panama to large spatial separations like the Eastern Pacific Barrier. Regardless of the method of separation, these biogeographic obstacles are known to correlate with speciation events. One of the more geologically recent barriers is the massive outflow of freshwater from the Amazon and Orinoco Rivers off the coast of Brazil. In this project, we conduct molecular analysis of two fish: the yellowtail damselfish, Microspathodon chrysurus, which ranges from the Caribbean to Brazil and a sister species, Microspathodon frontatus, which is endemic to the western coast of Africa. While M. chrysurus and M. frontatus are known to be genetically isolated by the vast expanse of the Atlantic Ocean, we hypothesize that the Amazonian outflow has caused a disruption in the gene flow between the Caribbean and Brazilian populations of M. chrysurus, inducing a speciation event. To analyze the separate populations, two mitochondrial genes (Cytochrome Oxidase 1 and Cytochrome b) were sequenced from specimens collected in each locality. Coalescent and population genetic analyses of the sequenced genes were conducted to elucidate discrepancies between the two populations. This study will aid in our understanding of how population divergence manifests at a molecular level and ultimately, how geological processes shape such speciation events.

P2.67 FRIEDRICH, SA*; CLAESON, KM; LEE, S; WARD, AB; PCOM, Adelphi University; *sarahfr@pcom.edu*

The effects of varying temperature and retinoic acid on vertebral processes in zebrafish, Danio rerio

Environmental conditions can have a direct impact on vertebral development. To look at this further, we studied the zebrafish *Danio rerio* because it has a rapid development rate and its genome is fully sequenced. This makes *Danio* a prime organism for studying the link between environment and morphology. Of particular concern are the influences of variable temperatures and retinoic acid (RA) levels. Previous research has shown that fish raised in higher temperatures have fewer vertebrae than fish raised at lower temperatures, while total body length remains the same. Also RA levels affect somite development, impacting vertebral body length and total length of the organisms. For our research we hypothesized that variable temperature and RA levels during early development would affect the size, shape, and position of vertebral processes, as well as ribs on non−Weberian vertebrae independent of vertebral body changes. To test this hypothesis, *Danio* were raised in different groups − a control raised at 28.5 degrees in embryo media, a variable temperature group with steady RA levels, and a variable RA group at control temperature. All were harvested at three months then cleared & stained. 2D Morphometrics were used to examine the axial skeleton, including ribs, and to compare the differences across the vertebral column. Results indicated that there was not an overall isometric change. In the specimens with shorter vertebral bodies, we saw a decrease in neural arch length, which was greater than a decrease in abdominal rib length. In canonical variates analyses plots, lowest temperature and RA deficient groups were most removed from the controls. This influence of variable temperature and RA levels will be important to explore considering their relationship to climate and geographic location.

52.3 FRIESEN, C.R.*; MASON, R.T.; UHRIG, E.J.; BENTZ, E.; KING, R.B.; WUSTERBARTH, T.; Univ. Sydney, Oregon State Univ., Northern Illinois Univ.; *christopher.friesen@sydney.edu.au*
Interspecific and interpopulational variation in traits associated with postcopulatory sexual selection in garter snakes
Postcopulatory sexual selection sperm competition and cryptic female choice is a ubiquitous mechanism of evolutionary change. Traits such as testis mass, sperm number and sperm length often vary in predictable ways among species and populations that have experienced different levels of postcopulatory selection. Garter snakes (genus *Thamnophis*) are a model for the study of reproductive biology and behavioral ecology. Much of the work on garter snakes has been conducted on the large mating aggregations of the Interlake region of Manitoba, Canada. We address the question: Is there evidence that the Interlake populations of red−sided garter snakes experience strong postcopulatory selection relative to congeneric species? We present sperm length data from six different species of garter snake *Thamnophis*, three subspecies of *T. sirtalis*. We also address the same question at the interpopulational level and present sperm length, sperm count and testes mass data from two different populations of the *T.s.parietalis. Finally, we present data comparing total sperm numbers and a qualitative assessment of the copulatory plug in T. sirtalis and T. radix. We interpret our results in light of the vast theoretical models of sperm competition.*

P2.169 FRIESEN, C.R.*; OLSSON, M; University of Sydney; *christopher.friesen@sydney.edu.au*
The effect of oxidative stress on sperm traits in the painted dragon lizard
Over the past decade, evolutionary ecologists have begun to focus on the physiological mechanisms underlying trade−offs among traits. Since von Schantz et al.'s (1999) groundbreaking paper, oxidative stress (OS) biology has become a focal point in the integration of proximate mechanisms with ultimate explanations, and has been especially influential in the study of sexually selected condition−dependent traits. One area of research that has been left behind in the integration of evolution and OS biology is postcopulatory sexual selection sperm competition and cryptic female choice. It is noteworthy that OS has been linked to infertility in human males for almost twenty years, but only one study has directly addressed OS in the context of sperm competition. Here we present data on the effect of experimental manipulation of the oxidative status on sperm motility, viability, and velocity in painted dragon lizards (*Ctenophorus pictus*).

96.5 FRITTS−PENNIMAN, AL*; MAHARDIKA, GN; BARBER, PH; Univ. of California, Los Angeles, Udayana Univ., Denpasar, Bali, Indonesia; *afrittspenniman@ucla.edu*
Genetic signatures of ecological speciation in a coral−associated nudibranch
In marine environments there are insufficient geographic barriers to attribute the great diversity of species to vicariance. However, coral reefs provide many opportunities for diversification through ecological niche specialization. For example, corals often host other invertebrates and fishes in mutualistic or parasitic relationships. The evolution of new, or more specific associations between corals and other reef organisms may lead to the creation of new species. Gene flow among populations found on different hosts may occur, but strong selection imposed by host species characteristics has the potential to reduce gene flow to the point of speciation. Previous work on *Phestilla* nudibranchs suggests that speciation may have occurred as a result of switching to different coral host genera. However, it remains unclear whether *Phestilla* species that are limited to a single host genus are diverging at the population level based on host species. I am examining how geography and coral host influence genetic divergence among specimens of *Phestilla sibogae* and *Phestilla minor* collected from locations spanning the Coral Triangle in the Indo−Pacific Ocean. Preliminary results reveal cryptic species and ongoing divergence associated with both geography and coral host in *Phestilla minor* but not in *Phestilla sibogae*. The development of single nucleotide polymorphism (SNP) markers is underway to detect host−driven adaptive genomic divergence, and ultimately identify which genes may be involved in speciation.

99.1 FRITZENWANKER, J.H.*; LOWE, C.J.; Hopkins Marine Station of Stanford University; *jhfritzenwanker@web.de*
Posterior axis elongation without segmentation: insights into the origins of the bilaterian trunk
One common feature of bilaterian animals is their anteroposterior (AP) axis which is divided into two major regions; the head and the trunk. In many groups the posterior trunk elongates by a process of posterior growth characterized by a posterior, terminal growth zone from which tissue is added. However, due to sparse comparative data, it is not clear how mechanisms of trunk development arose at the base of the bilaterians. All functional studies of posterior axis elongation to date in bilaterians have been conducted in either chordates or arthropods, which are characterized by a segmented body plan where mechanisms of segmentation are tightly coupled with posterior growth. This makes it challenging to untangle the two processes experimentally. We have begun to study posterior axis elongation during the development of the unsegmented hemichordate *Saccoglossus kowalevskii* to determine what components of the posterior growth/segmentation−network, shared between chordates and arthropods, is associated with posterior growth in this novel developmental system. We are exploring these mechanisms by characterizing the gene regulatory networks regulating posterior patterning during trunk development.

121.1 FRITZSCHE, A.K.*; SATTERFIELD, D.A.; ALTIZER, S.M.; University of Georgia, Odum School of Ecology, Athens GA; *afritzsche@gmail.com*

Migratory trade−offs: Do monarch butterflies sacrifice immune defense for lipid storage?

The annual migration of the monarch butterfly is one of nature's most captivating phenomena, yet little is known about the physiological changes that enable such long distance flight. Along their migratory pathway, monarchs forage extensively to accrue lipids that fuel flight and sustain the butterflies during the five month overwintering period in Mexico. Investment in lipid storage and other flight−related tissue is costly, and potentially diverts resources away from other processes, such as immune defense. Whether or not monarchs face this energetic trade−off between lipid storage and immunity might depend on the distance they travel to reach the overwintering sites. We collected 165 adult monarchs overwintering in Michoacán, Mexico and quantified their lipid stores and immune function. Immunity was assayed in two ways: total hemocyte (immune cell) counts and phenoloxidase activity (PO). We also sampled wing tissue for analyses of stable hydrogen isotopes (δ D) to estimate the natal origins where monarchs fed as larvae prior to migration, and thus to infer the distance each monarch migrated. Rather than a trade−off, we found a positive relationship between immune defense and lipid mass, especially in the subset of monarchs that flew the longest estimated distances. Longer flight distance was associated with greater lipid mass and larger wings. Our results suggest that a longer migration distance might provide additional time and opportunity for foraging, leading to monarchs with sufficient resource pools to avoid facing an energetic trade−off. Future work will examine this relationship at other points during the migratory cycle.

99.7 FROEHLICH, J.M.*; SEILIEZ, I.; GABILLARD, J.C.; BIGA, P.R.; University of Alabama at Birmingham, Institut National de la Recherche Agronomique, UR1067 Nutrition Métabolisme Aquaculture, INRA, UR1037 Station Commune de Recherches en Ichtyophysiologie Biodiversité et Environnement SCRIBE; *jmfroehlich@uab.edu*

EPIGENETIC REGULATION OF INDETERMINATE MYOGENESIS: Characterization of histone modifications during the myogenic program in rainbow trout, Oncorhynchus mykiss

While fish biologists have recognized for many decades that most teleost fishes grow under a paradigm divergent from that of terrestrial vertebrates, including mammals, the exact underpinnings of the molecular program governing such growth remain elusive. To better understand the protein−to−DNA interactions regulating two genes known to play pivotal roles in myogenesis among vertebrates, Pax7 during quiescence, proliferation, and self−renewal; and myogenin during terminal differentiation and myotube formation, we profiled the accessibility of chromatin in MPCs, myoblasts, and myotubes isolated from rainbow trout (*Oncorhynchus mykiss*) at the histone H3 using chromatin immunoprecipitation (ChIP) assays based on trimethylation marks at three key lysine residues: K4, K9, and K27. Quantitative PCR of chromatin fragments, enriched for each of these methylated lysine residues, revealed differential regulation of the promoter for Pax7 at Polycomb (PcG) and trithorax (trxG) group binding sites. Similarly, the myogenin promoter appeared to be regulated in a cell stage−specific manner near the transcriptional start site (TSS). With increasing research interest in histone methyltransferase and demethylase enzymes, these descriptive data reveal potential targets for growth modulation in important food fish species, including the ever−important salmonids modeled here.

S9.2−3 FROST , Paul C*; WAGNER, Nicole D; Trent University; *paulfrost@trentu.ca*

A beginner's guide to nutritional profiling in physiology and ecology

The nutritional history of an organism is often inherently difficult to ascertain. This information on past diet is particularly important when explaining the role of nutrition in physiological responses and ecological dynamics. One approach to infer the past dietary history of an individual is through characterization of its nutritional phenotype, an interrelated set of genomic, proteomic, metabolomic, and physiological properties that are sensitive to dietary stress. Comparisons of nutritional phenotypes between the study organism and reference phenotypes can provide insight into the type and intensity of past dietary constraints. Here we describe the process of using nutritional profiling in ecophysiological research where a suite of molecular responses are cataloged for animals experiencing known types of intensities of dietary stress and are quantitatively compared to those of unknown individuals. We supplement this delineation of the process of nutritional profiling with a first−order analysis of its sensitivity to the number of profiling response variables and their responsiveness to diet, the size of reference populations, and to the influence of confounding environmental and organismal variables.In doing so, we demonstrate the considerable promise this approach has to transform future study nutritional effects in physiology and ecology by providing more and better information on responses to dietary stress in animals and their populations

71.5 FULLER, A B*; BURROWS, J R; EARLEY, R L; University of Alabama, Tuscaloosa; *atom.fullerene@gmail.com*

Choosing a Caretaker: Do heterospecifics eavesdrop on sexual signals to assess hosts for their offspring?

Heterospecific eavesdroppers are known to use sexual signals to detect potential prey or hosts. We provide experimental evidence that some potentially mutualistic eavesdroppers can also use sexual signals to assess signaler traits. Male longear sunfish (*Lepomis megalotis*) care for the offspring of bluenose shiners (*Pteronotropis welaka*) in an arrangement that may benefit both species. We show that shiners distinguish between hosts based on opercular flap length, a sexual signal used by female sunfish to choose mates and correlated with male success in aggressive interactions. Male sunfish were experimentally modified to have lengthened, average, or shortened opercular flaps. When a small school of shiners was placed in a tank with two sunfish, they preferred to spend more time near the individual with longer opercular flaps. When placed in a tank containing only one sunfish, shiners responded equally to individuals with long and short flaps. Our data indicate that bluenose shiners, like female sunfish, are able to select between male sunfish based on the relative quality of their sexual signals.

39.7 FUQUA, R.D.*; PACE, C.M.; JENSEN, D.; MONROY, J.A.; NISHIKAWA, K.C.; Northern Arizona University;
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Residual force enhancement in the extensor digitorum longus muscle: The effect of titin length in activated muscle

When active muscles are stretched, tension increases and then settles to a steady state that is greater than the isometric force at the stretched length. The mechanism underlying this behavior, termed residual force enhancement (RFE), remains unknown. Previous studies have suggested a role for the elastic protein, titin, in generating force enhancement. In this study, we investigated titin's role in contributing to force enhancement in the extensor digitorum longus muscle (EDL). As a fast contracting muscle, the EDL expresses a relatively short titin isoform resulting in higher titin−based stiffness compared to the soleus muscle. We hypothesized that RFE will be greater along the length tension curve in the EDL compared to the soleus as a result of its shorter titin isoform. To determine how force enhancement changes along the length tension curve, we measured RFE in EDL and soleus muscles from wild−type mice. An isometric contraction, an active 5% Lo stretch contraction, and a passive 5% Lo stretch were performed at 95% Lo, Lo, 105% Lo, 110% Lo, 115% Lo and 120% Lo. Along the length−tension curve, both muscles showed an increase in total force enhancement, passive force enhancement, and the force enhancement due to activation alone. The EDL showed greater passive force enhancement and a greater effect of activation than the soleus. This suggests that the shorter, stiffer titin in the EDL not only increases the passive force but also, that titin stiffness increases upon activation. Our data support the hypothesis that titin is activated by Ca^{2+}−influx which causes titin stiffness to increase and demonstrates that the length of titin influences active force enhancement. This work was supported by NSF IOS−1025806.

P2.98 FURIMSKY, M.; BROOKS, M.*; ROBERTSON, J.; Westminster College, New Wilmington, PA;
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Early Growth and Development of the Rostrum in Paddlefish (Polyodon spathula)

Paddlefish are native to large river systems of central North America. The rostrum of the paddlefish is not present at hatching, but develops relatively rapidly in young fish. Evidence indicates that this physically significant structure serves important electro− and mechano−sensory functions. Here, we investigate the initiation and pattern of early growth of the rostrum, focusing on the hyaline cartilage that constitutes the central structural element. We examined tissue composition in fish from immediate post−hatch to stages with a well−developed rostrum; we describe the histological transition associated with the initiation of growth of the rostrum, the pattern by which hyaline cartilage growth occurs to extend the rostrum, and the physical relationship of the growing rostrum to the cartilaginous braincase and other structures. We also describe the formation of the medullary cavity − an adipose−filled, vascularized space that forms early in the proximal region of the developing rostrum. To explore the regulation and processes associated with rostrum growth, we used immunohistochemistry with markers for cell proliferation, chondrogenesis and neurogenesis. As a dramatic example of vertebrate post−embryonic morphogenesis, understanding the control of and mechanisms underlying rostrum growth informs developmental regulation, chondrogenesis and skeletogenesis, and sensory augmentation and integration.

4.1 GABLER, MK*; FISH, FE; COUGHLIN, DJ; University of North Carolina Wilmington, West Chester University of PA, Widener University; *mkg5178@uncw.edu*
Pectoral fin muscular architecture of batoids in relation to ecological lifestyle

Batoid fish swim using two different modes of locomotion, undulation and oscillation. To achieve these locomotory modes, batoids have evolved enlarged pectoral fins with distinct muscle layers. The structure of the underlying musculature in the pectoral fins are expected to explain some of the ecological differences seen among species utilizing these particular swimming modes. CT scans of 15 species of batoids were classified according to swimming mode to measure the absolute volume of the dorsal, abductor muscle and the ventral, adductor muscle. Histochemical methods including succinate dehydrogenase (SDH) and immunofluoresence were used to determine the different fiber types comprising these muscle masses in three batoid species (*Dasyatis sabina*, *Potamotrygon motoro*, and *Rhinoptera bonasus*). Species that swam by oscillation of the fins had an equal volume of abductor and adductor muscle in the pectoral fins, whereas undulatory species had a larger volume of abductor muscle compared to adductor muscle. Oscillatory species, which are primarily pelagic in lifestyle, have equivalent volumes of muscle in association with generating equal forces on the up and down strokes. Oscillatory species were shown to possess a higher proportion of slow oxidative, red fibers in their muscular bundles, while undulatory species had a higher proportion of fast glycolytic, white fibers. The differences in the muscle architecture and composition observed between oscillatory and undulatory batoids is associated with the differing lifestyles of members of the group.

24.3 GAGLIARDI, S*; RAVI, S; MCNEILLY, L; COMBES, S; Harvard University, Bunker Hill Community College;
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Kinematics of Hummingbird Flight in a Longitudinal Vortex

Hummingbirds are very maneuverable fliers capable of migrating great distances and foraging in challenging conditions. However, little is known about how they maintain stability in highly variable flows. In order to understand hummingbird flight in constantly changing outdoor conditions, it is necessary to begin by investigating the kinematics of hummingbirds subjected to known perturbations. This will shed light on basic control strategies implemented during flight. To determine how hummingbirds respond to a strong perturbation about the roll axis, we created a steady longitudinal vortex in a wind tunnel, by placing a stationary airfoil at the entrance to the test section. A stationary feeder was positioned downstream of the airfoil, at the center of the vortex. Female Ruby−Throated Hummingbirds were filmed while hovering at the feeder, within a vortex with a diameter approximately equivalent to their wingspan. We assessed hummingbird body dynamics and wing kinematics by tracking multiple points in high speed videos, and found that hummingbirds use various mechanisms to maintain stable flight in unfavorable wind conditions. Birds flying in the longitudinal vortex displayed changes in body attitude and asymmetric wing kinematics. These mechanisms attenuated the roll induced by the oncoming flow, allowing the birds to continue feeding despite being subjected to a strong aerial disturbance.

61.3 GALL, MD*; WILCZYNSKI, W; Vassar College, Georgia State University; *megall@vassar.edu*

Prior experience with conspecific signals enhances auditory midbrain responsiveness to conspecific vocalizations

There is a long history in neuroethology of investigating how communication signals influence the brain and behavior. It has become increasingly clear that brain areas associated with sensory processing are plastic in adults and that this plasticity is related to reproductive condition. However, the role of communication signal reception in adult auditory plasticity has received relatively little attention. Here we investigated whether the reception of communication signals (a frog chorus) could enhance the responsiveness of the auditory system to future reception of communication signals (a single male call). We found that animals that had been exposed to ten days of a male chorus had stronger auditory midbrain responses to a male call than animals that had been exposed to ten days of random tones. Moreover, this enhanced responsiveness appears to be specific to communication signals, as there was no difference between the chorus exposed and tones exposed groups in midbrain responsiveness to a single tone stimulus. Our results suggest that exposure to dynamic social stimuli, like frog choruses, may play an important role in shaping the neural and behavioral responses to communication signals.

59.8 GALLAGHER, A/J*; ORBESEN, E/S; HAMMERSCHLAG, N; SERAFY, J/E; University of Miami, Florida USA, National Marine Fisheries Service, NOAA, University of Miami, Florida, USA; *agallagher@rsmas.miami.edu*

Evolutionary traits explain the vulnerability of apex predatory sharks to human−induced environmental changes

Understanding how species respond to and cope with novel conditions is becoming increasingly important for predicting how their populations are affected by environmental impacts and stressors. Since no two species are affected the same way, a continuum of sensitivity or resilience often emerges, which may be useful for identifying which species may be especially at risk. We examined the survival of 12 pelagic shark species encountered in as bycatch in a pelagic longline fishery in relation to fishery target and other operational, environmental, and biological variables. Survival estimates ranged from 33% (night shark) to 97% (tiger shark) with eight of the 12 species examined being significantly affected by at least one of the examined variables. We placed our survival results within a risk assessment framework that incorporated species−specific reproductive potential (age at maturity and fecundity) in order to generate an index of species susceptibility. The bigeye thresher, dusky shark, night shark, and scalloped hammerhead exhibited the highest vulnerabilities to bycatch mortality. We discuss our results in terms of the evolutionary history of closely related species and use morphological and physiological traits to suggest that specialized species appear to be the most threatened (i.e., the crash test hypothesis). This study suggests that the evolutionary history and biological traits of species, in addition to survival rates and life−history parameters, may be useful to consider in conservation planning, and techniques that avoid fisheries interactions in the first place may be the best strategy for mitigating bycatch mortality for highly vulnerable species.

P2.39 GALLARDO, M*; SCHNYER, A; SCHIKOWSKI, E; COX, S; GILLIS, G; Mount Holyoke College, Univ. of Massachusetts, Amherst; *ggillis@mtholyoke.edu*

Indirect evidence of elastic energy storage and release during limb recovery in toad hopping

Elastic energy is critical for amplifying muscle power during the propulsive phase of anuran jumping. In this study we use cane toads (*Bufo marinus*) to address whether elastic recoil is also involved after takeoff as the hindlimbs flex prior to landing. The potential for such spring−like behavior stems from the unusually flexed configuration of a toad's hindlimbs in a relaxed state (mean knee angle = 109°). If during the takeoff phase the knee extends beyond this, underlying elastic tissues will be stretched, allowing passive recoil to help drive limb flexion during the aerial phase. To test if this happens we used high−speed video and electromyography to record hindlimb kinematics and electrical activity in a limb extensor (*m. semimembranosus*) and flexor (*m. iliofibularis*). Results show that longer hops involve greater degrees of knee extension during takeoff, and hops longer than 27 cm achieve knee angles greater than 109° (with the longest hops leading to values closer to 150°). Longer hops are also associated with significantly more intense semimembranosus activity and higher knee extension velocities during takeoff. Knee flexion velocities (after takeoff) also tend to increase with hop distance, but iliofibularis intensity decreases significantly. Thus, more knee extension during takeoff is associated with greater subsequent knee flexion velocities despite reductions in knee flexor intensity, a result consistent with elastic energy playing a role in knee flexion in longer hops.

P1.140 GALT, NJ*; FROEHLICH, JM; BIGA, PR; University of Alabama at Birmingham, Birmingham; *nicholasgalt@uab.edu*

The Regulation of Myostatin by Cortisol in Three Closely Related Salmonids

Glucocorticoids are strong positive regulators of myostatin (mstn) in mammals, and the glucocorticoid response elements (GREs) appear to be well conserved within the promoter of mstn in vertebrates, including many fishes. However, putative GREs have not been identified in the promoters of the three functional mstn genes (mstn−1a, −1b, and −2a) present in rainbow trout (*Oncorhynchus mykiss*). Interestingly, this is contrary to what has been observed in other salmonids, including Atlantic salmon and brook trout. We hypothesize that promoter region differentiation allows for greater diversity in local tissue control, and could explain stress tolerance differences observed across Salmonids. The goal of this study was to determine the effects of cortisol, the endogenous glucocorticoid in fishes, on mstn gene expression in rainbow trout and two close relatives, cutthroat trout (*Oncorhynchus clarki*) and Chinook salmon (*Oncorhynchus tshawytscha*). To this end, fish received a single intraperitoneal injection of either cortisol (50 ug/g, n=10), RU−486 (200 ug/g, n=10), both cortisol and RU−486 (n=10) or the vehicle (10 ul/g vegetable oil:shortening, n=10). Tissue samples were collected 48 hours following the injection and analyzed for myostatin mRNA expression by qPCR. Our results demonstrate that the regulation of mstn in these fishes, unlike mammals, is not highly regulated by glucocorticoids, but instead is extremely complex. Further research is needed to functionally characterize and annotate the mstn promoters in these and other fishes.

P2.157 GAO, S*; LANE, S; VALLE, S; DEVICHE, P; Arizona State University, Tempe; *sisi.gao@asu.edu*
The role of testosterone and vasotocin on the stress response of male passerines
In many seasonally reproducing birds, the stress response and plasma testosterone (T) vary according to reproductive condition. In rodents, plasma T regulates the stress response through vasopressin. In birds, studies have examined the interactive effect of both T and vasotocin (AVT; the avian vasopressin) on the stress response only in domesticated species, and have yielded conflicting results. We hypothesized that T and AVT regulate this response in adult male House Sparrows (*Passer domesticus*). During the non−breeding (January) and breeding (March, May) seasons, we caught birds, rapidly collected blood (baseline, BL), restrained them for 30 min, and collected a second blood sample (stress−induced, SI). Plasma CORT increased in response to stress throughout the year, but less so in January than during the spring, thereby confirming seasonal changes in the stress response. Plasma BL T was lower in winter than spring and, irrespective to season, always decreased during stress. To test if T and AVT regulate the stress response, captive males in non−reproductive condition received empty (control), 3 mm−long, or 6 mm−long T−filled Silastic capsules to result in low, medium, and physiologically high plasma T. Over the following 6 weeks, each bird was bled immediately after removal from its home cage (BL), received an iv injection of AVT [control, low (1.5 µg/kg), high (3 µg/kg)], was restrained for 30 min, and then bled again (SI). Neither T treatment nor AVT injection affected plasma BL or SI CORT. These observations do not support the hypothesis that seasonal changes in the stress response are T or AVT−regulated and with previously published studies, suggest that this regulation may be species− and/or environment−specific. Supported by National Science Foundation Award 1026620 to P.D.

16.6 GARCIA, M.J.*; EARLEY, R.L.; Univ. of Alabama; *mjgarcia@crimson.ua.edu*
Local Adaptation of Trait Integration: Predicting the Evolutionary Trajectories of Complex Phenotypes
An individual's phenotype results from the interactions of many highly "integrated" traits. A fundamental goal in evolutionary studies is to understand the mechanisms that generate/maintain such connections, and how patterns of integration affect the trajectory of phenotypic evolution. Quantitative genetic theory predicts that links among traits influence the overall phenotypic response to selection − selection acting on one trait may affect the evolution of a second trait if the traits covary genetically. Our study examines the potential for selection to act on multiple traits and their connections in an emerging vertebrate model, the mangrove rivulus fish (*Kryptolebias marmoratus*). We generated 32 isogenic strains from field caught animals collected from nine populations. Individuals from each strain were raised under common garden conditions. From birth, growth and egg production are monitored regularly. At 11 months of age, baseline hormones were collected and behavioral assays (aggression, risk−taking, exploration) performed. Using a variety of multivariate approaches rooted in quantitative genetics, we explore the mechanisms and evolutionary consequences of trait integration.

S4.1−2 GARNIER, R; WATT, KA; CHEUNG, C; PILKINGTON, JG; MCNEILLY, T; PEMBERTON, JM; NUSSEY, DH; GRAHAM, AL*; Princeton University, University of Edinburgh, Moredun Research Institute; *algraham@princeton.edu*
Just how much do antibodies cost? Nutrition and humoral immunity in wild Soay sheep
Nematode infection and malnutrition are hypothesized to generate a "Negative Spiral," with synergistic detrimental effects on host immunity, health and fitness. A cornerstone of this hypothesis, and much of ecoimmunology, is that investment in immunity has nutritional costs. Obtaining evidence of such costs has proven challenging, however. The Soay sheep population of St. Kilda (Scotland) offers an opportunity to quantify costs, due to the availability of an extensive sample bank, a longitudinal dataset, and laboratory assays developed for veterinary research. Massive die−offs of these sheep (*Ovis aries*) occur in some winters, due to a combination of malnutrition and gastro−intestinal nematodes (notably *Teladorsagia circumcincta*). We previously detected that antibody−mediated immunity is positively associated with survival and negatively associated with reproduction in these sheep, but whether nutritional costs play a role is unknown. In the summer prior to three major die−offs, we thus assessed nutritional status of individual ewes by measuring several plasmatic markers: albumin, total proteins, blood urea nitrogen and creatinine. On the same set of individuals, we measured antibodies of various specificities and isotypes (including natural antibodies as well as antibodies specific to *T. circumcincta* and to self antigens). We first show how these markers of nutritional state and immunity are associated. We demonstrate that different antibody types incur differential nutritional costs, and that parasitism itself has detectable nutritional costs. We then discuss how these physiological costs relate to the survival of the sheep through the subsequent population crash as well as subsequent reproductive success.

121.4 GARNIER, R.*; CAUDRON, Q.; WATT, K.A.; PILKINGTON, J.G.; PEMBERTON, J.M.; NUSSEY, D.H.; GRAHAM, A.L.; Princeton University, USA, University of Edinburgh, UK, University of Edinburgh, UK; *romaing@princeton.edu*
Quantitative liver histology of Soay sheep: nutritional and immunoparasitological causes of organ damage and death in the wild.
Understanding what drives population fluctuations in the wild is a long−standing question in ecology. The Soay sheep (Ovis aries) on the island of St Kilda (Scotland) exhibit unstable population dynamics: some winters are characterized by population crashes' in which up to 60% of sheep die, and gross pathology indicates a role for both gastro−intestinal nematodes and malnutrition. Based on liver samples obtained during necropsies of individuals that died during the crash of winter 2011−2012 and on plasma samples obtained in the summer prior to the population crash, we quantify the relations between the histological state of the liver at the time of death and nutritional and immunological markers before winter. To do so, we developed a computer−based image processing algorithm to quantitatively describe liver degeneration from histology slides stained with a hematoxylin and eosin protocol. We also measured albumin, total proteins, blood urea nitrogen and creatinine as plasmatic markers of nutrition, as well as pepsinogen as a marker of parasite infection intensity. Finally, we assessed plasma titres of nematode−specific and autoreactive antibodies in the summer prior to death. After outlining the principle of the quantitative histology approach and its usefulness for projects at the crossroads of ecology and biomedicine, we will show associations between liver degeneration and plasmatic nutritional and immunological markers which help to explain heterogeneity in the causes and timing of death. We will discuss these findings in light of costs of immune defense and the complex population dynamics of the Soay sheep population.

90.7 GARRETT, J*; SOCHA, J.J.; Virginia Tech; *jfg@vt.edu*
Coordination of abdominal pumping, spiracular valving, and tracheal compression in the Madagascar hissing cockroach
In some insect species, respiratory ventilation is thought to occur as the result of three coordinated activities: abdominal pumping, volumetric displacement of the tracheal system, and spiracular valving. The specific coordination pattern that makes ventilation possible is not well understood, and can vary with species as well as with the metabolic demands of developmental stage, body size, activity level, and atmospheric environment. Here, we examined the timing of these three activities using the Madagascar hissing cockroach (*Gromphadorhina portentosa*), chosen for its relatively large size and unobstructed spiracle anatomy. In experiments at the Advanced Photon Source of Argonne National Laboratory, we recorded synchrotron X−ray video footage of the living animal and synched it with external video of a spiracle and the whole abdomen. This enabled us to quantify the frequencies, durations, and duty cycles of abdominal pumping, spiracle opening and closing, and compression of tracheal tubes and air sacs. In addition, after recording normoxic behaviors we induced higher frequencies of abdominal pumping by reducing the environmental oxygen concentration near the spiracles. In normoxia, abdominal spiracles open briefly (200 − 800 ms) approximately one second after the abdominal pumping sequence begins. As the spiracle opens, some tracheal tubes (typically those of small to medium diameter, approximately 50−300 microns) collapse, which may expel additional air from the system. Our observations suggest that the specific coordination of these movements is fundamental to delivering oxygen throughout the animal's body. In addition, this new understanding will be used to develop new microfluidic pumping devices based on the respiratory dynamics of the hissing cockroach. Supported by NSF 0938047.

P1.81 GüTH, R.*; HARRIS, M.; SALAZAR, E.; NAWATHE, V.; SHARIFI, M.; TANG, W.; MISRA, S.; UNGUEZ, G.A.; New Mexico State University, Las Cruces; *rgueth@nmsu.edu*
Temperature effects on the electric discharge and gene expression in the electric organ of Eigenmannia virescens
Environmental factors affect protein composition and behavioral outputs of motor systems. For instance, ambient water temperature alters the physiological and contractile properties of skeletal muscle of teleosts (Watabe 2002). The weakly electric gymnotiform fish *Eigenmannia virescens* possesses a highly specialized electromotor system that evolved from skeletal muscle and generates an electrical discharge (EOD) used for communication and navigation. Unlike muscle, this electric organ (EO) tissue does not contract and is activated continuously by distinct electromotoneurons at frequencies between 250−600Hz (Assad 1998). Previous studies showed that the EOD frequency in *E. virescens* is affected by changes in water temperature (Enger 1968; Boudinot 1970). However, these studies examined the duration of this effect for only short durations of time of less than 20 minutes. This work will expand these data by characterizing the effect of water temperature on *E. virescens* EOD and EO gene expression over at least 2 weeks. To date, we have developed a wireless multi−sensor framework capable of monitoring EODs (under review, IEEE BioCAS 2013) and are expanding this system to continuously record water temperature. This will allow long−term, continuous EOD recordings from fish kept at different water temperatures (25° vs 30°C; n=5 each). Following stabilization of EOD frequencies at 2 weeks, EO tissue will be harvested and analyzed for changes in gene expression. These data will expand our current understanding of long−term effects of ambient temperature on EO activity, and furthermore help elucidate the role of temperature in regulation of gene expression in electromotor systems.

123.2 GEHRKE, A.R.*; SCHNEIDER, I.; NAKAMURA, T.; CHANDRAN, M.; BRAASCH, I.; POSTLETHWAIT, J.; SHUBIN, N.; The University of Chicago, The University of Oregon; *agehrke@uchicago.edu*
Ancient origins of the vertebrate Hoxd appendage developmental system
Mammalian limbs are built by two sequential periods of *Hox* gene activation, commonly referred to as "early" and "late" phases that pattern proximal and distal segments, respectively. The regulatory systems responsible for the dual nature of *Hoxd* gene expression in limbs have been extensively studied in mouse, where early and late phase enhancers lie on opposite side of the *HoxD* cluster. Fish exhibit a similar pattern of *Hoxd* gene activation during fin development, but the extent to which these patterns are homologous with limbs remains controversial. We sought to identify the enhancers that control potential early and late phase *Hoxd* expression in a variety of fish species, including zebrafish, gar, and skate. Using multiple sequence alignments with key taxa, we identified the ortholog of an early phase enhancer in the gar genome, which was subsequently cloned and injected in zebrafish in a reporter assay. This enhancer drove strong GFP expression in the fins beginning at 31 hours post fertilization, reminiscent of an "early" phase activation. Additionally, we identified the orthologs of a number of potential "late" phase enhancers in gar, zebrafish, and skate. We found that these enhancers activate expression in the distal fin of zebrafish in transgenic assays, much like their mammalian counterparts. Altogether, these data suggest an ancient origin of the vertebrate *Hoxd* appendage developmental system, and that changes in fin morphology may have resulted from modifications to this network rather than the evolution of novel expression domains.

P3.20 GEORGE, A/S*; PHELPS, S/M; University of Texas at Austin; *13ageorge@gmail.com*
Winning Influences Aggression and Singing Behavior in Neotropical Mice
The winner effect is known to modulate behaviors in a wide variety of taxa, ranging from dominance hierarchies in fishes to male−male singing behaviors in song birds. We examine the effect of winning social encounters on the aggressive and singing behaviors of Alston's singing mice, *Scotinomys teguina*. The singing mice, genus *Scotinomys*, are found in the cloud forests of Central America. They emit elaborate frequency−modulated trills ranging from 15−50 kHz which are used in male−male competition and mate attraction. Previous field studies have shown that responses of *S. teguina* to songs of a dominant congener, *S. xerampelinus*, differ in sympatry and allopatry. We hypothesize that *S. teguina* modulates song based on aggressive experience with either conspecifics or heterospecifics. Here, using a resident−intruder paradigm, we explore the behavioral differences following winning and losing social encounters within *S. teguina. We recorded the spontaneous singing behavior of* aggressively naïve male *S. teguina*, as well as their singing in response to noise, to song and to female bedding. Males sang in all four conditions, but sang most in response to conspecific song. Next, we assigned males either resident or intruder status and staged daily aggression tests for four days. We found an increase in aggression among residents across trials. Following aggressive experience, we found residents sang more, but this increase in song rates was not specific to responses to conspecific song. Our results suggest individual and population differences in song may reflect the role of recent aggressive experience.

21.7 GEORGE, M*; O'DONNELL, M; CARRINGTON, E; University of Washington, Seattle, WA 98105, California Ocean Science Trust, 1330 Broadway Ave Suite 1530 Oakland, CA 94612; *mngeorge@uw.edu*

Shell damage and repair in the bay mussel under a range of pCO2 conditions

Shell damage is a threat for mussels (*Mytilus*) living on rocky shores. One source is predatory snails (*Nucella*) which use a serrated tongue to drill through the shells of bivalves. However, this method of predation is often interrupted in nature, leaving mussels with shell damage, resulting in the loss of body fluids and infection by parasites. In response mussels rapidly repair damage to maintain homeostasis. Previous studies in our lab have shown that this repair process represents a significant cost to the mussel. With this in mind, we explored whether future oceanic conditions which result from climate change will act as an added stressor on the repair process. Consistent shell damage was produced across a group of mussels and shell repair was monitored within experimental seawater mesocosms with a range of pCO_2 concentrations (400 − 2500 µatm) for a 2 month period. Shell repair was quantified using both a visual scoring method and microCT scans of intact shells. Variation in shell repair was seen across treatments with no observable impact of increased pCO_2. A consistent progression of shell repair was seen, with mussels filling in holes with an organic matrix which then slowly hardened and turned white over the course of weeks. MicroCT analysis of density within the repair region implies the repair region was not calcified over the course of the experiment, regardless of treatment. Shell repair appears to be an energy intensive process of high priority at the onset of shell damage. However, it remains unclear how long it takes to produce material which mimics undamaged shell, if such an endpoint is even possible.

P3.157 GEORGI, JA*; MANFREDI, KR; Midwestern University, Glendale; *jgeorgi@midwestern.edu*

Head Stability During Walking in Alligator mississippiensis

Increasingly more studies are addressing the connection between locomotion and the semicircular ducts. However, the relationship between these organs that sense the rotational movement of the head and locomotion is indirect. During most locomotion, movement of the head is mediated by the neck, trunk, and limbs. It is, therefore, critical to understand the patterns of head movement during locomotion. We used 3D motion capture on 8 walking American alligators (*Alligator mississippiensis*) ranging in total length from 0.92 to 1.58 m, and compared these data to previously reported data for African spurred tortoises (*Geochelone sulcata*). In alligators, as in tortoises, the length of the stride increases with body size ($p = 0.005$). In contrast to tortoises, alligators showed increases in stride duration ($p = 0.028$) and duty factor ($p=0.031$) with increasing body size. In tortoises, head instability increases with stride speed, but those increases are inversely proportional to body size with smaller increases in larger tortoises. Although there is also an increase in head instability in alligator ($n = 5$), this relationship is constant across body sizes (SMA slope comparison $p = 0.478$). In addition, the increase in head instability at higher stride speed (SMA slope = 0.069) is much smaller than that for even the largest tortoise (SMA slope = 0.208). These data show broad scale differences in movements of the head in response to limb−based locomotion between vertebrate taxa. This supports the growing evidence that semicircular duct morphology may be adapted to different types of locomotion. Whether the changes in head stability simply relate to the ontogenetic differences in step cycle or whether there is a significant component of semicircular duct control is not addressed by this study and remains to be investigated.

P3.133 GERALD, GW; Nebraska Wesleyan University; *ggerald@nebrwesleyan.edu*

Measuring energetic costs of fossorial locomotion in lizards and snakes

Measuring the energetic costs of locomotion, termed "cost of transport," is important when attempting to assess both intraspecific and interspecific variation in locomotor efficiency during both similar and disparate locomotor gaits. The traditional way of measuring costs of transport, which entails measuring gas exchange over time during a bout of locomotion, are not feasible for some modes of animal locomotion (due to, for example, an inability to assess consistent movements on a treadmill). However, measuring excess post−exercise consumption (EPOC) can be used to estimate energetic costs of movement during short bouts of activity and to facilitate comparisons among species and locomotor modes. In this study, EPOC was used to quantify fossorial locomotion in both lizards and snakes to empirically test the hypothesis that the limbless, tubular body type present in snakes and some lizards was selected for because limbs interfere with efficient fossorial movements. We predicted that lizards with relatively longer limbs would exhibit higher energetic costs during movement through narrow tunnels. We quantified EPOC after movements in different tunnel widths and found that the EPOC cost of transport (ECOT) increased with decreasing tunnel widths and with relatively larger limbs. This work supports the hypothesis that the increasing use of underground microhabitats by ancient lizards could have selected for limbless, tubular bodies over time that led to the evolution of present−day snakes and other limb−reduced lizards.

98.4 GERMAN, D.P.*; FOTI, D.M.; LOCKWOOD, B.L.; Univ. of California, Irvine, Univ. of Indiana; *dgerman@uci.edu*

Elevated amylase activities have different genetic underpinnings in prickleback fishes with different diets

Many herbivorous vertebrates have elevated activities of the starch−degrading enzyme amylase in their digestive tracts, and this can arise by increased expression of a few genes, or increased amylase gene copy number. In this project, we compared amylase gene sequences, sequence variants, and amylase biochemistry in prickleback fishes (family Stichaeidae) with different diets to better understand the underpinnings of dietary amylase activity variation. The herbivorous fish *Cebidichthys violaceus* expresses at least two amylase isoforms (and likely three or more) that have 14 missense mutations among them. These two main *C. violaceus* isoforms have different isoelectric points (7.68 vs. 8.62), and structural differences that could affect function. *Xiphister mucosus* (herbivore) *X. atropurpureus* (omnivore), *Phytichthys chirus* (omnivore), and the carnivorous *Anoplarchus purpurescens* each appear to express a single amylase isoform. Thus, the elevated amylase activity in the species of *Xiphister* is largely explained by elevated expression of one gene. The herbivorous *C. violaceus* and *X. mucosus* evolved their dietary habits and elevated amylase activities independently, however, despite their genetic differences assays on crude gut homogenates suggest that both herbivores digest different starches with similar efficiencies. These data have implications for the digestion of different algal starches, as green algae use amylose and red algae use amylopectin as their storage polysaccharides, respectively. Therefore, convergent evolution of herbivory in *C. violaceus* and *X. mucosus* has different genetic underpinnings, but any functional consequences of these differences remain to be revealed.

P2.127 GERMAN, DP*; SUNG, A; JHAVERI, PK; AGNIHOTRI, R; Univ. of California, Irvine; *dgerman@uci.edu*

Digestive physiology varies among prickleback fishes (Stichaeidae) with different diets and evolutionary histories

The digestive physiology of an animal can reveal the strategy that an animal takes to acquire resources from their food. In this study we examined how the activity levels of carbohydrases, proteases, and lipase change along the guts of five closely related prickleback fish species with different diets: *Cebidichthys violaceus* (herbivore), *Xiphister mucosus* (herbivore), *X. atropurpureus* (omnivore), *Phytichthys chirus* (omnivore), and *Anoplarchus purpurescens* (carnivore). Digestive enzyme activities were measured in the pyloric caeca (which include pancreatic tissue in pricklebacks), and in the proximal, mid, and distal intestines of the fishes. Analyses are in progress, but all five species showed decreasing amylase activity moving distally along the intestine, whereas disaccharidase activities tended to peak in the mid intestines of the herbivores and omnivores, and decrease moving distally along the intestine of the carnivorous *A. purpurescens*. Measurements of short chain fatty acid concentrations (i.e., indicators of microbial fermentation) in the fishes' guts are in progress. Overall, the patterns of enzymatic activities are consistent with the "plug−flow reactor" model of digestion, and any reliance on microbial endosymbionts in the digestive process remains to be determined. Enzyme activity patterns (including proteolytic and lipolytic activities) will be discussed in the context of the fishes' feeding ecology and evolutionary history. In conclusion, this study is unique in its inclusion of closely related fishes with different diets, and lays the foundation for more detailed studies of nutritional physiology in the Stichaeidae.

14.3 GERNAY, S.−M.*; GILET, T.; LAMBERT, P.; FEDERLE, W.; University of Liège (ULg), Free University of Brussels (ULB), University of Cambridge; *smgernay@ulg.ac.be*

Elastic behaviour of dock beetle adhesive structures

The adhesion of many insects is mediated by liquid capillary bridges formed at the tips of multiple hair like structures (called setae) under their feet. Resulting adhesion forces can exceed a hundred times the insect's body weight and they are effective on a large variety of substrates, controllable in very short times and self cleaning. The underlying mechanism leading to these properties involves a complex coupling between the high aspect−ratio structures and the dynamic evolution of the liquid meniscus. In this experimental work, we concentrate on the role played by the compliance of seta tips. We analyse in detail their surface contact and deflection for perpendicular loading using interference microscopy. Challenges related to the micrometric scale of the phenomenon and the tiny amount of liquid are addressed. The results are rationalized through the lens of elasto−capillarity theory.

132.5 GERRARD, R*; TUBBS, C; San Diego Zoo Institute for Conservation Research; *rgerrard@mail.missouri.edu*

In−vitro Assessment of the Potential Effects of Environmental Contaminants on California Condor (Gymnogyps californianus) Reproductive Health

The recovery of the critically endangered California condor (CAC; *Gymnogyps californianus*) has required significant human intervention and management. Inland CAC populations face challenges associated with lead poisoning, which pushed this species to the brink of extinction in 1987. Coastal CACs scavenge marine megafauna that offer reduced lead exposure, but increased potential exposure to organochlorides. Although whether organochlorides contributed to the CAC's original population decline is controversial, recent evidence of exposure to organochlorides, such as DDTs, PCBs, and chloradanes, exists. Specifically, eggshells of coastal birds have recently been found to be significantly thinner than inland birds, providing a possible linkage between environmental chemical exposure to impaired reproductive health. To investigate the effects of organochlorides on CAC reproduction we have cloned CAC estrogen receptors 1 and 2 (ESR1 and ESR2) and characterized their activation by pertinent organochlorides. Treatment of HEK293 cells expressing CAC ESR1 with 10^{-12}−10^{-4}M p,p' DDE, PCB153 or trans−nonachlor resulted in weak to moderate receptor activation. In comparison, ESR2, which has not been identified in any bird of prey, showed overall greater sensitivity to these compounds with trans−nonachlor being the most potent agonist followed by PCB153 and p,p'DDE. Our findings suggest that CAC reproductive health may be affected by persistent organochlorides in coastal environments. However, additional studies are needed to elucidate the extent of CAC exposure to these endocrine−disrupting contaminants to better inform the management of this critically endangered species.

P3.78 GERSON, AR*; SMITH, EK; TALBOT, W; O'NEILL, JJ; MCKECHNIE, A; WOLF, BO; University of New Mexico, University of Pretoria; *agerson@unm.edu*

Differential use of hyperthermia as a thermoregulatory strategy in birds exposed to high temperature

Desert dwelling birds regularly experience exceedingly high air temperatures, sometimes far in excess of standard body temperature. In order to thermoregulate under such extreme conditions, desert birds have evolved a suite of behavioral and physiological strategies. One such strategy is the use of hyperthermia. It was the goal of this study to investigate the use of hyperthermia and its potential benefits to thermoregulation among a number of desert birds ranging in size from 7 g to 150 g. We measured metabolic rate and evaporative water loss using flow through respirometry. Body temperature was continuously monitored using implanted temperature sensitive PIT tags while birds were exposed to temperatures from 30°C up to 60°C in some species. We found the use of hyperthermia depended greatly on air temperature, body size, and the evaporative strategy used. Species that primarily utilize cutaneous evaporation maintained much lower body temperatures, metabolic rates, and rates of water loss and were able to maintain much greater gradients between Tb and Ta than birds that rely primarily on respiratory evaporation. The use of hyperthermia by birds that rely primarily on respiratory evaporative water loss may have evolved as a means to increase respiratory evaporative water loss rates, without concomitant increases in breathing frequency, reducing the potential for alkalemia.

P2.110 GHAHRAMANI, Z.N.*; TIMOTHY, M.; KIM, S.; FORLANO, P.M.; CUNY Brooklyn College; *zackgmani@gmail.com*

An intrasexual comparison of tyrosine hydroxylase fiber innervation of the vocal motor system in a teleost with alternative reproductive tactics

The plainfin midshipman, *Porichthys notatus,* is a seasonal breeding marine teleost that produces vocal signals for intraspecific communication. There are two distinct reproductive male morphs: Type I males establish nests and vocally court females while type II males, incapable of vocal courtship, sneak−spawn to steal fertilizations from type I males. Previously established sexual polymorphisms in the hindbrain−spinal vocal circuitry of midshipman are related to divergence of male reproductive tactics, specifically the ability to produce long−duration advertisement calls. Catecholamines, including the neurotransmitters dopamine and noradrenaline, are known regulators of reproduction and sexually motivated behaviors across vertebrates, including vocal−acoustic communication. We tested the hypothesis that there are intrasexual differences between the two males in the catecholaminergic fiber innervation of the vocal motor circuitry. Animals were collected from nesting sites in Tomales Bay, CA during the summer nesting season. Subjects were sacrificed by transcardial perfusion and brains were labeled for tyrosine hydroxylase (TH, rate−limiting enzyme in catecholamine synthesis) by immunofluorescence (−ir). Preliminary results demonstrate that type II males have a greater total intensity and density of TH−ir fibers within the vocal motor nucleus (VMN), and greater numbers of TH−ir varicosities contacting vocal motoneurons. Our findings support the hypothesis that catecholamines are direct modulators of vocal behavior and are additional substrates underlying social and reproductive behavioral divergence between male midshipman morphs.

83.5 GHOSAL, RATNA*; LEVESQUE M, HAUDE; SORENSEN W, PETER; Department of Fisheries, Wildlife and Conservation Biology University of Minnesota St. Paul, MN 55108, USA; *rghosal@umn.edu*

Chemical characterization of a species identifying pheromone in the common carp (Cyprinus carpio)

Pheromones, chemical information that passes between members of the same species, are commonly used by fishes. This presumably is a consequence of the ease with which chemical cues pass through water and the lack of light which characterizes aquatic ecosystems. Generally, fish pheromones are species−specific but how this might be is a paradox because all pheromonal compounds identified to date are relatively common metabolites of hormones or biliary sterols: no specialized species−specific products have been identified. To address this, we recently hypothesized that species−specificity in fish pheromones may be conveyed by species−specific combinations of suites of metabolites or complexes' rather than novel products. To test this, we examined the chemical complexity of the odor released by juvenile common carp, which we previously found to drive aggregation. Holding waters of juveniles were fractioned into nonpolar and polar fractions using C18 columns and their behavioral activity tested in attraction mazes. We found partial activity in both the polar and the nonpolar fractions. Further evaluation of the nonpolar fraction found it to contain at least two active components. Finally, we tested the long−standing hypothesis that mixtures of L−amine acids, a major class of fish odorant, might have pheromonal activity. Analysis of carp holding water found it to contain all 20 primary amino acids with asparagine and cysteine being dominant and at different ratios than for food. However, when these mixtures were tested we found that while the food amino acid mixture was attractive, the carp mixture was not. We now speculate that species−specific peptides, perhaps related to MHC, may play a role in fish pheromone complexes. (Funded by the Minnesota Environmental and Natural Resources Trust Fund)

46.1 GHOSE, SL*; SWEI, A; VREDENBURG, VT; BLACKBURN, DC; California Academy of Sciences, San Francisco, San Francisco State University, California; *sonia.ghose@gmail.com*

Recent surge in prevalence of fungal pathogen in amphibians in central Africa: Will host skin microbial communities provide a defense?

Chytridiomycosis is an infectious disease caused by the fungus *Batrachochytrium dendrobatidis* (Bd) that is linked to global declines and extinctions of amphibians. A leading hypothesis for the origin of Bd is that it originated in Africa and spread to naïve populations in the Americas, Europe and Australia with grave consequences. Studies on Bd collected in the last decade in Africa indicate that Bd is widespread, however there is little historical documentation of Bd in African amphibian populations. We used a Bd−specific PCR assay to test amphibian museum specimens collected from 1926−2003 in Ethiopia, Kenya, Lesotho, Tanzania and Uganda. We found low prevalence across the timescale sampled (0.9% overall) and found no evidence for the emergence of Bd. In contrast, our 2011 data for amphibian populations in the field revealed high prevalence in Burundi (73.7%), Cameroon (38.5%), and the Democratic Republic of Congo (11.1%). Sequence data of Bd clones that we collected in 2011 suggest that the global panzootic lineage of Bd (GPL) is present in Burundi and Cameroon. The GPL has been linked to global amphibian declines and may be newly emerging in Africa. It is, therefore, essential to study the potential host defenses of African amphibian species. In particular, beneficial bacteria have been identified as providing protection from disease in amphibians. Thus, we returned to Cameroon in June 2013 to collect skin microbiome and additional Bd data to delineate the relationship between the diversity of amphibian bacterial skin symbionts and Bd infection. Here we present data collected to date and discuss the implications for our understanding of Bd disease dynamics in Africa.

35.2 GIARRA, M.N.*; VLACHOS, P.P.; SOCHA, J.J.; Virginia Tech, Purdue University; *matthew.giarra@gmail.com*

High−Speed X−Ray Visualization of Blood Flows in the Grasshopper Heart

Insects transport hemolymph (blood) through the body using an open circulatory system and numerous small pumps. The main pump is the dorsal vessel, an axially−oriented tube that produces muscular contractions within its posterior section (the heart). Many species exhibit periodic reversals of flow in the vessel, wherein the directions of contractile waves alternate between anterograde and retrograde on the minute time−scale. Beyond this, the details of the flow kinematics in the heart are unknown. We aimed to understand the details of flows by measuring time−resolved fluid velocities in the hearts of living grasshoppers (*Schistocerca americana*). To quantify flows, we used synchrotron x−ray imaging to record the motion of 10 ¼m flow−tracer particles in the hearts of seven animals. The particles were injected into the pericardial sinus and allowed to advect into the heart prior to imaging. In succession, we recorded flows with a high−speed camera (125 fps) and then with a standard camera (30 fps). These cameras captured 6 to 20 seconds and 10 to 30 minutes of data per specimen, respectively. Using the high−speed imagery, we measured time−resolved flow velocities over multiple heartbeats using a custom particle image velocimetry algorithm. The standard−speed videos were used to verify that the high−speed videos were representative of long−term flow patterns. Our data suggest different heart flow characteristics than has been described in previous studies of insects. Specifically, we observed that the flow in the heart alternates direction every few seconds, a time scale an order of magnitude shorter than what others have reported. Such rapid flow reversals may indicate that the insect heart serves some other function besides purely directional pumping. Supported by NSF 0938047.

S3.2−3 GIBSON, Matt*; IKMI, Aissam; FRITZ, Ashleigh; RAGKOUSI, Katerina; Stowers Institute for Medical Research; *mg2@stowers.org*

Epithelium establishment and tentacle development in Nematostella vectensis

Evolution of the capacity to form secondary epithelial outgrowths from the principal embryonic axes was a crucial innovation that potentiated the diversification of animal body plans. Nevertheless, the mechanisms regulating embryonic appendage development remain largely unexplored in early−branching metazoans. Here, I will describe our efforts to approach this problem from both cellular and developmental perspectives using *Nematostella* tentacle morphogenesis as a model system. We find that three fundamental processes contribute to the initial stage of embryonic tentacle development. First, a pseudostratified ectodermal placode forms at the oral pole of developing larvae and is transcriptionally patterned into four tentacle buds. Subsequently, Notch signaling−dependent changes in apicobasal epithelial thickness drive elongation of these primordia. In parallel, oriented cell rearrangements revealed by clonal analysis correlate with shaping of the elongating tentacles. While these events outline the cellular basis for morphogenesis of the first quartet of tentacles, a determinate and surprisingly complex spatio−temporal pattern of tentacle addition unfolds during subsequent developmental stages. Combined, our results suggest that spatial control over relatively simple transformations of epithelial architecture could have played a central role in body plan evolution.

43.5 GIDMARK, NJ*; TARRANT, J; BRAINERD, EL; Brown University; *gidmark@uw.edu*

Convergence in morphology and masticatory function between the pharyngeal jaws of grass carp and oral jaws of mammalian herbivores

Herbivory is a mechanically difficult dietary specialization, as plant cell walls are chemically inert. In evolutionary shifts to herbivory, many amniotes (especially mammals) have evolved a suite of morphological and functional attributes that aid in mechanical processing of plant material: 1) teeth are flattened to improve grinding performance; 2) teeth are translated laterally in the occlusal plane to impart shearing forces; 3) grinding motions are accomplished with complex 3D jaw kinematics, despite relatively linear tooth kinematics; and 4) motions are highly rhythmic, showing low inter−cycle variability. Here, we explored morphology and *in vivo* masticatory function in a non−amniote herbivore, the grass carp, *Ctenopharyngodon idella*. Unlike mammals, the oral jaws are edentulous in grass carp, and all mechanical food processing is accomplished from pharyngeal jaws − modifications of the fifth ceratobranchial in the posterior of the throat. We implanted radiopaque markers into the skull and pharyngeal jaws to track jaw movements using a biplanar x−ray video system. We then used laser scans to register hard−tissue morphology of the jaws to movements of markers tracked on the videos. From these XROMM reconstructions, we demonstrate that the pharyngeal jaws in grass carp grind on the base of the skull, not tooth−on−tooth occlusion. We quantified large lateral translations (nearly 5% of total body length) of flattened tooth cusps that were the result of complex rotations (10−15 degrees) in all three rotational degrees of freedom. Chewing cycles were highly stereotyped: c.v. averaged 12%. These results demonstrate that the suite of morphological and functional characteristics seen in mammalian herbivore specialists has convergently evolved in a cyprinid fish.

P1.72 GIDMARK, NJ*; KONOW, N; ARELLANO, C; ROBERTS, TJ; Brown University; *gidmark@uw.edu*

Determinants of muscle shape change during lengthening and shortening contractions

As a muscle contracts, it can change shape. In pennate muscles, the line of action of a muscle fiber diverges from that of the whole muscle−tendon unit (MTU). Therefore, shape changes can alter the force and velocity of contraction by modulating how fiber force and length change translate into MTU force and length change. This behavior can be characterized by the MTU:fiber speed ratio, or "gearing". We explore the drivers and constraints of muscle shape changes by measuring several aspects of muscle shape, length, force and fiber length as muscles undergo shortening and lengthening contraction *in vivo* and *in situ*. We use high−speed x−ray video recordings to track radiopaque markers implanted along muscle fibers, at the muscle belly margins, and within the aponeuroses of turkey lateral gastrocnemius during jumping and landing behaviors. Muscle force was measured from strain gauges glued to the bony tendon. We digitally fit a plane to the aponeurosis markers and used fiber markers to calculate fiber pennation angle relative to this plane. We compared contractions involving two contrasting fiber length change patterns: The gastrocnemius shortened during jumping and mainly lengthened during landing. *In situ*, we recreated these patterns using an ergometer and nerve stimulation to elicit lengthening and shortening contractions, while measuring the same set of variables. Preliminary analysis of six individuals shows that: 1) changes in muscle width were strongly predicted by changes in fiber length (widening with fiber shortening and vice versa); 2) changes in aponeurosis width were weakly predicted by changes in fiber length and reflect a force−dependent pattern; 3) gearing is typically higher during lengthening than shortening contractions. Supported by NIH grant AR055295.

P3.64 GIFFORD, M/E*; CAREAU, V; CLAY, T/A; Univ. of Arkansas, Little Rock, Deakin University, Victoria, Australia; *megifford@ualr.edu*

Individual (co)variation in standard metabolic rate, feeding rate, and exploratory behavior in semi−aquatic salamanders

Repeatability is an important measurement in evolutionary analyses because it provides information regarding the benefit of repeated measurements and a putative upper limit to heritability estimates. Repeatability of different aspects of energy metabolism and behavior have been demonstrated in a variety of organisms over short and long time intervals. Recent research suggests that consistent individual differences in behavior and energy metabolism might covary. We present data on the repeatability of body mass, standard metabolic rate (SMR), voluntary exploratory behavior, and feeding rate in a semi−aquatic salamander, *Desmognathus brimleyorum*, and ask whether individual variation in behavioral traits are correlated with individual variation in SMR on a whole−animal and mass−residual basis. All measured traits were repeatable, but repeatability estimates ranged from very high for body mass (r=0.98), intermediate for SMR (r=0.39) and food intake (r=0.58), to low for exploratory behavior (r=0.25). In addition, repeatability estimates for all traits except body mass declined over time (i.e., from 3 to 9 weeks). Despite significant repeatability in all traits, we find little evidence that behaviors are correlated with SMR at the phenotypic or among−individual levels on a mass−residual basis. The phenotypic correlations between SMR and exploratory behavior were negative in all trials, but significantly so in one trial only. Salamanders in this study exhibited individual variation in how their exploratory behavior changed across trials (but not body mass, SMR, and food intake), which might have contributed to observed changes in correlations across trials.

84.3 GIGNAC, PM*; SANTANA, SE; Oklahoma State University, CHS , University of Washington; *paul.gignac@okstate.edu*
The impact of scale on ecomorphology: Using the feeding systems of bats and crocodilians as ontogenetic and macroevolutionary models
What links phenotypic stability and instability with morphological diversity? Comparative anatomists tend to approach this question from one of two perspectives. For key anatomical complexes such as the feeding apparatus, morphological changes during ontogeny are often interpreted in functional terms and linked to their putative importance for fitness. Across larger time scales, morphological transformations in these complexes are examined through character stability or mutability during cladogenesis. Because the fittest organisms must pass through ontogenetic changes in size and shape, it is predicted that addressing such transformations on different time scales would illuminate the factors generating phenotypic diversity. However, this is partly based on the assumption that adult form, in particular, tightly fits the adult niche. To assess the import of this assumption, we contrasted two systems for which ontogenetic and macroevolutionary changes in the feeding apparatus have been strongly implicated in ecological function and lineage diversification, Chiroptera and Crocodylia. Chiropterans reach their adult feeding niche at a comparable body size to when they attain somatic maturity. Crocodylians, on the other hand, reach their adult feeding niche far below their potential maximum size. Here we interpret developmental and evolutionary changes in bite−force capacity and cranial musculoskeletal anatomy within established frameworks of whole−animal performance and evolutionarily stable configurations; we offer insights into how body−size dependent phenotypes and their performance capacities may obscure our ability to identify mechanisms of morphological diversification, and we chart future directions to avoid such pitfalls in biomechanics research.

2.4 GIL, MA; University of Florida; *m.gil@ufl.edu*
Risk vs. reward effects on reef fish herbivory
Perceived risk of predation drives species distributions and key interactions across terrestrial and aquatic ecosystems. Optimal foraging theory posits that decisions to forage are determined by an individual's perception of the trade−off between risk and reward. Many reef fishes are known to prefer close proximity to structural habitats (e.g., corals) that provide a refuge from predators, but the effects isolation from reef habitat on key ecological processes are poorly understood. In this study, I examined the relationship between distance from reef habitat and herbivory, and whether this relationship depends on the quality of the reward' (food) being offered. I measured algae loss over time from turf and macroalgae "platters" on cinderblocks at 5 levels of isolation (within reef, as well as 5, 10, 20, and 30 m from the reef edge) and 2 levels of quality (1 thallus versus 4 thalli per algal species per plot) across 6 study sites. My results indicated that distance had a significant negative effect on the proportion of algae consumed but no significant interaction was detected between distance and quality. These results suggest that habitat isolation could be an important factor weakening top−down control of algae on reefs, especially those receiving nutrient enrichment. Using video analyses of the experimental trials, I am now exploring consumer behaviors that could be driving the herbivory patterns observed.

32.4 GILES, S*; FRIEDMAN, M; University of Oxford, UK; *sam.giles@earth.ox.ac.uk*
Getting inside the head of ancient ray−finned fishes
The endocranial cavity is found inside the skull of vertebrates, and represents the space in which the brain and associated nervous tissues sit. During fossilisation, these soft tissues rot away, leaving a void. This may become filled with sediment, producing an endocranial cast, or endocast. If preserved, this infilling can be used to study the endocranial anatomy of the animal to which it belonged. Preservation of these infillings, however, is understandably rare. Moreover, traditional investigative techniques are time consuming and often destructive in their nature, particularly the use of Sollas' grinding technique. The advent of computed tomography (CT) has provided a non−invasive way of studying the internal cavities of extinct and extant species alike. We applied lab−based CT to the crania of two fossil ray−finned fishes: *Mimipiscis*, from the Late Devonian (~385−380Ma) of Western Australia; and *Kentuckia*, from the early Carboniferous (~360−350Ma) of Kentucky. These taxa represent two early members of the clade that today comprises nearly half of all living vertebrates. Both of these taxa are key in analyses of early ray fin relationships, with *Mimipiscis* resolved as the more stemward of the two. Our models reveal somewhat unexpected features of the endocranial cavity of *Mimipiscis*, in particular poorly developed optic lobes and anterolaterally directed olfactory tracts. Comparison with other taxa shows that these characters are found elsewhere in outgroups to the ray fin clade, such as the lobe−finned fishes. In contrast, large optic lobes and anteriorly directed olfactory tracts are found in *Kentuckia*, uniting this taxon with other ray−finned fishes, to the exclusion of *Mimipiscis*. These new morphological data confirm current hypotheses on early ray fin interrelationships while providing insights on when key innovations arose in the brains of these fishes.

S10.1−3 GILET, T.*; BOUROUIBA, L.; University of Liège, Belgium, Massachusetts Institute of Technology; *tristan.gilet@ulg.ac.be*
Rain−operated foliar disease transmission
Plant diseases are a major cause of crop loss worldwide. They are known to be triggered by rainfalls. We here combine high−speed visualizations and physical modelling to elucidate the causal link between rain impact on foliage and pathogen spreading. We identify two dominant scenarios by which the pathogens get ejected from leaves. The leaf compliance is shown to strongly affect these mechanisms. The laws of fluid dynamics set tight limits on this epidemiological problem. They suggest a revision of the current agricultural practices in order to contain the spread of foliar diseases.

S5.3−2 GILLIS, GB*; EKSTROM, L; AZIZI, E; Mount Holyoke College, Wheaton College, Univ. of California, Irvine; *ggillis@mtholyoke.edu*
Using Anuran Landing as a Model for Studying Controlled Deceleration
Anything that jumps must land, and unlike jumping, where muscles produce energy to accelerate the body into the air, landing requires muscles to dissipate energy to decelerate the body. Among anurans, toads (genus *Bufo*) are outstanding at landing, using their forelimbs to stabilize the body after touch−down as they slowly lower their hindlimbs to the ground. We have been using toads as a model to understand the biomechanics and motor control strategies of landing. Our results show that toads prepare for landing differently depending on how far they hop. For example, the forelimbs are more extended at impact during long hops than short hops. This kinematic trend is mirrored by predictable alterations in the intensity of pre−landing forelimb muscle activity, which tends to be more intense during long hops than short hops. These differences in forelimb kinematics and muscle activity seem to be associated with preventing muscles that are involved in dissipating energy after impact from stretching to overly long lengths. Indeed, a combination of *in vivo* and *in vitro* experiments has demonstrated that the elbow−extending anconeus, which is stretched during landing as the elbow flexes, rarely reaches lengths longer than those associated with the plateau of the muscle's length−tension curve. We have also been studying how sensory information is involved in modulating landing preparation. Without vision, motor control patterns in major forelimb muscles appear unchanged from those in which sight is available. However, preliminary data from hops taken off elevated surfaces suggest that muscle recruitment patterns are altered in response to this perturbation. Taken together, these results suggest that toads rely less on vision than on proprioceptive and/or vestibular feedback to control landing.

P2.100 GILMAN, CA*; GENEVA, AJ; GLOR, RE; ALBERTSON, RC; IRSCHICK, DJ; University of Massachusetts Amherst, University of Rochester; *cgilman@bio.umass.edu*
Preliminary Analysis of Hemiclitoris Development in the Lizard Anolis distichus
Genitalia are extraordinarily diverse and show remarkably rapid evolution, relative to other morphological traits, across a wide range of animal taxa. Male and female genitalia in many animal groups begin as the same embryonic structures and later go through hormone−mediated differentiation. Surprisingly, little is known about the genetic mechanics of these processes. Even less is known about external genitalia differentiation in reptiles. Unlike other amniote groups, lizards and snakes possess a set of paired reproductive intromittent organs, called hemipenes. In a number of lizard species, females retain miniaturized versions of the male genitalia, called hemiclitorises. In these species, hemiclitorises can be used for taxonomic purposes, as they retain many morphological characteristics of the male genitalia, which are often species−specific. In lizards, the external genitalia of both sexes grow at the same rate until approximately halfway through embryonic development. Following this period, the hemipenes of the males continue to grow while the hemiclitorises of the females regress until they are about half the length of their male counterparts. We investigated the development of male and female external genitalia in *Anolis distichus* to determine the timing and patterning of growth and regression of these structures using histology, immunohistochemistry and whole mount *in situ* hybridization.

P1.100 GIUFFRIDA, BA*; ADAMS, HN; MENSINGER, AF; Wareham Middle School, Adelphi University, University of Minnesota Duluth; *bethgiuffrida@yahoo.com*
The Functional Significance of the Papillae Surrounding the Anterior Lateral Line Superficial Neuromasts in Oyster Toadfish, Opsanus tau
The oyster toadfish, Opsanus tau, is a benthic fish that inhabits shallow coastal waters along the Eastern United States. The toadfish anterior lateral line consists of canal neuromasts situated in 4 subdermal canals along each side of the head and numerous superficial neuromasts Each superficial neuromast is surrounded by paired fleshy appendages termed papillae. The hair cells are arrayed perpendicular to the papillae and it has been hypothesized that the papillae restrict water flow through the neuromast causing them to function as canal neuromasts. However, recent neurophysiological studies found evidence of both canal and superficial neuromasts in the anterior lateral line. The current study tested the alternative hypothesis that the papillae evolved to protect the hair cells from sedimentation. Sand or glass beads, ranging in size from 100 nm to 1 mm were added to a one cm diameter circle centered around a single superficial neuromast and the tissue examined with scanning electron microscopy (SEM). The combination of mucous production and/or fish movement displaced the sediment from the neuromasts quickly with 98 % of the foreign objects displaced within four hours. Tissue was fixed within 10 minutes of bead or sand application and SEM examination was unable to detect any sediment within the papillae or on the cupula, although sand and glass beads were prominent on the outside of the papillae and the surrounding epidermis. The result suggests that the papillae act to protect the hair cells from sediment deposition.

P3.86 GMUCA, N*; PEARSON, LE; BURNS, JM; LIWANAG, HEM; Adelphi University, University of Alaska Fairbanks, University of Alaska Anchorage; *nataliagmuca@mail.adelphi.edu*
The fat and the furriest: Morphological changes in harp seal fur with ontogeny
For mammals in polar regions, the extreme cold of the environment presents a constant challenge to thermal homeostasis. The harp seal (*Pagophilus groenlandicus*) is a true seal species whose range extends from the North Atlantic to Arctic Oceans. Adult harp seals primarily use blubber for insulation, but newborn harp seals instead rely on their fur coat while their blubber layer develops. Harp seal pups are weaned abruptly, less than two weeks after birth, and must learn to swim and dive in frigid waters on their own. This study examined how the morphological characteristics of harp seal fur change as the animals age. We compared hair length, hair circularity, and hair density for neonates (1 day old, N=7), thin whitecoats (4 days old, N=3), fat whitecoats (9 days old, N=4), newly weaned pups (2 weeks old, N=5), molted pups (3 weeks old, N=4), and adult harp seals (N=4). Hairs were shorter ($P<0.001$) and flatter ($P=0.001$) in older animals. Additionally, hair density decreased with age, in terms of the average number of hair bundles per unit area as well as in the average number of underhairs present in any given bundle. All of these morphological changes were associated with a reduction in the insulative function of the pelt. These results are consistent with known evolutionary patterns of fur morphology associated with the transition from fur to blubber in aquatic species, yet this is the first time these morphological differences have been demonstrated across age classes within a single species.

P1.83 GNANADESIKAN, GE*; VONHOLDT, BM; Princeton University; *ggnanade@princeton.edu*

The Canine Methylome: the impact of domestication on the regulatory genome.

Domestic organisms provide a particularly useful context in which to study behavioral questions because the process of domestication itself involved artificial selection primarily on the basis of behavior. For example, several canine behavioral traits (e.g. trainability) have recently been genetically mapped as quantitative trait loci in a comparative genomics approach across distinct breeds. Many complex phenotypes, such as behavior, are likely a consequence of both polygenic and regulatory variation. An inspection of the epigenome of domestic dogs and wolves, their wild progenitor, could therefore reveal how differential gene regulation plays a major role in shaping behavioral traits along with the suite of morphological changes associated with species domestication. As this domestication syndrome appears across multiple domestic species, this suggests that a shift in regulation may have been a major step in domestication. We therefore expect significant and important differences in the epigenomes of dogs and wolves. One component of the epigenome known to be highly involved in both genetic regulation and behavior is the methylome, particularly in regions with high CpG content. We have therefore performed CpG enriched bisulfite sequencing of 62 dogs and 35 Yellowstone wolves with average coverage of 24− and 32−fold, respectively. Through our analysis of the methylome, we will identify differentially methylated regions and explore gene body methylation patterns which will establish the first comparative glimpse into the regulatory genome of dogs and wolves and may illuminate the role of gene regulation in domestication.

P1.120 GOLDBOGEN, JA*; FRIEDLAENDER, AS; POTVIN, J; Stanford University, Oregon State Univ, Saint Louis Univ; *jgoldbogen@gmail.com*

Ecomorphological and behavioral analysis of lunge feeding and niche partitioning in rorqual whales

Rorqual whales (Balaenopteridae) represent the third most speciose family of extant cetaceans and occupy diverse trophic niches worldwide. With the exception of Megaptera (humpback whales), rorqual species within Balaenoptera are generally similar and superficially appear as scaled facsimiles of one another. Therefore, the mechanical scaling effects of body size have been invoked to characterize the performance envelope of a given rorqual species with respect to foraging capacity. However, this assumption has not been tested directly and fine−scale morphological as well as behavioral differences may significantly affect these interconnected biological processes. We performed comparative phylogenetic analyses of morphological dimensions related to locomotor performance and engulfment capacity across the full body size range of rorqual species. Although mass−specific engulfment capacity (or Engulfed Mass Ratio (EMR): engulfment capacity divided by body mass) was positively allometric (both within and across species) and generally increased with body size (ranging from 0.3 in minke whales to 1.7 in blue whales), each species inhabits a unique morphospace. Interestingly, several species that are capable of high EMR appear to reach a common maximum (1.7 in the largest Bryde's, sei, fin, and blue whales) that may reflect an anatomical limit related to the allometry of the ventral groove blubber as well as the skull. Using hydro−mechanical models of engulfment and best knowledge of lunge feeding kinematics from tag data, we provide an estimate for the performance envelope and energetic scope of balaeopteridae. Our analyses provide new insights into rorqual prey preferences, ecological niche, life history, and body size evolution.

S3.2−1 GOLDSTEIN, Bob; University of North Carolina, Chapel Hill; *bobg@unc.edu*

Using C. elegans and other organisms to understand conserved mechanisms of morphogenesis

Apical constriction changes cell shapes, driving fundamental morphogenetic events, including gastrulation in diverse organisms and neural tube closure in vertebrates. Apical constriction is thought to be triggered by contraction of apical actomyosin networks. I will present results from my lab showing that such actomyosin contractions begin *before* cell shape changes in both *C. elegans* and *Drosophila*, demonstrating that such contractions must not be not sufficient for cell shape change. In *C. elegans*, actomyosin networks were initially dynamic, contracting and generating significant cortical tension without substantial shrinking of apical surfaces. Apical cell−cell contact zones and actomyosin only later move increasingly in concert, with no detectable change in actomyosin dynamics or in cortical tension. Thus, apical constriction appears to be triggered not by a change in cortical tension, but by dynamic linking of apical cell−cell contact zones to an already contractile apical cortex. I will also present our work seeking to identify molecular mechanisms of cell shape change that have been conserved across the bilaterally symmetrical animals.

57.7 GOLLER, B*; ALTSHULER, DL; Univ. of British Columbia, Vancouver, BC; *goller@zoology.ubc.ca*

A moving background disrupts station holding in Anna's hummingbirds

The movement of visual features across the retina, termed optic flow, is an important source of information for control of locomotor behavior in animals. For example, during forward flight the animal perceives self−induced optic flow as it moves relative to visual features in its environment. Insects have been shown to use optic flow to control velocity and altitude, measure distance, and navigate through cluttered environments. During station holding behavior, such as hovering flight in hummingbirds, self−motion optic flow is minimal and perceived optic flow could indicate a loss of positional stability. Do hummingbirds use background visual motion to stabilize their position during hovering? We addressed this question by tracking the head position of Anna's hummingbirds (*Calypte anna*) in a free flight arena with three types of projected black and white patterns: spirals, vertical gratings, and horizontal gratings. When the projected patterns are steady, the birds maintain stable 3D position. Moving patterns cause the birds to translate along one of three axes: backward−forward, right−left or upward−downward, depending upon the background pattern motion. The response is not blunted by experience, as a looming spiral pattern continues to produce a response even after 40 repeated trials, though the properties of the response (oscillation frequency and amplitude) change significantly over time. In response to a background with both stationary and moving portions the hummingbirds increase their response with increased background motion. Our results suggest that hummingbirds use perceived motion relative to background features as an important cue to stabilize hovering.

105.4 GOMEZ, J.E.*; JOERN, A.; Kansas State University; *jegomez@k−state.edu*

Responses of a grassland spider community to disturbance from fire and bison grazing

A major overarching hypothesis in community ecology is that habitat spatial and temporal heterogeneity promotes species diversity. In grassland ecosystems, such spatial and temporal heterogeneity at the landscape level results from the interaction of fire, ungulate grazing and climate ecosystem drivers. Ubiquitous arthropod predators like spiders on grassland systems modulate prey community and ecosystem processes. Responses of predators (spider communities) to major disturbances on grassland ecosystems have not been study in detail. At Konza Prairie Biological Station, unique long−term manipulations (fire frequency and bison grazing) at watershed levels have resulted in a mosaic of habitat types. The habitat complexity and heterogeneity hypothesis: predicts that the overall abundance and species diversity increases with spatial heterogeneity of habitat structure. To address this hypothesis 23 sites were established along a gradient of habitat in bison grazed and ungrazed watersheds at KPBS. At each sites the spider and insect communities were sampled using vacuum and sweep−nets. And a series of vegetation characteristics were measured to characterize the spatial heterogeneity and structural complexity of each site. Preliminary results for this study indicate that species richness increases within the growing season. Spider abundance increases on ungrazed sites may result from an increase in spatial heterogeneity and microhabitat diversity with plant growth over the summer. Spider diversity and abundance increased over time (during the summer) independently from fire frequency. This may be promoted by higher microhabitat availability latter in the growing season as result of plant growth differentiation. Bison grazing influenced habitat heterogeneity maximizing microhabitat availability and use early in the summer.

P2.118 GONZALEZ−GOMEZ, PL*; SUAREZ, R; MADRID, N; VASQUEZ, RA; BOZINOVIC, F; California State University, Dominguez Hills, Queensland Brain Institute, Facultad de Ciencias, Universidad de Chile, Facultad de Ciencias, Universidad de Chile, Pontificia Universidad Católica de Chile; *plgonzalezgomez@gmail.com*

Cognitive ecology in hummingbirds: the role of sexual dimorphism and its anatomical correlates on memory

In scatter−hoarding species several behavioral and neuroanatomical adaptations allow them to store and retrieve thousands of food items per year. Nectarivorous animals face a similar scenario having to remember quality, location and replenishment schedules of several nectar sources. In the green−backed firecrown hummingbird (*Sephanoides sephanoides*), females display an opportunistic strategy, performing rapid intrusions into males territories. In response, males behave aggressively during the non−reproductive season. In addition, females have higher energetic demands due to higher thermoregulatory costs and travel times. In this study we compared cognitive abilities and hippocampal size between males and females. Males were able to remember nectar location and renewal rates significantly better than females. However, the hippocampal formation was significantly larger in females than males. We discuss these findings in terms of sexually dimorphic use of spatial resources and variable patterns of brain dimorphisms in birds.

40.6 GOOS, JM*; COTHRAN, RD; JEYASINGH, PD; Oklahoma State University, University of Pittsburgh; *jared.goos@okstate.edu*

Integrating genetics, physiology, and ecology to understand the evolution of condition dependent sexual traits: an elemental approach

Condition dependence of sexual traits may help explain why sexual traits are extremely variable in the face of directional selection and how these traits may convey valuable information of potential mates. Previous studies have demonstrated condition dependence by exposing individuals to different resource environments and observing responses in sexual traits. No studies, however, have directly measured male condition (i.e., the pool of material resources available to allocate to traits (including sexual traits) and its relationship to sexual trait expression. Moreover, since materials (i.e., nutrients derived from food) are likely to vary over space and time, it is critical that we examine condition across a variety of resource supply environments. Using *Hyalella* amphipods, in which males possess a sexually selected claw, we quantified the additive genetic variance in claw expression, and in the acquisition and allocation of carbon (C) and phosphorus (P), two important elements in both the growth and maintenance of sexual traits, in contrasting C and P supply environments. Our previous radioisotope studies have indicated greater variation in male assimilation physiology of both C and P throughout ontogeny than females, indicating that the variation observed in male sexual traits may be evident in condition as well. Here we discovered relationships between male sexual trait expression and condition. Specifically, male condition accurately predicts trait expression in low−quality environments, while this relationship is less reliable in high−quality environments. These results have important implications for sexual selection theory and the evolution of sexual traits as we examine the relationship between male condition and sexual trait expression at the most fundamental level of organization.

P3.135 GORDON, J.C.*; DALEY, M.A.; CARR, J.; HOLT, N.C.; BIEWENER, A.A.; Royal Veterinary College, UK, Harvard University, Cambridge, MA, Harvard University, Cambridge, MA; *jcgordon@rvc.ac.uk*

Guinea fowl running in rough terrain with reduced proprioceptive feedback

A fuller understanding of neuromuscular control of stable bipedal locomotion over rough terrain would progress many disciplines including biorobotic control. Bipedal birds such as the guinea fowl routinely negotiate complex terrain and serve as a useful animal model for integrative neuromechanics. To investigate the role of proprioceptive feedback in neuromuscular control of locomotion, we used bilateral surgical denervation, followed by re−innervation, of the lateral gastrocnemius in eight guinea fowl. This technique leads to recovery of motor output with absence of autogenic proprioceptive feedback in the gastrocnemius. Following re−innervation, we examined locomotor stability in the face of unexpected drop and obstacle perturbations, using external measures of body and limb dynamics (forces and kinematics). We then implanted tendon buckles, sonomicrometry and indwelling EMG to directly measure in vivo gastrocnemius neuromuscular function. Removal of proprioceptive feedback in a major distal limb extensor is expected to reduce dynamic stability in response to terrain perturbations. This should manifest as reduced myoelectric variability in distal limb EMG activation alongside greater variation in limb and body mechanics in the steps immediately following a perturbation. However, considering the potential speed−dependent nature of stabilizing strategies and higher reliance on intrinsic stability at high speed, reduced proprioception might influence slow movement (walking) to a greater extent than fast movement (running).

122.1 GORDON, J.C.*; RANKIN, J.W.; WILSON, A.M.; DALEY, M.A.; Royal Veterinary College, UK; *jcgordon@rvc.ac.uk*

How do movement speed and terrain visibility influence neuromuscular control of bipedal locomotion?

Bipedal locomotion requires dynamic stability accomplished via complex interactions of sensory information, neuromuscular control and intrinsic mechanics. To prevent falls and maintain desired movement, control must seamlessly adapt for both anticipated and unexpected perturbations. Previous guinea fowl obstacle negotiation studies suggested different behavioural strategies for stability depending on whether birds ran over ground or on a treadmill. One hypothesized reason for the difference is reduced obstacle visibility on a treadmill. To further investigate context−dependent shifts in neuromuscular control we presented high and low contrast obstacles to guinea fowl (*Numida Meleagris*, N = 6) walking (0.7ms−1) and running (1.3ms−1) on a treadmill. We recorded muscle activity using indwelling electromyography (EMG) in 8 hind limb muscles. Manipulating obstacle contrast induced only subtle myoelectric shifts across all muscles. However, treadmill speed substantially influenced obstacle negotiation strategy. We observed larger total intensity shifts across hind limb muscles in walking compared to running, with greater anticipatory muscle activity shifts in proximal muscles, and larger reactive changes in distal muscles. We also observed larger variations in swing−stance timing during walking. Across terrain conditions, principle component analysis revealed that 2PCs can explain 85% of muscle activity variance, the 1st PC (63%) representing co−variance in a hip flexor and distal extensors, and the 2nd PC (22%) representing co−variance in hip extensors. Our findings provide direct evidence for speed−dependent shifts in control, with a greater reliance on stride−to−stride neural adjustments at slow speed, shifting towards feed−forward activation and intrinsic mechanical stability at high speed.

98.1 GOTO, D*; RAINWATER, E; FASSBINDER−ORTH, C; Creighton University; *carolfassbinder−orth@creighton.edu*

Lipid digestion and absorption are impaired during an alphavirus infection in nestling birds

Nestling birds serve as reservoirs for several arthropod−borne diseases, especially arboviruses. However, few studies have investigated the effects of an arbovirus infection on nestlings during this critical period of development. Digestive function is an integral component of nestling development, and was measured by three parameters in this study: pancreatic lipase activity, digestive efficiency, and lipid content of excreta. Nestling house sparrows were inoculated at 7 days of age with an arthropod borne alphavirus called Buggy Creek virus (BCRV). Pancreas samples were collected from birds post mortem at 9, 10, and 11 days of age to be analyzed for lipase activity. Daily dry matter feed input and dry matter excreta output were measured, and the digestive efficiency of each bird was calculated during the experiment (from 5−11 days of age). Excreta samples were dried at 60 °C for 24 hours, followed by a lipid extraction using the Soxhlet side arm extractor and diethyl ether. Lipase activity and digestive efficiency were significantly lower for BCRV (lineage A)−infected birds post infection. Additionally, lipid content was higher in the excreta of BCRV−A infected birds post infection compared to controls, peaking at twice the amount of lipid found in control bird excreta at 4 days post infection. These results indicate that an alphavirus infection decreases digestive efficiency and lipid digestion and absorption in nestling birds. While the contribution of carbohydrate and protein digestion impairment to the decrease in digestive efficiency is unknown, it is likely that this severe decline in lipid digestion and absorption largely contributes to the decrease in digestive efficiency witnessed, and also to the poor body and tissue growth that has been recorded for BCRV−infected nestling birds.

41.6 GOUGH, W.T.*; FARINA, S.C.; FISH, F.E.; Cornell University, West Chester University; *wgough0788@gmail.com*

Aquatic burst locomotion by hydroplaning and running in Common Eiders (Somateria mollissima)

Eiders have high wing loadings that are near the accepted threshold for flightlessness in birds that can cause flight to be energetically expensive. Surface swimming by paddling generates waves that can limit maximum speed. These coastal sea−ducks can overcome the speed limitations of self−generated waves, known as hull speed, by performing rapid behaviors that generate dynamic lift (hydroplaning). We obtained high−speed videos (210 fps) of Common Eiders from a boat around the Isles of Shoals in the Gulf of Maine. A portable GPS unit was used to measure the speed as the boat paced the ducks. The videos showed two distinct hydroplaning behaviors: (1) "steaming", which involved rapid paddling with the wings to propel the duck along the surface of the water and (2) "wing−assisted running," during which the ducks lifted themselves completely out of the water and used their hind feet to paddle along the surface while flapping their wings. When steaming, the wings made substantial contact with the water in a rowing motion. During running, the wings were used for flight and only the feet made contact with the water, with a gait using alternating strokes of the hind limbs. The mean wingbeat frequency of steaming (4.57 ± 0.44 Hz) was slower than the wingbeat frequency of wing−assisted running (8.69 ± 0.65 Hz). The hull speed, which is based on the waterline length, was calculated to be 0.72 ± 0.05 m/s for Eiders. During steaming, ducks were found to exceed hull speed by 5.9 times. When burst locomotion by Eiders is necessary, hydroplaning and running are likely energetically economical and rapid alternatives to diving or flight for these heavy marine ducks.

63.5 GOY SIRSAT, S.K.*; SIRSAT, T.S.; SOTHERLAND, P.R.; DZIALOWSKI, E.M.; University of North Texas, Denton, Kalamazoo College, Kalamazoo; *sarahsirsat@gmail.com*

Development of Endothermy in the Altricial Red−Wing Blackbird (Agelaius phoeniceus)

We examined development of endothermy in altricial Red−winged Blackbirds (*Agelaius phoeniceus*) by measuring oxygen consumption, body temperature and ventilation from 35 to 15&degC. Mitochondrial respiration of permeabilized muscle (breast−*pectoralis* and thigh−*quadriceps*) was also measured. Animals were examined at externally pipped (EP) stage through fledging (12 days post hatch, dph). Nestling whole−body metabolic rate began an endothermic response to cold temperature midway between hatching and fledging. Neonates less than 5 dph were unable to maintain elevated oxygen consumption and body temperature when exposed to decreasing temperature, whereas 7 dph nestlings could maintain oxygen consumption until ~25&degC, after which metabolism dropped. From 10 dph to fledging, animals maintained elevated oxygen consumption and body temperature when exposed to cold: full endothermic capacity was achieved. Ventilation followed a similar developmental trend. LEAK respiration of breast was significantly higher than thigh after 3 dph, while breast oxidative phosphorylation (OXPHOS) of complex I (CI) increased significantly from thigh after 10 dph. Breast OXPHOS through CI+II was significantly higher than thigh after 5 dph. Thigh OXPHOS through CI and CI+II increased significantly with age after 5 dph, while breast LEAK and both types of OXPHOS increased significantly with age after 3 dph. Increased metabolic capacity at the cellular level occurred prior to that of the whole animal. This change in capacity was obtained steadily upon hatching as evidenced by the shift of metabolic rate from an ectothermic to endothermic phenotype, and the increase of mitochondrial activity of the primary shivering muscles of this avian species. Supported by NSF IOS 1146758 (EMD).

89.3 GOYMANN, W.; MPI fuer Ornithologie, Seewiesen; *wolfgang@goymann.org*
The comparative environmental and evolutionary endocrinology of black (Centropus grillii) and white−browed coucals (C. superciliosus), two sympatric birds differing in mate competition and parental care patterns
John Wingfield's contributions to environmental endocrinology have been crucial for the ongoing success of this lively field of research. One of John Wingfield's strengths is his ability to conceptualize his tremendous knowledge about the natural history of animals and combine it with highly relevant research questions regarding the hormonal control mechanisms of behavioral and other traits. Together with Emily Rissman he was, for example, among the first to study hormonal correlates of sex−role reversed behaviors in birds. In his laboratory, I started to continue this line of research investigating hormonal factors involved in sex−role reversal of black coucals, the only altricial bird species with obligate female competition for territories and access to males and male−only care. In subsequent years I have expanded my focus to also include the white−browed coucal, a sympatric coucal species that is socially monogamous and biparental. I will present comparative data regarding the breeding ecology and sex−hormone physiology of these closely related species. Further, I will compare the parental effort between black and white−browed coucals and relate it to corticosterone concentrations. The results and their implications for current ideas regarding the mechanisms of sex−role reversal and parental care will be discussed at the meeting.

57.1 GRACE, J.K.*; ANDERSON, D.J.; Wake Forest University; *gracjk7@wfu.edu*
Nestling maltreatment predicts adult stress response and personality in a free−living seabird
Non−breeding Nazca booby adults exhibit an unusual and intense social attraction to non−familial conspecific nestlings. Non−parental Adult Visitors (NAVs) seek out and approach unguarded nestlings during daylight hours and display parental, aggressive, and/or sexual behavior. In a striking parallel to the "cycle of violence" of human biology, degree of victimization as a nestling is strongly correlated with frequency of future maltreatment behavior exhibited as an adult. During maltreatment episodes, nestlings experience a surge in circulating corticosterone (CORT), consistent with the possibility that repeated activation of the hypothalamic−pituitary−adrenal axis permanently organizes future adult maltreatment behavior. We investigated long−term consequences of maltreatment on the CORT stress response and personality traits in free−living Nazca booby adults with known NAV victimization histories. A bird's maltreatment experience as a nestling negatively predicts baseline CORT as an adult and positively predicts protraction of the adult CORT stress response. Degree of maltreatment experience also positively predicts anxiety−related behaviors and negatively predicts aggressive behaviors performed as an adult. These findings are remarkably similar to those of mammals exposed to moderate/severe perinatal stress, suggesting a conserved response to early social trauma between mammals and birds.

96.2 GRAHAM, N.M.*; SMITH, C.L.; ROUTMAN, E.J.; San Francisco State University; *synapsida@gmail.com*
Population structure of Linanthus dichotomus (Polemoniaceae) using microsatellite analysis: can phenotypic variation restrict gene flow and lead to a pollinator shift?
Linanthus dichotomus, an annual plant distributed across California, Nevada and Arizona, is an interesting organism for the study of pollinator−mediated speciation. The flowers of subspecies *L. d. dichotomus*, found in the majority of the species' range, are vespertine in nature. However, in northern California the flowers of subspecies *L. d. meridianus* open early in the day and stay open until the following morning. Previous studies compared *L. d. meridianus* to *L. d. dichotomus* populations and found significant differences in flower morphology, anthesis timing and floral scent compound ratios. This evidence suggests a possible pollinator shift in *L. dichotomus meridianus* from a specific, nocturnal pollinator system, to a generalist diurnal system. We are investigating the genetics of adaptation to a new pollinator system and its effects on gene flow between these two subspecies.

78.3 GRANBERG, R.M.*; PERRY, G.; VERBLE, R.M.; Texas Tech University; *rachel.granberg@ttu.edu*
Home range size and survival of Texas horned lizard as a function of physical environment
The Texas horned lizard (THL; *Phrynosoma cornutum*) is a federal Species of Concern and declining across its native range. Current literature describes habitat loss and degradation as a major factor in this decline. Ashe juniper (*Juniperus ashei*) has formed monotypic stands in many areas of central Texas, potentially exacerbating a potential lack of thermoregulatory niches. This work evaluates the impact of disturbance, vegetation structure, and environmental parameters on horned lizard home range size and survival. I predicted that home ranges would be smaller and survival rates would be higher in disturbed habitats, due primarily to higher availability of thermoregulatory niches, via a patchy heterogenous vegetation structure. Using radio telemetry, I collected home range information on individuals from June to September 2013. Extensive vegetation surveys were conducted to assess how disturbances alter habitat structure and vegetation composition. Preliminary results suggest that individual survival and recruitment was higher in recently burned areas. Furthermore, fire creates a heterogeneous structure of vegetation and increased plant diversity. However, when paired with mechanical thinning, patch size increases and randomness of spatial patterns decrease.

83.4 GRAVISH, N.*; GOLD, G.E.; ZANGWILL, A.D.; GOODISMAN, M.A.D.; GOLDMAN, D.I.; Harvard University, Georgia Tech; *gravish@seas.harvard.edu*

Ant traffic and communication in confined environments

Many social insects construct subterranean nests which provide a safe location for rearing the young. However, nests can be confining; this can limit effective transportation of both resources and information. Moreover, in ant colonies the mechanistic nature of inter−ant communication places physical limits on the mobility of workers in subterranean nests. Thus collective mobility and communication in subterranean nests are at odds: the physical interactions necessary for information and resource exchange create obstacles that impede traffic flow and reduce worker mobility. To understand the effect of confinement on ant mobility and communication, we monitored the traffic of fire ant (*Solenopsis invicta*) workers in laboratory tunnels of diameter D = 2 − 6 mm. We observed the traffic of 5 groups of workers drawn from 3 colonies. We observed that regions of high ant density were correlated with a decrease in ant speed in all tunnels. The occurrence of high−density regions in a tunnel often coincided with bouts of tactile interaction using antennae (called antennation). The duration of antennation, T, was linearly proportional to the number of ants in the group, N. The slope of T versus N increased as D decreased indicating that smaller tunnels were more prone to formation of traffic jams. To elucidate the contributions of behavior and geometry on foraging traffic we developed a model, which incorporated the minimal features of ant tunnel traffic physical interactions and confinement, with one free parameter the duration of antennation. We found that the model reproduced the traffic patterns observed in experiment. Our experimental and simulation results indicate that traffic jams may be mitigated in foraging tunnels both by alteration of tunnel geometry and modulation of ant behavior. We compare these predictions with observations from natural fire ant tunnels.

P3.66 GRAY, K.T.; ESCOBAR, A.M.; MINEO, P.; SCHAEFFER, P.J.; BERNER, N.J.*; Sewanee: University of the South, Miami University, Oxford, OH, Miami University, Oxford, OH; *nberner@sewanee.edu*

Acclimatization in tadpoles of the Green frog (Rana clamitans)

Acclimatization (or acclimation) is the process by which individual organisms vary their characteristics in response to some aspect or aspects of their environment, and is an important mechanism by which organisms respond to fluctuations in their surroundings. Modifications in characteristics brought on by natural seasonal temperature differences can offset the depressive effects of lower winter temperatures. Tadpoles of the Green frog (*Rana clamitans*) overwinter as tadpoles in some parts of their range, including locally in Sewanee, TN. Because they demonstrate escape behavior in the winter when disturbed, we hypothesized that Green frog tadpoles would demonstrate acclimatization in some commonly modified biochemical and behavioral characteristics. To test this hypothesis, we collected tadpoles in winter (January) and summer (June and July) in Lake Cheston, Sewanee, TN. We measured a number of acclimation parameters (enzyme activity, metabolic rate, and escape behavior) at local winter (8°C) and summer (26°C) temperature, and determined membrane phospholipid fatty acid composition in winter− and summer−collected tadpoles. Tadpoles showed no acclimatization in metabolic rate (O_2 consumption of winter− and summer−collected tadpoles were not significantly different when measured at the same temperature) while simultaneously demonstrating acclimatization in the activities of all metabolic enzymes tested (significantly higher activity in muscle homogenates from winter− than summer−collected tadpoles for cytochrome c oxidase, citrate synthase and lactate dehydrogenase). Data for escape behavior as well as membrane lipid composition will also be presented.

99.2 GRAY, J.*; FREEMAN, JR. , R.M.; GERHART, J.; KIRSCHNER, M.W.; Harvard Medical School, University of California, Berkeley; *jessica_gray@hms.harvard.edu*

miRNAs in hemichordate development

miRNAs act as post−transcriptional regulators of gene expression networks in a number of developmental processes, and multiple evolutionary expansions of miRNAs are associated with body plan innovations. However, despite growing evidence for the role of miRNAs in model organism development and genome−wide small RNA studies in numerous species, data is lacking for a functional role of miRNAs in the development of non−model organisms. The question remains whether the evolution of targets and functions of miRNAs might have driven the evolution of developmental pathways or if they are instead uniquely regulated in different lineages. We are investigating the developmental expression and function of microRNAs in the direct−developing hemichordate *Saccoglossus kowalevskii*. As deuterostomes, hemichordates and vertebrates share a common ancestor and many developmental signaling pathways, making *Saccoglossus* an ideal model for uncovering how ancestral miRNAs may have contributed to evolution of development in the deuterostome lineage. Small RNA sequencing revealed that *Saccoglossus* miRNAs are dynamically expressed throughout development, suggesting potential roles in a number of developmental processes. An initial functional screen based upon these sequencing results has confirmed a conserved role for miR−1 in muscle development and revealed a potentially novel role for the neural miRNA miR−124 in dorsal/ventral patterning. The targets and functions of both conserved and non−conserved *Saccoglossus* miRNAs will be compared with their homologs and functional counterparts in vertebrates. Our work provides a first exploration of miRNA function in hemichordate development, which will contribute to understanding how the role of miRNA regulation in development has changed through evolution.

75.7 GREEN, C*; LUNDBERG, N; FERRARA, A; FONTENOT, Q; Louisiana State University Agricultural Center, Nicholls State University; *cgreen@agcenter.lsu.edu*

Development of larval salinity tolerance in two populations of alligator gar Atractosteus spatula

Adult alligator gar *Atractosteus spatula* are euryhaline, but it is unclear when larvae or juveniles develop salinity tolerance. Larval gar cannot tolerate salinities >8 psu, however adults thrive in full strength seawater (~35 psu). The goal of this study was to determine the effects of salinity on ion regulation and overall survival of larval alligator gar using acute salinity transfers. Two geographically distinct populations of gar larvae were used, one inland population and one coastal population. Larval gar were subjected to a salinity challenge with increasing salinity in later trials to determine salinity tolerance and dose−response curves for acute salinity exposures. After each 24−h acute salinity exposure, dry mass, whole body ion composition, gill and intestinal Na^+/K^+−ATPase (NKA) activity, and ion transport protein levels (NKA, $Na^+/K^+/2Cl^-$ cotransporter (NKCC); using qPCR) were measured. Larvae were dried at 60ÚC for 24 hours, weighed in grams then dissolved in 50% nitric acid and analyzed using flame spectroscopy to quantify Na^+, K^+, and Ca^+ whole body ion concentration. Older larvae of *A. spatula* survived salinities up to 18 psu. Based on LC50 dose response curves salinity tolerance of larval alligator gar increased in stages with the first increase occurring at 10 d post hatch and another increase at 25−30 d post hatch. Based on preliminary analysis dry mass was consistent across salinities for each population.

105.1 GREENFEST−ALLEN, E.*; LUND, R.; GROGAN, E. D.; Penn Center for Bioinformatics, University of Pennsylvania, Carnegie Museum, Saint Joseph's University; *allenem@upenn.edu*

Community structure of fishes in a Mississippian Bay

The 323 million year old Bear Gulch Lens of the Bear Gulch Member, Heath Formation of Montana, USA preserves an Upper Mississippian marine bay in its entirety, across both its spatial and temporal spans. Here we take advantage of this preserved environment and the quality and diversity of the associated fish fauna to gain rare insight into the structure and spatio−temporal stability of Paleozoic fish communities. Potential fish communities within the bay fauna were identified as sets of taxa that tend to co−occur, or recur, across the bay transect. We introduce a network−based approach that integrates patterns of abundance and occurrence to infer potential interactions between pairs of taxa in the fauna. Recurrent groups were then identified as sets of taxa that formed coherent connected sub−networks, or modules, within this interaction network. Using this approach, we identified nine potential communities, representing a unique association of taxa linked by shared habitat preferences. All recurrent groups were present in each sampled habitat zone and the relative contribution of most to the regional fish community is consistent across the bay despite the environmental and temporal fluctuation across the habitats, suggesting a degree of temporal stability among the fish communities. Results from this analysis were integrated with an independent partitioning of the fauna into a set of functionally defined ecomorphotypes, allowing assessment of potential interactions between taxon recurrence and ecological role.

P2.101 GREENFEST−ALLEN, E*; STOECKERT, C; MAGNUSON, M; University of Pennsylvania; *allenem@pcbi.upenn.edu*

Defining a Beta Cell: An Objective Gene Signature Framework

A growing body of biological work is dedicated to producing key cellular populations via directed culturing of embryonic stems cells (ESCs) or reprogramming of existing mature cell populations. Here, we present the system of pancreatic beta cell development as an exemplar for establishing a standard gene signature framework for defining target cell types and evaluating progress toward the goal of directed differentiation. Because loss of beta cell function and mass is a contributing factor of diabetes, many attempts have been made to generate beta cells from pre−existing cell populations; most have produced at best "beta−like" cells that share characteristics of both immature beta cells and the source populations or steps along the way. Here, we use knowledge of the genetic signatures of specific pancreatic cellular populations to better define both the end point and the pathway to mature beta cells. We performed comprehensive transcriptome profiling of twelve murine pancreatic progenitor and adult cell populations covering pancreatic differentiation from embryonic day 8.0 through post−natal day 60. Using these data, we estimated a gene−interaction network that was iteratively partitioned to identify a set of robust, connected sub−networks comprised of genes with similar expression profiles. Our network analysis further identified temporal alterations in gene−interactions regulating stepwise production of beta cells. In particular, we observed a strong demarcation between pre−and post−endocrine cell specification, suggesting that the genetic toolbox underlying early morphogenesis is distinct from that utilized in the differentiation of individual endocrine cells, once the endocrine cell−fate has been specified. Coupled with functional annotations derived from curated biological ontologies we used these data to delimitate a set of genetic and process−based signatures that define pancreatic cell populations.

S6.3−2 GREENLEE, Kendra J.*; MONTOOTH, Kristi L.; North Dakota State University, Fargo, Indiana University, Bloomington; *kendra.greenlee@ndsu.edu*

Predicting performance and plasticity in the development of respiratory structures and metabolic systems

The scaling laws governing metabolism suggest that we can predict metabolic traits across taxonomic scales that span large differences in mass. Yet, scaling relationships can vary with development, body region, and environment. Within species, there is variation in metabolic rate that is independent of mass and which may be explained by genetic variation, the environment or their interaction (i.e., metabolic plasticity). Additionally, some structures, such as the insect tracheal respiratory system, change throughout development and in response to the environment to match the changing functional requirements of the organism. We discuss how study of the development of respiratory function meets multiple challenges set forth by the NSF Grand Challenges Workshop. Development of respiratory system structure and function 1) is inherently stable and yet can respond dynamically to change, 2) is plastic and exhibits sensitivity to environments, and 3) can be examined across multiple scales in time and space. Predicting respiratory performance and plasticity requires quantitative models that integrate information across scales of function from metabolic gene expression and mitochondrial biogenesis to the building of respiratory structures. We present insect models where data are available on the development of the tracheal respiratory system and of metabolic physiology and suggest what is needed to develop predictive models. Incorporating quantitative genetic data will enable mapping of genetic and genetic−by−environment variation onto phenotypes, which is necessary to understand the evolution of respiratory systems and their ability to enable respiratory homeostasis as organisms walk the tightrope between stability and change.

P2.76 GREENWAY, R.S.*; TOBLER, M.; Oklahoma State University, Stillwater; *ryan.greenway@okstate.edu*

Xiphophorus hellerii in toxic sulfide springs: patterns of adaptation like in other sulfide spring poeciliids?

In Mexico, fish of the family Poeciliidae are common in the freshwater tributaries of the Río Grijalva. Within each tributary, there are also localized habitats with extreme environmental conditions in the form of springs rich in hydrogen sulfide (H_2S), which is highly toxic for most organisms. Populations of the fish *Poecilia mexicana* have independently colonized these toxic habitats from ancestral freshwater habitats in three separate tributaries of the Río Grijalva. In one drainage, the *Rio Pichucalco*, additional species of poeciliid fish can be found in sulfidic springs, including a population of *Xiphophorus hellerii* (green swordtail), which occurs alongside *Poecilia sulphuraria*, a recently diverged sister species of *Poecilia mexicana* endemic to sulfidic habitats. This study aimed to determine if this population of *X. hellerii* has adapted to the toxic conditions in a similar fashion as *P. sulphuraria* and other populations of *P. mexicana* in sulfidic springs in the Río Grijalva system. To test this, *X. hellerii* from a sulfidic stream and a non−sulfidic stream were subjected to sulfide tolerance trials, and several morphological and physiological traits were compared between these populations. I predicted that *X. hellerii* originating from the sulfidic stream will have a higher tolerance to hydrogen sulfide as well as larger heads, gills, and livers when compared to fish from the non−sulfidic stream.

109.6 GREENWOLD, MJ*; BAO, W; SAWYER, RH; University of South Carolina; *greenwold@biol.sc.edu*

Molecular evolution and expression of feather structural proteins, alpha and beta keratins, in birds

Feathers are one of the most distinguishing features of birds and feather diversity is directly related to sexual selection and ecological niches. Today's feathers are composed of two types of fibrous, structural proteins, alpha and beta keratins. While, alpha−keratins are found in all vertebrates, beta−keratins are found exclusively in reptiles and birds. Alpha keratins are separated into two types, Type I or acidic alpha−keratins and Type II or neutral/basic alpha−keratins and avian beta−keratins are divided into 4 subfamilies (feather, scale, claw and keratinocyte beta−keratins). This study details the expansion and contraction of these gene families in birds using the genomes of 48 phylogenetically diverse birds. In birds, we found that the mean number of alpha−keratins is significantly lower than in reptiles and mammals and that at least 14 "epithelial" or "hair" alpha−keratins have been lost in the avian lineage. Additionally, we find that the avian specific feather beta−keratins comprise a large majority of each species' total number of beta−keratins and that aquatic and semi−aquatic birds have a proportionally smaller number of feather beta−keratins and a larger proportion of keratinocyte beta−keratins than terrestrial birds. Comparative transcriptome analysis of the scutate scale, dorsal and wing feather during embryonic development identifies 26 of the 27 alpha−keratins and at least 102 beta−keratins are differentially expressed in the chicken. These data indicate that the expansion of beta−keratins and contraction of alpha−keratins in the stem lineage of birds likely shaped the early evolution of feathers and subsequent alpha and beta−keratin gene family dynamics continued to shape the evolution of feathers in birds.

3.4 GREIVES, T*; KINGMA, S; KRANSTAUBER, B; HAU, M; North Dakota State University, University of Groningen, Max Planck Institute for Ornithology, Max Planck Institute for Ornithology; *timothy.greives@ndsu.edu*

Continuous release melatonin implants delay daily activity onset and alter reproductive success in the great tit (Parus major)

Endogenous rhythms are thought to enhance fitness by facilitating proper timing of biological functions with environmental conditions. The majority of research on circadian rhythms however have been conducted in the lab, where the fitness relevance of endogenous rhythms cannot easily be determined. The pineal hormone melatonin is an important component for the entrainment of circadian rhythms with the organism's diel environment. The current study aimed to begin to uncover the effects of disrupting endogenous rhythms via manipulation of melatonin rhythmicity in a free−living vertebrate. Three weeks prior to egg−laying, wild male great tits (*Parus major*) received a silastic implant either left empty or filled with melatonin; this manipulation is known to elevate daytime melatonin to levels comparable with normal night peak levels. Additionally, all individuals received a radio−transmitter, and using automated telemetry recording, the precise timing of daily behavioral activity onset was recorded. Individuals were followed throughout the breeding season and measures of reproductive success and extra−pair paternity were assessed. Male great tits receiving melatonin implants delayed daily activity onset compared with control birds, presumably due to the inability to use the melatonin rhythm to entrain endogenous rhythms, and were thus unable to anticipate sunrise. These birds, however became active during the morning light. Control birds became active before sunrise during the dawn chorus. Melatonin−treated birds were more likely to be cuckolded and tended to sire fewer total offspring. These results indicate a strong selective advantage for a functional circadian system capable of anticipating important diel environmental transitions.

P2.95 GRILL, S.*; DORGAN, K. M.; Hochschule Bremen, Dauphin Island Sea Lab; *sgrill@stud.hs−bremen.de*

Burrowing by small polychaetes − mechanics, behavior, and muscle structure of Capitella sp.

Most worms extend burrows in mud, which acts as an elastic solid, by fracture. To extend a burrow by cracking, the worm applies force dorso−ventrally, which is amplified at the crack tip. Smaller worms are limited in the extent to which they can displace sediments, and therefore in how much force they can apply to burrow walls. We hypothesized that a transition in burrowing strategy, specifically the ability to burrow by fracture and muscle morphology, would indicate a minimum body size below which burrowing by fracture would not be feasible. Kinematics of burrowing in a mud analog, external morphology and muscle structure were examined in juveniles and adults of the polychaete, *Capitella* sp., which is small enough that burrowing by fracture may potentially be limited by body size. *Capitella* sp. moves by peristalsis, and no obvious differences were observed among worms of different sizes; even very small juveniles were able to burrow through a clear mud analog by fracture. Interestingly, we found that in addition to longitudinal and circular muscles needed for peristaltic movements, left− and right−handed helical muscles wrap around the thorax of worms of all sizes. We developed a physical model to test whether contraction of these helical muscles may increase the internal pressure in the thorax, enabling even small worms to extend burrows by fracture. Further research is needed, however, to determine whether surficial sediments inhabited by small worms fail by fracture or plastically deform under forces applied by *Capitella* sp. Our results raise questions about whether worms in a size range close or below to the limit of being able to extend burrows by fracture, including juveniles of larger species, might show additional adaptions to enable locomotion.

127.2 GRINDSTAFF, JL*; WASELIK, M; Oklahoma State University, Stillwater; *jen.grindstaff@okstate.edu*

Developmental exposure to corticosterone and adult challenge with endotoxin have interactive effects on behavior in zebra finches (Taeniopygia guttata)

Exposure to parasites, immune challenges, and other stressors during development has the potential to alter personality expression in adulthood, but previous research has generally not addressed the potential interactive effects between developmental and adult stress exposure on adult personality and behavior. The objective of this study was to assess the potential for interactive effects between exposure to stressors during development and adulthood on two aspects of personality, activity and boldness, in a captive population of zebra finches (*Taeniopygia guttata*). We used oral dosing with corticosterone (CORT) to simulate natural activation of the stress response and challenge with the endotoxin lipopolysaccharide (LPS) to simulate exposure to a bacterial challenge. CORT treatment was administered during development and LPS challenge was administered in adulthood. Developmental CORT treatment reduced the boldness of females in adulthood, but did not impact male boldness. LPS challenge in adulthood reduced the activity levels of females, but male activity levels were not significantly affected. Finally, birds were bolder if treated developmentally with CORT and not challenged with LPS as adults or if they were not exposed to CORT during development but were challenged with LPS in adulthood. This demonstrates that exposure to stressors during development can have persistent effects on adult behavioral expression and can also have interactive effects with exposure to stressors during adulthood.

P3.145 GROSSI, B.; IRIARTE−DIAZ, J.*; LARACH, O.; CANALS, M.; VASQUEZ, R.A.; Universidad de Chile, University of Chicago; *josdiiri@gmail.com*

Walking like dinosaurs: Chickens with artificial tails recreate non−avian theropod locomotion

Birds still share many traits with their dinosaur ancestors, making them the best living model to reconstruct certain aspects of theropod biology. Bipedal, digitigrade locomotion and parasagittal hindlimb movement are some of those inherited traits. Living birds, however, maintain an unusually crouched hindlimb posture and locomotion powered by knee flexion, in contrast to the inferred primitive condition of non−avian theropods: more upright posture and limb movement powered by femur retraction. Such functional differences, which are associated with a gradual, anterior shift of the centre of mass in theropods along the bird line, make the use of extant birds as analogues to study non−avian theropod locomotion problematic. Here we show that, by experimentally manipulating the location of the centre of mass in living birds, it is possible to recreate limb posture and kinematics inferred for extinct bipedal dinosaurs. Chickens raised wearing artificial tails, and consequently with more posteriorly located centre of mass, showed a verticalization of the femur during standing and increased femoral displacement during locomotion. Our results support the hypothesis that gradual changes in the location of the centre of mass resulted in more crouched hindlimb postures and a shift from hip−driven to knee−driven limb movements through theropod evolution. This study suggests that, through careful experimental manipulations during the growth phase of ontogeny, extant birds can potentially be used to gain important insights into previously unexplored aspects of bipedal theropod locomotion.

8.8 GRUBICH, JR; WESTNEAT, MW*; BOS, AR; The Field Museum of Natural History, American University in Cairo; *jgrubich@fieldmuseum.org*

Fish Gristle: mechanical performance of IOPM ligaments among functionally diverse jaws.

The motor patterns, feeding kinematics, and functional morphology of jaws have been studied in numerous reef fish taxa. However, the underlying mechanics of the ligaments and tendons that make up the critical linkages of fish feeding mechanisms have received less attention. The interopercular mandibular ligament (IOPM) provides a key functional link between the lower jaw and suspensorium in the jaw mechanisms of fishes. Here, we examine the tensile properties of this ligament among five ecomorphologically diverse reef fish species (*Chlorurus gibbus, Cheilinus lunulatus, Sphyraena qenie, Plectropomus areolatus,* and *Epibulus insidiator*) that span the continuum of feeding strategies from substrate biting to ram/suction feeding including the advent of extreme jaw protrusion. Using a materials testing machine, we tested the tensile load capacity of this ligament in each species. We used cross−sectional area of the main jaw closing muscle, the adductor mandibulae, to estimate the upper bound of maximum force transmitted through the IOPM during feeding. Our preliminary analysis shows considerable mechanical variation among species. IOPM ligaments of biting taxa show the greatest strains (e.g. *C. gibbus* = 54.6%, *C. lunulatus* =19.9%, and *S. qenie* = 29.6%). In contrast, suction feeding taxa that exhibit jaw protrusion had much smaller strains 3.5% and 10.7% for *E. insidiator* and *P. areolatus*, respectively. Mean stiffness of the ligament also varied more than a 325 fold from 14.65 kN/m for the excavating parrotfish *C. gibbus* to 4769 kN/m for the suction feeding grouper, *P. areolatus*. Comparing mechanical properties of fish skull linkage components offers new if not counterintuitive insights into the selective forces that have shaped the diversity of feeding strategies found in reef fishes.

S6.2−2 GRUNBAUM, D.*; PADILLA, D.K.; University of Washington, Stony Brook University; *grunbaum@ocean.washington.edu*

SCALES OF ENVIRONMENTAL CHANGE, ENVIRONMENTAL MATCHING AND THE DYNAMICS OF PHENOTYPIC PLASTICITY

A recurrent theme across biology is the need to understand linkages between genotypes and phenotypes, especially in the context of evolution and regulation of phenotypic plasticity. Organism−level genotype−phenotype relationships set by the roles and limits of phenotypic plasticity, responsiveness to environmental fluctuations and trends, and variability among organisms have major impacts on lower levels of biological organization (development, physiology, behavior) and higher levels (population and community dynamics, evolution). However, these relationships, especially how rate and magnitude of spatial and temporal environmental change promote or inhibit evolution of alternative plastic phenotypic responses in different organismal systems, are poorly understood. Here, we develop a modeling case study of competing, co−occurring congener marine snail species, which exhibit distinct morphologic and behavioral plasticity in response to fluctuations in their shared environment. We examine mechanisms coupling stability and change across a spectrum of scales in environmental drivers, in individual morphologies and behavioral strategies, and in population−level characteristics such as abundance, diversity and species dominance. We assess the adaptive value of phenotypic plasticity, conditions that will or will not favor plasticity, and impacts of plasticity on abundance and coexistence. Quantitative organism−level models offer untapped opportunities for integrating across scales to interpret and predict biological dynamics in present and future environments.

P1.132 GUARDADO, D*; PERFITO, N; HAU, M; BENTLEY, G.E.; Univ. of California, Berkeley , Max−Planck Inst. of Ornithology, Germany; *daisy.guard@gmail.com*

Reproductive axis activation following photostimulation in a wild female songbird

The ability to respond to environmental signals is critical for the timing of reproduction. To this end, the seasonal change in photoperiod is one of the most reliable environmental cues available. Both male and female songbirds increase circulating gonadotropins (luteinizing hormone, LH, and follicle stimulating hormone, FSH) in response to photostimulation. However, the sexes exhibit distinctly different patterns of gonadal maturation. Currently, we do not understand the neural mechanisms responsible for the sex differences described above, as females have not been studied in this regard. We can begin to investigate this topic by utilizing the "first−day release model," which predicts rapid changes in several photoperiodically controlled genes and activation of the reproductive axis following exposure to a single long day. This model was developed using male Japanese quail. Recently, our lab has shown that this model is also relevant to males of a wild species, the great tit (*Parus major*). Similar key genes are involved in the photoperiodic response of the two species. However, it is not known if females of any species exhibit similar changes in gene expression in response to long days. To determine this, we exposed wild female great tits to a long day stimulus and measured changes in key genes during the first 46 hours of photostimulation (Dio2, Dio3, FSH−² and GnRH). Preliminary results suggest that patterns of gene activation in female great tits are similar to those observed in males, suggesting that sex differences in patterns of gonadal development might be achieved by a mechanism other than that which underlies the basic photoperiodic response.

12.3 GUERMOND, SM*; BEAZLEY, M; MEYER, E; Oregon State University; *sarah.guermond@science.oregonstate.edu*
Interacting effects of light and temperature on the transcriptome of Madracis auretenra
Coral reefs are in decline globally, in part because of bleaching−induced mortality resulting from multiple stressors including temperature and light. To enable studies of gene expression in *Madracis auretenra*, a Caribbean coral for which no sequence resources were previously available, we sequenced, assembled, and annotated the transcriptome using RNA from a colony collected at Flower Garden Banks (FGB) in the Gulf of Mexico. We prepared both normalized and non−normalized cDNA libraries, and found that normalized cDNA provided more complete gene representation and contained less contamination from the algal symbiont. Although interacting effects of elevated temperatures and light are important for coral bleaching, most gene expression studies of bleaching have profiled their combined effects. To disentangle the effects of each factor, we profiled gene expression in factorial combinations of temperature and light intensity. To simulate environmentally relevant conditions, we slowly increased temperatures from 28°C to a final temperature (31°) only one degree higher than the average annual maximum temperature encountered by corals at FGB. Bleaching occurred at approximately 4 degree heating weeks in the high light, high temperature treatment. To quantify these effects, we measured symbiont density using qPCR. We then profiled gene expression in all treatments to identify transcriptional responses specific to each factor and to their interaction. Our findings suggest that responses to warming sea water temperatures may depend on factors such as depth and turbidity that affect light intensity, and identify different genes and physiological processes affected by each factor separately and in combination.

40.4 GUERRA, M.A.*; CANNATELLA, D.C.; RYAN, M.J.; University of Texas at Austin; *m.guerra@utexas.edu*
Call polymorphism mediates assortative mating between genetic morphs in an Amazonian frog
Theory predicts the importance of sexual selection in driving speciation processes. Empirical studies supporting this phenomenon, however, are far less common, and these are usually confined to comparisons among allopatric populations. This study empirically tests the potential of sexual selection to drive genetic and call differentiation in natural allopatric and sympatric populations of the Amazonian frog *Physalaemus petersi*. Male frogs use advertisement calls to attract females to breeding sites, and females use the calls to identify and discriminate among conspecific males. Acoustic characteristics of male calls in *P. petersi* vary among populations. Call analyses from several populations of the Ecuadorian Amazon has led us to classify them into three possible call morphs (based on the complexity and the dominant frequency of the males' calls). This call polymorphism also coincides with a genetic polymorphism. Populations of different call morphs can be allopatric, sympatric and even syntopic. Signal variation is crucial to achieve behavioral reproductive isolation, but this variation must also be salient to females. The goals of this study are: 1) to test female discrimination ability and strength of selection, and 2) to assess the degree of assortative mating by call morphs (and thus genotypes) in nature. We performed female choice phonotaxis experiments in an allopatric and a syntopic population of *P. petersi* using one of the call morphs. Our results show that females discriminate mainly based on the dominant frequency of the male's call, and female discrimination is the same regardless of the presence of other call morphs in the area. Also, we report the degree of assortative mating found in nature. This study highlights the significance of sexual selection in reproductive isolation.

BERN.1 GUILLETTE, L.J.; Medical University of South Carolina; *lou.guillette@gmail.com*
Howard A. Bern Lecture: "The Fragile Fetus" − The Environmental Endocrinology of the Developing Reproductive System
Professor Louis Guillette is one of the world's leading figures in endocrine disruptor research. Dr. Guillette holds an Endowed Chair of Marine Genomics at the Hollings Marine Laboratory and is Professor of Obstetrics and Gynecology at the Medical University of South Carolina. In 2010 he was awarded the prestigious Heinz Science Medal for his work in the area of environmental health, is a Fellow of the American Association for the Advancement of Science, and one of only 30 Professors of the Howard Hughes Medical Institute. He is internationally recognized for his research in the field of reproductive endocrinology and developmental biology, having published over 300 papers and edited five books. Dr. Guillette and colleagues have shown how environmental toxicants interact with the endocrine system of wildlife species and alter their development and reproductive health, and how these findings are relevant to human reproductive health. His work has been featured in the national and international media (BBC, NHK, ABC, CBC and PBS) including such programs as NOVA, Horizon, and FRONTLINE.

28.2 GUINDRE−PARKER, S.*; RUBENSTEIN, D.R.; Columbia University, NYC; *slg2154@columbia.edu*
Oxidative Costs of Reproduction and the Evolution of Cooperative Breeding
For cooperative breeders where more than two individuals care for young, high costs of parental care may contribute to the evolution of this social behavior. This hypothesis has gone largely untested for two reasons. First, the physiological mechanisms underlying reproductive costs remain a mystery, and second, the reproductive costs for cooperatively breeding species have not been studied in a comparative context. Here we compared the costs of reproduction in two closely related species of African starlings that differ in their social behavior: the cooperatively breeding superb starling (*Lamprotornis superbus*) and the non−cooperatively breeding greater blue−eared glossy starling (*Lamprotornis chalybaeus*). To determine if physiological costs associated with reproduction underlie differences in sociality, we assessed (1) the potential of oxidative stress an imbalance between reactive oxygen species and antioxidants as a currency of the costs of reproduction and (2) the physiological differences between species/individuals of different breeding roles. We found that oxidative stress is representative of behavioral workload, suggesting that oxidative balance is an adequate measure of both breeding effort and the costs of reproduction. Moreover, the change in oxidative balance differed by species and breeding role, as social fathers of the non−cooperative species increased in oxidative stress to a greater extent from early to late breeding. Thus, having helpers at the nest may reduce the costs as measured by oxidative balance of paternal care and ultimately help drive the evolution of cooperative breeding behavior. For species inhabiting harsh and unpredictable environments, the differential costs of breeding may therefore explain why some species breed cooperatively while others living in the same environment do not.

71.3 GUMM, J. M.*; BURNS, H.; CHERRIER, E.; Stephen F. Austin State University; *gummj@sfasu.edu*

Mate preference based on visual and chemical cues in colorful freshwater fishes

Understanding how females identify mates is fundamental to understanding the evolution of mating preferences and reproductive isolation among species. In colorful freshwater fishes, known as darters (genus *Etheostoma*), visual signals play a role in preferences for conspecifics over heterospecifics and are used by females to prefer males within species. Darters respond to both chemical and visual stimuli for appropriate predatory avoidance behavior. The role of chemical cues for mate preference, however, remains unclear. We tested the hypothesis that female *Etheostoma stigmaeum* use chemical cues to choose mates between conspecific males and heterospecific male *E. swaini*. These two species are sympatric, and males express similar breeding colors, but hybridization is not known to occur. Female *E. stigmaeum* were tested in standard dichotomous mate choice trials with a choice to associate with chemical cues derived from conspecific males or those from heterospecific males. We found that females had significant preferences for conspecific male chemical cues. Our results establish the use of chemical cues for mate choice in darters and highlight the potential for multimodal signaling to contribute to reproductive isolation between these species.

P1.150 GURSKI, L.M.*; FURINESS, S.; COCKETT, P.; PENNOYER, K.; BIRD, C.E.; Texas A&M University, Corpus Christi; *lgurski@islander.tamucc.edu*

Microclimates affect the genomic composition of Hawaiian limpets

The crashed Hawaiian limpet fishery, is an excellent system in which to study the effects of overharvesting on genetic diversity, composition and adaptive capacity in a highly genetically structured population. The Hawaiian limpet, *Cellana exarata*, exhibits substantial gene flow restriction among islands, lives high in the intertidal zone and experiences increasingly hotter and more desiccating conditions due to global climate change. Here, we employ genome−wide sequencing (~20K SNPs) to test for alleles that are more prevalent in three different rocky shoreline microhabitats: hot horizontal surfaces, cooler vertical surfaces, and even cooler crevices. We perform this test across an overharvesting gradient from the least impacted Big Island of Hawai'i to the most impacted island of O'ahu. We identify several genes that are affected by microhabitat, but detect little effect of overharvesting on the adaptive capacity of the limpets. The low level of overharvesting impact on adaptive capacity may be due to low levels of gene flow from adjacent islands, and the severely reduced O'ahu population may remain large enough to buffer the extinction of advantageous alleles.

119.1 GUTMANN, A.K.*; MCGOWAN, C.P.; University of Idaho; *agutmann@uidaho.edu*

Built to hop: functional specialization of the hindlimb of the desert kangaroo rat (Dipodomys deserti)

Kangaroo rats hop bipedally whereas most other rodents exclusively use quadrupedal gaits. One hypothesis is that hopping evolved as a means of producing the large accelerations needed to escape predators. If this is the case, one would expect the musculoskeletal anatomy of the kangaroo rat hindlimb to be extremely specialized for accelerating. We measured the mass, fascicle length, and pennation angle of all major muscles in the kangaroo rat hindlimb, and the mass and length of the ankle extensor tendons. We also measured moment arms for all major muscles in the hindlimb. Based on these data, we calculated muscle physiological cross−sectional area, tendon cross−sectional area, tendon safety factor, elastic strain energy storage, and fiber length factor. We compared these data with published data for the rat (*Rattus norvegicus*), a quadrupedal generalist. Relative to body weight, the kangaroo rats were noticeably more well−muscled than the rats (1.7 times more hindlimb muscle mass/body mass). The hip extensors and the knee flexors represented the two largest muscle groups in both the kangaroo rats and the rats, but these muscle groups were larger in the kangaroo rats (1.6 and 1.8 times more muscle mass/body mass respectively). (Note: Many muscles belong to both muscle groups.) This is due primarily to relatively longer fascicle lengths. These large muscle groups produce the power kangaroo rats need for high acceleration. Additionally, the kangaroo rat ankle extensors had a high tendon safety factor and high fiber length factor indicating that the ankle extensor tendon can withstand high forces and the ankle extensor muscle−tendon unit is better suited for joint position control than elastic energy storage. Thus, there is substantial evidence that the kangaroo rat hindlimb is adapted for accelerating.

101.1 HABEGGER, L*; MOTTA, P; PULASKI, D; HUBER, D; DUMONT, E; University of South Florida, Tampa, University of Massachusetts, Amherst, University of Tampa, Tampa, University of Massachusetts, Amherst; *mhabegge@mail.usf.edu*

Feeding biomechanics in billfishes: inferring the role of the rostrum using FEA

Perhaps the most striking feature characterizing billfishes is the extreme elongation of the premaxillary bones comprising the rostrum. Surprisingly, the role of this structure is still controversial. The goal of this study was to investigate through finite element (FE) analysis the role of the rostrum during feeding, and to predict different patterns of feeding behavior in two billfishes with different rostral morphologies. We applied three loading regimes (lateral, dorsoventral and axial) to the FE models that mimic proposed feeding behaviors, and compared the predicted stress within the rostra of the two species. We validated our FE models using stress calculated from "in situ" strain gage studies. Preliminary results of the FE analyses accord well with the strain gage data. Overall, preliminary results imply that the bill in blue marlin may be better suited to perform a wider range of motions during feeding than the bill of swordfish. Spearing behavior, for example, may be more likely to occur in blue marlin as stress along the bill was predicted to be smaller compared to the stress observed in swordfishes under the same loading regime. On the other hand, swordfishes may be more likely to hit prey with lateral shakes of the head, since models of dorsoventral movements predicted much higher stresses. In both species the middle section of the rostrum was predicted to be most highly stressed, suggesting this region to be the most likely area of breakage under higher loads. These analyses support previous hypotheses about feeding behavior in blue marlin and swordfishes. Moreover, "in situ" and modeling studies may be the most suitable approach to quantifying the biomechanics of these elusive and extraordinarily fast fishes.

P3.16 HACK, N/L*; IYENGAR, V/K; University of California Santa Cruz, Villanova University; *nhack@ucsc.edu*

Big wigs and small wigs: the roles of size, sex and shelter in spatial distribution patterns in the maritime earwig Anisolabis maritima

Animal aggregations can occur for a variety of abiotic factors, such as resource limitation, or biotic factors including sexual selection and predator−prey interactions. Although it is challenging to determine the underlying mechanism of such grouping behavior, we conducted experiments in which we examined the interactions and distribution patterns among pairs of the maritime earwig *Anisolabis maritima* (Order Dermaptera). This insect, found in aggregations under beach debris around the world, is sexually dimorphic regarding its most distinctive feature in that females have straight posterior forceps/pinchers whereas males have asymmetrical, curved forceps. We placed pairs of individuals varying in sex and size and monitored their distribution with and without shelter at 15 min, 12 h and 24 h to determine the roles that these factors may play in spatial patterns and gain insight into the mating system. Overall, we found that females were less likely to cohabitate than males, and they were more tolerant of males than other females. Males, on the other hand, were less aggressive and distributed themselves randomly, except when males were different−sized, in which case they preferred cohabitation. Shelters appeared to play a key role in reducing aggressive interactions, and our results have interesting implications regarding how inter− and intrasexual interactions influence distributional patterns in nature.

14.1 HAGEY, T*; HARTE, S; VICKERS, M; HARMON, L; SCHWARZKOPF, L; University of Idaho, James Cook University; *thagey@vandals.uidaho.edu*

How Geckos Stick in Nature: Ecology and Biomechanics of Gecko Feet

Phenotype and performance play a fundamental role in evolution and ecology. Studies of form and function often use correlations between morphology, performance, and habitat use to examine patterns of ecomorphology and morphological adaptation. Geckos, of the taxonomic group Gekkota, are an understudied yet diverse clade of lizards in which studies of form and function would greatly improve our understanding of their evolution. Geckos have the rather unique trait of adhesive toe pads, enabling them to use arboreal and rocky environments in a way few other creatures can. Gecko toe pad morphology and adhesive abilities are highly variable across species, suggesting ecological adaptations may have driven their evolution, yet few studies has considered gecko adhesive morphology and performance in an ecological context. In this study, we quantified morphology, adhesive performance, and habitat use of 13 gecko species from Queensland, Australia including tropical, arid, arboreal, and rock−dwelling species. We found toe detachment angle to be correlated with residual limb length. We also found residual limb length to be correlated with the use of arboreal and rock microhabitats as well as negatively correlated with perch diameter. This study is one of the first examples investigating gecko adhesive performance and specific microhabitat parameters. We suggest additional comparative studies investigating gecko limb kinematics and setal mechanics to corroborate our observational results.

30.6 HAHN, TP*; SCHULTZ, EM; KELSEY, TR; MACDOUGALL−SHACKLETON, SA; CORNELIUS, JM; Univ. California Davis, Nature Conservancy, Univ. Western Ontario; *tphahn@ucdavis.edu*

Adaptive timing of life cycle stages in a temporally−flexible nomadic songbird.

Appropriate timing of life cycle events in varying environments is fundamental to survival and reproductive success. Achieving this when food supply and other environmental conditions vary capriciously in space, time, or both presents special problems. We have been interested in the question of whether dealing effectively with such conditions depends on adaptively specialized timing mechanisms or is based on a common system shared by taxa occupying a wide range of environments. Our studies of crossbills − nomadic songbirds that display particularly flexible annual schedules − reveal elements of adaptive specialization to deal with unpredictable changes in food supply, such as loss of absolute reproductive refractoriness to long days and tonic activity of the septo−infundibular gonadotropin releasing hormone system in the brain, and features in common with more typical seasonal breeders, such as a regularly−scheduled annual plumage molt and a consistent seasonal reproductive hiatus in autumn. Crossbills appear to be variations on the seasonal breeder theme, rather than fundamentally different in the way they orchestrate their annual schedules.

47.7 HAIGO, SL*; RODRIGO−ALBORS, A; TAZAKI, A; TANAKA, EM; REITER, JF; University of California, San Francisco, Technische Universität Dresden; *saori.haigo@ucsf.edu*

Cellular insights into the morphogenesis of vertebrate repair and regeneration

Among vertebrates, urodele amphibians have a remarkable ability to perfectly regenerate damaged organs and lost appendages, while mammals show restricted tissue repair, often with scarring of repaired organs. To elucidate conserved and divergent mechanisms utilized by regenerating versus repairing vertebrate animals, we are studying the cellular basis of the morphogenesis of spinal cord regeneration in the axolotl and skin wound healing in the mouse. We first sought to identify the activated zone of cells surrounding a full−thickness excision of the mouse skin. Similar to the axolotl, which activates a ~500 micrometer zone to reconstruct the lost spinal cord following tail amputation, we find that the mouse skin has a similar ~500 micrometer zone adjacent to the wound that is activated to repair the epidermis following injury. Moreover, this activated zone maintains this ~500 micrometer distance from the wound edge despite changing the size of the wound. These data suggest a conserved spatial region exists within vertebrates in response to any wound, whether the organ ultimately repairs or regenerates, or varies in the initial extent of injury. Next, to investigate how the neural progenitor cells from this 500 micrometer source zone initially reconstruct the regenerating spinal cord, we have developed real time, deep tissue in vivo imaging of juvenile axolotls and find that these cells undergo single and collective migration with exploratory protrusive activity at the leading edge during the initial phase of tail regeneration. Lastly, we'll discuss the role of the planar cell polarity (PCP) signaling pathway, a key regulator of developmental morphogenesis, during the morphogenesis of tissue repair and regeneration.

28.5 HAISHAN, W*; COLIN, T; IAIN, C; Princeton University; *haishanw@princeton.edu*

Quantifying fish school dynamics via automated tracking software SchoolTracker

Collective motion of fish schools has long been attracted by scientists ranging from biologist to physicists and computer scientists. Numerous models have been proposed to simulate such phenomenon, however, little is known about the individual−level interaction rules and network dynamics of fish schools due to the lack of empirical spatial−temporal motion data. Here we proposed a computer vision software named SchoolTracker which is able to automatically and accurately track large scale fish schools in the presence of frequent occlusions. We applied this software for tracking zebra fish (Danio rerio) schools and golden shiner (Notemigonus crysoleucas) schools which are comprised of individuals ranging from tens to hundreds. Quantitative analysis of the obtained tracks reveals the individual interaction rules and social dynamics of fish school. We also compared the school behavior difference between these two types of fish.

S6.1−2 HALE, M. E. ; Univ. of Chicago; *mhale@uchicago.edu*

Stability and change in the development of movement systems: Meeting short−term functional demands of the early life history and long−term needs for growth and maturation to the adult form.

Most fish species experience tremendous change in morphology and physiology through development. In addition to undergoing increase in size, their body shape and the organization of functional systems are often transformed. Through this period of growth and maturation, fishes must remain functional. As physiological and biomechanical demands shift through development with changes in predation pressures, food resources, Reynolds number and other factors, developmental processes must play the dual roles of ultimately achieving the adult form while generating intermediate stages that are adapted to the environment for each life history period. One example of developmental change in the morphology and function is the pectoral fin system. The structure and role of larval and adult zebrafish pectoral fins are strikingly different. In adults, the fins are generally actuated arrhythmically and serve roles in maneuvering and stability. In larval zebrafish, pectoral fins beat rhythmically and are coordinated with axial bending. Experimental work and computational modeling have shown that the larval fins do not generate propulsive force but instead are used to direct fluid flow near the body and augment cutaneous respiration. The morphology and movement of the larval fins suggest specific adaptations to this function. The pectoral fins of larvae and adults have distinct adaptive peaks of morphology and function, requires that there is a period of dramatic change in this system as an animal transitions between these organizations. Here I examine how fishes accomplish changes between functionally stable organizations in the pectoral fin system and in other comparative examples and I discuss implications for how change in function is navigated more broadly.

73.4 HALL, RW*; SPONBERG, S; DANIEL, TL; Univ. of Washington; *rhall9@uw.edu*

Fusion of proboscis mechanoreception and vision contributes to flower tracking in a freely flying moth

How do organisms in challenging sensory environments integrate independent information from multiple sensory modalities in order to improve performance? The crepuscular hawkmoth, *Manduca sexta*, hovers and tracks moving flowers during natural foraging behaviors. Prior experiments have shown that tracking performance depends on luminance, with an 30% increase in processing delay as light levels drop from dusk (300 lux) to moonlight (.3 lux). While vision is clearly involved, the role of mechanosensory information from the proboscis may also contribute to tracking performance. We tested this hypothesis with freely flying hawkmoths feeding from a robotically actuated artificial flower. The front face of the flower provided visual motion cues, while the concealed nectar reservoir provided independent mechanical motion cues. The face and nectary were decoupled so that one or the other could be moved in isolation. Movement was generated by a signal composed of a superposition of multiple sine waves (.2−20Hz). We reconstructed the moths' frequency response to determine the gain, phase, and error of its tracking performance. Results show that there is significant tracking to both modalities, providing strong evidence for the use of the proboscis as a sensory feedback system. At low frequencies, there was a significant phase lead when tracking the visual−only reference suggesting predictive filtering, such as velocity estimation. However, the gain of the mechanical system was much greater at low frequencies before trading off with vision at higher frequencies. Tracking error was reduced at low frequencies when both modalities were present indicating positive sensory fusion. The integration of multiple independent sensory modalities enhances performance of difficult behaviors in sensory deprived environments.

32.3 HALLAS, JM*; GOSLINER, TM; San Francisco State University, California Academy of Sciences; *jhallas@calacademy.org*

Problems with dating a nudibranch: age and ancestral range reconstruction of the genus Acanthodoris Gray, 1850 (Mollusca, Gastropoda, Nudibranchia)

In the absence of a reliable fossil record, the use of geological events to calibrate a relaxed molecular clock has been widely employed. However, the placement of such events on a phylogenetic tree can be problematic in accurately dating lineages. The unique distribution of the nudibranch genus *Acanthodoris* Gray, 1850 allows for an examination of the use of calibration points despite a fossil record, and their effect on ancestral range reconstruction (ARR). For this study, a phylogeny of *Acanthodoris* was estimated from a dataset of three genetic markers: 16s, cytochrome c oxidase 1 (COI), and histone 3 (H3), using maximum likelihood and Bayesian inference. To estimate the age and ancestral ranges of *Acanthodoris*, two independent analyses were conducted using a relaxed molecular clock in BEAST and the dispersal−extinction cladogenesis (DEC) model in LAGRANGE. The opening of the Bering Strait (5.4−5.5 Mya) and the formation of the Baja California Peninsula (~5.5 Mya) were used as calibration points in both analyses, but one had an additional calibration date of 95−105 Mya, which coincides with the spilt of Africa from South America. As expected the analysis which utilized the spit between Africa and South America placed the age of *Acanthodoris* much older than the analysis that did not, with a difference of ~90 Mya. However, both analyses gave similar dispersal scenarios for the common ancestor of *Acanthodoris* originating in the Atlantic. The ARR that lacked the older calibration point suggests that there were two separate dispersals from the northwestern Atlantic, with one dispersal event into the northeastern Pacific. In contrast, the older analysis proposes two independent colorizations of the northeastern Pacific as well as an extinction event in the northeastern Atlantic followed its recolonization.

P3.80 HALLOT, F.*; DUBOIS, K.; MILBERGUE, M.; PETIT, M.; LE FRANÇOIS, N.R.; VÉZINA, F.; Univ. du Québec à Rimouski (Canada) − CSBQ− CEN − BORÉAS; *fanny.hallot@uqar.ca*

Consequences of thermal variability on flexibility of avian metabolic performance

With climate change it is expected that temperature variations will increase in frequency and amplitude. Since temperature strongly affect energy budget of homeotherms through thermoregulatory requirements, increased temperature variability could lead to effects on individual physiological performance and fitness. In theory, animals should be able to adjust to temperature variations through thermal acclimatization and this should allow them to buffer, up to a certain limit, the effects of increased variability in temperatures. However, in avian systems little is known of the effect of temperature variations on the pattern of thermal acclimatization. Using captive zebra finches (*Taeniopygia guttata*) as our model species, we conducted an experiment to determine whether recent thermal variations affect the rate of individual metabolic adjustments to subsequent changes in ambient temperatures. Two groups of birds were kept for 7 weeks to either a constant (21°C) or variable (fluctuating between 35°C to 7°C every 7 days) temperature treatment. Then each group was divided into two subgroups, which were exposed to a constant cold (7°C) or constant warm (35°C) temperature for 5 weeks. During this second period, metabolic parameters (basal metabolic rate; BMR and maximal thermogenic capacity; M_{SUM}) were measured weekly on all birds in order to measure the rate of change and amplitude of metabolic adjustments (difference in values between 7°C and 35°C). Data were being analyzed at time of submission. We expect a higher rate of change and higher amplitude of metabolic performance in individuals previously exposed to temperature variations than in those maintained at stability.

18.3 HAMMERSCHLAG, N*; GRAHAM, F/J; NELSON, E/R; HARTOG, K; HAMMERSCHLAG−PEYER, C/M; University of Miami, RJ Dunlap Marine Conservation Program; *nhammerschlag@rsmas.miami.edu*

Habitat Partitioning and Intrapopulation Variation in Migration Patterns of Sympatric Apex−Predatory Sharks Across a Dynamic Marine Landscape

Ecological and evolutionary processes are inherently linked to movement. Although previous work has expanded our understanding of animal movement ecology, further studies are needed for apex predators given that changes in their movement patterns can impact ecosystem structure and function. Previous studies that have investigated foraging and movement patterns of highly migratory apex predators have generally not considered intrapopulation variation in resource use, despite the recent realization that within−population differences can impacts population dynamics. Apex predatory sharks are among the most threatened vertebrates on the planet and understanding the broad−scale movement patterns as well as areas of their core use and re−use is important for implementation of effective place−based management strategies. However, studying the movement patterns of sharks is difficult given the inherent challenges of working in the marine environment coupled with the highly migratory behavior of these animals. To address these knowledge gaps, we conducted a joint satellite tagging study to investigate the movements of three apex predatory sharks in the subtropical Atlantic (tiger *Galeocerdo cuvier*, great hammerhead *Sphyrna mokarran*, and bull shark *Carcharhinus leucas*). Although home ranges overlapped among all three species, we found both inter−specific habitat partitioning as well as intrapopulation variation in migration patterns. These results are discussed in terms of foraging ecology with implications for their conservation.

P1.142 HANAUER, RE*; KETTERSON, ED; Indiana University; *rhanauer@indiana.edu*

Effects of frequent disturbances on corticosterone production and infection intensity in a songbird, the dark−eyed junco

When an animal colonizes a new habitat, it may encounter unfamiliar circumstances that it is not adapted or acclimated to and that are therefore likely to elicit stress responses. The steroid hormone corticosterone (CORT) increases in response to stressors, and can facilitate a return to homeostasis. However, long−term elevation of CORT poses potential costs to processes such as immunity and reproduction. Therefore, when the frequency of stressful events increases, it could be beneficial to reduce the magnitude of the CORT response. We asked whether exposure to repeated disturbances would cause a songbird to reduce its CORT response to acute stress, and whether repeated disturbances affected condition or parasite infection intensity. Adult dark−eyed juncos captured from the wild in early spring were kept in captivity for several weeks before the experiment began in May, the normal breeding season for juncos. Animals were kept on Indiana photoperiod. The control group was disturbed the minimum necessary for animal care. The experimental group was subjected to 30 minutes of disturbance four times per day for 13 days. The disturbances included close approach/loud noise, predator calls, and human voices/music. After 13 days of treatment, high−disturbance birds had less abdominal fat and trended toward having lower CORT response to handling stress than control birds. There was no difference in baseline CORT levels. Effects of the high−disturbance treatment on infection intensity of the intestinal protozoan parasite coccidia will also be reported. Results will shed light on the consequences for animals exposed to novel and persistent anthropogenic disturbances.

S8.2−2 HANDELSMAN, Corey A*; WALKER, Jeffrey A; GHALAMBOR, Cameron K; Colorado State University, University of Southern Maine; *chandelsman@gmail.com*

Plasticity and constraints on the evolution of body shape: Phenotypic integration in locally adapted Trinidadian guppy populations

A major problem in evolutionary biology is to understand the dual nature of the environment as a source of natural selection and phenotypic plasticity. The degree to which plasticity constrains or facilitates adaptive evolution remains unresolved. Theory suggests that the degree to which plasticity in complex traits is integrated should constrain how much individual traits are free to evolve and respond to selection. The colonization of novel environments can induce phenotypic plasticity and comparisons between ancestral and derived populations can provide key insights into how integrated traits respond to directional selection. Body shape is a complex phenotype that is likely to show strong integration of constituent traits due to consequences for functional design and swimming performance. We tested the relationship between plasticity and evolutionary divergence in body shape by rearing locally adapted Trinidadian guppy populations in common gardens that simulated their ancestral (high) and derived (low) predation environments. Guppy populations adapted to high and low predation environments exhibited differences in body shape, and the presence or absence of predator cues also induced changes in shape. We compared these findings to four experimentally established populations that were introduced into low predation environments. Patterns of plasticity and phenotypic integration in body shape in the ancestral and derived populations were compared to identify constraints on the evolution of body shape and to determine how they can jointly influence the evolution of body shape in wild populations of guppies.

46.2 HANLON, S.M.*; LYNCH, K.L.; KERBY, J.L.; PARRIS, M.P.; University of Memphis, University of South Dakota; *hanloc2107@gmail.com*

Varying effects of Batrachochytrium dendrobatidis exposure and environmental substrate on foraging efficiencies and body condition in anuran tadpoles.

Many factors affect growth and developmental rates in organisms. In amphibian systems, the disease *Batrachochytrium dendrobatidis* (*Bd*) alters larval (i.e., tadpole) growth rates and survival. Similarly, environmental substrates to which food is affixed (e.g., bark, leaves, stones) could also alter growth rates by reducing/increasing the ease of which food is obtained. We conducted two experiments to examine how *Bd* or substrate influenced southern leopard frog (*Lithobates sphenocephalus*) tadpole mouthpart damage, amount of food ingested, and subsequent body condition, and analyzed our results through separate path analyses. Because *Bd* causes mouthpart damage, we hypothesized that *Bd* exposure would increase tadpole mouthpart damage, reduce food ingestion, and ultimately reduce body condition. Conversely, we predicted that environmental substrates would differentially alter mouthparts and vary in their effects on ingested food and body condition. In the *Bd* model, significant paths were observed between *Bd* and food ingested, mouthpart damage and food ingested, and food ingested and body condition. Additionally, independent of *Bd* exposure, a significant pathway was present between mouthpart damage, food ingested, and body condition. In the substrate model, a significant path was only observed between substrate and food ingested. The lack of other significant pathways was likely influenced by significant effects of substrate on tadpole survival where substrates reduced tadpole survival compared to free−floating food. To our knowledge, our study is the first to show foraging efficiency (amount of food ingested) as a step in the mechanism from *Bd* exposure to body condition, as well as from mouthpart damage to body condition.

111.7 HANNINEN, A.F.*; THOMASON, C.B.; GABOR, C.R.; ALTIZER, S.; University of Virginia, Texas Tech University, Texas State University, University of Georgia; *amanda.hanninen@gmail.com*

Breeding behavior is associated with sex−biased parasitism in the red−spotted newt

There are two prevailing hypotheses that have been proposed to explain the persistence of male−biased parasitism among vertebrates. First, males may maintain elevated androgens levels to produce elaborate traits and thus suffer the cost of reduced immunity and increased parasitism. Second, ecological factors can generate sex differences in parasitism. Males are often exposed to more parasites and increased transmission while traveling in search of a mate during the breeding season. We examined the dual role of hormones (physiology) and amplexus (ecology) in promoting male−biased parasitism in the red−spotted newt (*Notophthalmus viridescens*). We collected 42 newts, including amplectant pairs and solitary males and females, from Mountain Lake Biological Station during the breeding season. Following capture, water−borne hormones were collected and each newt was dissected for parasites. We found that amplectant males harbored significantly more trematode parasites relative to solo males and all females. Our results suggest that actively pursuing and engaging females during the breeding season may play a key role in promoting sex differences in parasitism. Furthermore, trematode−infected newts have higher corticosterone levels than uninfected individuals and those infected with other parasites, suggesting that chronic trematode infection may be energetically costly and stressful. Future analysis of both testosterone levels and immune function can inform how endocrinology and ecology interact to mediate male−biased parasitism.

P2.22 HANSEN, WK*; BATE, LJ; CHASTEL, O; BREUNER, CW; The University of Montana, Glacier National Park, Centre National de la Recherche Scientifique; *warrenhansen@gmail.com*

Stress and Reproduction in Harlequin Ducks

Conservation physiology uses physiological metrics to understand the health and reproductive success of species. Conservation studies tend to measure several aspects of reproductive success and survival to understand population viability. With conservation physiology, it is possible that measures of glucocorticoid physiology may offer a predictive view of individual and population success. However, the field is still in its infancy. We do not yet know how well glucocorticoid levels reflect reproductive success across species, or what metric of glucocorticoids is best to use. Toward this end, we measured plasma, fecal and feather corticosterone (CORT) levels in a breeding population of harlequin ducks *Histrionicus histrionicus*. These measures will enable us to estimate CORT secretion over several different time frames. Plasma measures will reflect immediate CORT secretion, fecal levels will reflect the previous 6−8 hours, and feather levels will allow us to estimate general glucocorticoid levels from just prior to the current breeding effort (back feathers grown during the pre−nuptial molt), and from the end of the previous breeding season (tail feathers grown during the last basic molt). These 3 different stress profiles (plasma, fecal and feather) may lend information to the quality of breeding and non−breeding habitat and to the quality of each breeding territory. We may also be able to make predictions about past and future breeding success based on tail and back feather CORT concentrations. In ecology and wildlife management, understanding sources of annual variation in reproductive success is important to identify to develop best management practices. This study will contribute to our understanding of the utility of glucocorticoid physiology as a tool in conservation.

83.2 HANSEN, B. K.*; FAIR, M. B.; University of Wyoming, Colorado State University; *buteoblues@raderstudios.com*

The benefits of high density: Do chemical cues facilitate food location in the gregarious snail, Potamopyrgus antipodarum?

While a minimum number of individuals is necessary for the continued presence of a species, very high densities often result in increased competition within and among species. Despite this, some invasive species may benefit from seemingly maladaptive densities through increased mating opportunities, predator avoidance and improved foraging. *Potamopyrgus antipodarum*, the New Zealand mudsnail, is a successful world−wide invader that has established populations in multiple habitat types, where it can maintain very high densities. Recent studies have demonstrated that *P. antipodarum* benefits from increased conspecific density through increased reproduction and improved foraging. To determine if this increase in foraging is facilitated by an enhanced ability of individual *P. antipodarum* to locate food resources when others are present, we compared the foraging activity of snails exposed to high or low conspecific density, with the addition of water that was or was not conditioned by feeding conspecifis. Because juvenile and adult snails have different nutritional demands, we tested their behavior separately. Consistent with previous experiments, we found that *P. antipodarum* were more likely to feed and spent more time feeding in high relative to low conspecific density, and that this appears to be facilitated by chemical cues produced by feeding individuals. We also found that juvenile *P. antipodarum* are more likely to feed than adults, which may result from increased nutrient demands during growth. While an understanding of Allee effects has long contributed to the maintenance of endangered populations, our results highlight the importance of understanding the effects of density when controlling invasive species.

P2.17 HANSER, J.T.*; CASTO, J.M.; Illinois State University; *jthanse@ilstu.edu*

Mitigation of Costs Associated with Laying Order in a Cavity Nesting Songbird

In many avian species, periodic and partial incubation prior to the completion of the clutch causes eggs to hatch in the order they are laid, promoting the establishment of size hierarchies among nestlings within a brood. Since later hatched nestlings are often at a competitive disadvantage, laying order holds significant fitness consequences for nestlings. However, females may be able to mitigate these effects by differentially allocating resources across the laying sequence, such that (1) later laid eggs hatch relatively more quickly than earlier laid eggs or (2), all else being equal, nestlings of later laid eggs are able to outcompete individuals of earlier laid eggs. We experimentally investigated this hypothesis by examining the relationship between laying order and hatching order as well as patterns of nestling growth in European starlings (*Sturnus vulgaris*). Nest boxes were checked daily and all eggs were marked to indicate the order of laying. Within experimental nests, eggs were removed soon after they were laid, stored in an empty nest box for the duration of the laying period, and placed back into the original nest following the completion of the clutch. Starting on the projected hatch day and continuing until hatching had finished, nests were checked every two hours from 0600 to 2000. While laying order and hatching order were positively correlated within control nests, this pattern was reversed within experimental nests, suggesting that either eggs laid later in the laying sequence require shorter periods of incubation to hatch than earlier laid eggs, or alternatively, delaying incubation lengthens the period of incubation required to hatch. Additional analyses will examine whether patterns of nestling survival and growth across the hatching order differed between treatments.

P1.148 HARMON, C. L. *; SIKES, J. M.; University of San Francisco; *clharmon@usfca.edu*

Eye development during regeneration and asexual reproduction in the basal bilaterian Convolutriloba longifissura

While morphological comparisons of photoreceptor anatomy suggest that animal eyes evolved multiple times independently, the molecular conservation of Pax6's role in eye development suggests common ancestry. Studies in acoels have revealed that Pax6 is not expressed in the cells of the eye during embryonic development, suggesting that other transcription factors were co−opted to initially pattern eyes in early bilaterians. Given their unique phylogenetic position as basal bilaterians, acoels provide a promising system to search for genes that may have patterned eye development before the split with the 3 major superclades. We have utilized next generation sequencing to develop an eye−enriched transcriptome from the acoel *Convolutriloba longifissura* and have characterized the spatiotemporal expression of candidate genes with promising roles in the specification of photoreceptors during postembryonic development. Functional characterization of these candidates along with other conserved eye development genes is currently underway. These findings suggest that the initial evolution of photoreceptors likely occurred without specification by Pax6 but via alternative developmental patterning and provide support to the independent evolution of eyes within the Metazoa.

P3.185 HARMON, K*; CHIN−PURCELL, M; DICKINSON, PS; Bowdoin College; *pdickins@bowdoin.edu*

Mechanisms and effects of stretch feedback in the lobster heart

The neurogenic heart of the lobster, *Homarus americanus*, is controlled by a small pattern generator, the cardiac ganglion (CG). Previous studies suggest that crustacean heart muscle provides feedback to the CG, and that this may be mediated by stretch sensitive dendrites projecting from the CG neurons themselves. We thus wished to determine whether this is the case in the lobster, and whether the effects of stretch as well as the mechanisms that underlie stretch sensitivity are the same in lobsters as in the crab and isopod species in which stretch has previously been examined. When the lobster heart was stretched tonically, contraction frequency increased significantly in approximately 89% of animals; it decreased in 7% and remained unchanged in 4%. Severing the putative stretch−sensitive dendrites that branch from the main trunk of the ganglion decreased or eliminated the response to stretch in 75% of preparations, suggesting that these processes are a major source of stretch sensitivity. To determine the cellular mechanism that underlies stretch sensitivity, we recorded intracellularly from CG motor neurons while stretching small bundles of muscle fibers. Stretch of a single muscle bundle did not alter cycle frequency, and we saw no change in membrane potential between bursts. Surprisingly, the amplitude of the driver potentials that underlie bursting in these neurons decreased when the muscles were stretched. Both the changes in heartbeat frequency in response to removal of the dendrites and the responses of the membrane potential to stretch differ considerably from those previously recorded in other species. Supported by NSF Grant IOS−1121973, NIH Grants 5P20RR016463−12 (NCRR) and 8P20GM103423−12 (NIGMS), and the Paller Fund of Bowdoin College.

33.5 HARRINGTON, K.A.*; HRABIK, T.R.; ALLEN, A.F.; University of Minnesota, University of Minnesota ; *harr1582@umn.edu*

Visual Sensitivities of Deep Water Fishes in Lake Superior

The mid and deep water trophic interactions have been well established in Lake Superior. The primary predator, siscowet, a fatty morphotype of lake trout (*Salvelinus namaycush*) will feed primarily on deepwater sculpin (*Myoxocephalus thompsonii*) on the lake bottom during the day. However, they will also consume kiyi (*Coregonus kiyi*) and follow them on their diel vertical migration (DVM) to obtain mysis (*Mysis duluviana*). Thus, the siscowet and kiyi remain at depth during the day and only migrate to shallow waters at night which maintains them in light limited environments. Therefore, it is unclear what is the main sensory system (vision or lateral line) mediating predator prey interactions. To determine the role of the visual system, spectral sensitivity curves were generated using electroretinography from 400−700 nm. All three fishes experience peak sensitivities between 500 and 550 nm with siscowet and kiyi displaying similar sensitivities consistent with their DVM pattern. However, the deepwater sculpin's visual system demonstrates a higher sensitivity between 475 and 550 nm relative to the other wavelengths in comparison to the other fishes. This suggests the deepwater sculpin has a unique sensitivity specialized for wavelengths available at depth. Despite a relatively new (< 15,000 years) colonization of deep lake waters, the fishes' visual systems have evolved to maximize prevailing light in their environment. Concurrent behavioral studies are determining whether the light intensities and visual sensitivities are sufficient to mediate predator prey interactions. Funded by Sea grant 1205A13881.

P1.12 HARRIS, R/M*; ALARCON, J/M; FENTON, A/A; HOFMANN, H/A; Marine Biological Laboratory, Woods Hole; Univ. of Texas, Austin, Marine Biological Laboratory, Woods Hole; SUNY−DMC, Brooklyn, Marine Biological Laboratory, Woods Hole; New York Univ., New York; *rayna.harris@utexas.edu*

An Integrative Neuromolecular and Neurophysiological Curriculum for the Neural Systems & Behavior Course at MBL

Neuroethology increasingly benefits from integrating across levels of organization to gain insights into the neural basis of behavior. The Neural Systems & Behavior (NS&B) course at MBL has established itself as the premier discovery−driven advanced training opportunity. We aimed to enhance and expand the existing excellence in neurophysiological training by incorporating stimulating and robust molecular and genomic approaches. Our innovations exposed students to a full range of modern techniques they can use to develop, design, and conduct integrative and cross−disciplinary studies which they used to examined the neuromolecular circuitry underlying coordinated movements in the stomatogastric ganglion and reproductive behavior of the medicinal leech. In order to develop a new integrative module, we used an active place avoidance to examine spatial memory in mice. We then used in vitro brain slice recordings to investigate potential changes in synaptic plasticity in the hippocampus. Using alternate slices, we obtained tissue punches of CA1 and CA3 regions to perform real−time PCR to detect changes in gene expression levels of key proteins whose activity is thought to underline functional changes in synapses subservient of memory. We used multivariate statistical analyses to integrate across all three levels of analysis to gain detailed insight into the mechanisms regulating memory formation. The approach yielded novel insights into the molecular and physiological mechanisms regulating learning and memory. Our results show that cutting−edge analyses can be integrated in the NS&B course setting.

90.8 HARRISON, J.F.*; KLOK, C.J.; VANDENBROOKS, J.M.; DUELL, M.E.; CAMPBELL, J.B.; JIRJIES, S.; SOCHA, J.J.; Arizona State University, Virginia Tech; *j.harrison@asu.edu*

Grasshoppers defy gravity? Body position effects on hemolymph and air distribution in Schistocerca americana

Gravity has strong effects on the fluid transport systems of terrestrial vertebrates and plants and should, in theory, be important for all terrestrial organisms. Insects retain the open circulatory system they evolved from aquatic crustacean ancestors, raising the question of how well their circulatory system copes with gravity. Air sacs of grasshoppers (*Schistocerca americana*) were visualized with synchrotron x−ray imaging at the Advanced Photon Source at Argonne National Laboratory. For adults in the head−up position, air sacs in the head expand whereas air sacs in the abdominal tip compress; the converse occurs in the head−down position. Similar changes occur when animals shift from supine to prone positions. Together, these changes demonstrate that the open body plan within the grasshopper can result in changes in the respiratory system in response to gravity, which may result from hydrostatic effects and/or the changes in flow of hemolymph. Nitrogen−paralysis accentuates these changes in the tracheal system, indicating that grasshoppers actively counter the effects of gravity on hemolymph distribution. Juveniles (third instar) showed reduced gravity effects on their air sacs, suggesting that gravity effects on hemolymph distribution may increase with size. Abdominal pumping (related to ventilation) and heart rate did not vary with body position. The mechanisms by which insects resist gravity effects on hemolymph distribution remain unclear, but the occurrence of differential air sac behaviors in adjacent segments suggest that flexible functional valves exist between body compartments. This research was funded by NSF 0938047.

33.6 HARVEY, TA*; SCHOLES, E; BOSTWICK, KS; LAMAN, T; MARSCHNER, S; Yale University, Cornell University, Harvard University; *todd.harvey@yale.edu*

From microscopic feather structure to whole−organism display behavior: uncovering the private courtship signals of Parotia wahnesi (Paradiseidae).

Characterizing the appearance and signaling performance of the courtship display of *Parotia wahnesi* is challenging due to its directional and temporal attributes. In a highly choreographed performance, ornamental plumages entice females through contrasting shape, intensity, and color, while ancillary plumages construct a backdrop framing those ornaments. We reconstruct the anatomy' of the extended courtship phenotype of the male *P. wahnesi* by investigating the geometry of the signal at a specific moment in the performance. We investigated: (1) the direction of light illuminating the male in his court, (2) the direction of the reflectance from the male's iridescent ornamental plumage, and (3) the position and orientation of the ornaments with respect to the female during display. To illustrate the geometric relationships of the three investigations, we combine our results in a three−dimensional reconstruction using computer−aided design. We show how the male leverages the geometry of his court, lighting environment and hierarchy of plumage structure to gain directional advantages and modulate his signal. Every attribute, whether intrinsic or extrinsic to the male himself, hones signal production to generate spectacular but private displays intended for visiting female birds, unobservable from other vantage points.

P3.195 HASSTEDT, M.R.*; ROBERTSON, B.D.; VANDERMEER, C.L.; MACDOUGALL−SHACKLETON, S.A.; Univ. of Western Ontario; *brober4@uwo.ca*

Sex steroid−independent effects of photostimulation on the song−control system of white−throated sparrows (Zonotrichia albicollis)

Brain nuclei within the song−control system of songbirds are seasonally plastic during adulthood. These nuclei are larger in birds exposed to long, spring−like days than short, winter−like days. There is overwhelming evidence that this effect is mediated by testosterone (T). However, castration studies have also demonstrated that photoperiod can have gonad−independent effects on song−control system plasticity, but these studies rarely control for extra−gonadal sources of T. In this study, we used anti−androgen and anti−estrogen treatments in combination with castration to determine the sex steroid−independent effects of photostimulation in white−throated sparrows (*Zonotrichia albicollis*). Birds were kept on short days or photostimulated for 1 month. Photostimulated birds were intact, castrated and treated with anti−androgens and anti−estrogens, or castrated and treated with T. HVC volume of photostimulated intact birds and photostimulated castrated and T−treated birds did not differ, but were significantly larger than the HVC of short−day intact birds. HVC volume of castrated birds given anti−androgens/−estrogens was significantly smaller than the other photostimulated birds, but significantly larger than short−day birds, indicating a sex steroid−independent effect of photostimulation. Similar results were observed for RA. The number of migrating neurons (immunoreactive for doublecortin) in HVC did not differ between treatment groups. Our data support the view that photostimulation alone can drive song−control system nuclei growth, and that concurrent exposure to T potentiates this growth.

129.6 HATEM, N.E.*; SUZUKI, Y.; Wellesley College; *nhatem@wellesley.edu*
Regulation of critical weight in the tobacco hornworm, Manduca sexta.
The regulation of the timing metamorphosis is a critical event in many organisms. In insects, a size assessment point called the critical weight marks the time at which metamorphosis is no longer delayed even when animals are starved. The timing of metamorphosis in the tobacco hornworm, *Manduca sexta*, is primarily regulated by juvenile hormone (JH). During the final instar, metamorphosis is inhibited by JH until the larva reaches the critical weight when JH titers drop. In contrast, studies have shown that in the fruit fly *Drosophila melanogaster*, the critical weight is regulated by nutrition−dependent insulin signaling in the prothoracic gland, the major site of ecdysteroid biosynthesis. Alterations of prothoracic gland size through the manipulation of insulin signaling lead to shifts in the critical weight. In this study, we examined the role of insulin/TOR signaling in the determination of the critical weight in *Manduca*. By feeding *Manduca* rapamycin treated diets, we inhibited TOR signaling in final instar larvae, and the effect on the critical weight was examined. In wildtype larvae, the peak size was unaffected when fed rapamycin although the growth rate was reduced. Critical weight was also unaffected when fed rapamycin. However, the size of the prothoracic gland at the critical weight was disproportionately smaller in larvae fed rapamycin. These results indicate that insulin/TOR signaling does not play a major role in the determination of critical weight in wildtype *Manduca*. Thus, JH overrides the nutritionally dependent critical weight regulation in this species. Our study shows that the critical weight is regulated by two distinct mechanisms, one that senses body size (mediated by JH) and another that senses nutritional input (mediated by insulin/TOR signaling). The relative contribution of these two mechanisms therefore determines whether body size or nutritional availability determines the timing of metamorphosis.

S9.3−2 HATLE, JD; Univ. of North Florida; *jhatle@unf.edu*
Ingestion and allocation of macronutrients underlying reduced reproduction and life extension in grasshoppers
Reduced reproduction and reduced diet (aka. dietary restriction) each extend lifespan in many animals. Because the degree of dietary restriction needed to extend lifespan usually reduces fecundity, the dogma has been that both manipulations work through the same means. We have addressed this hypothesis by measuring feeding rates, physiological parameters of stress, and storage. In many ways, the two treatments produce similar responses. Reduced reproduction (via ovariectomy or RNAi on vitellogenin) reduced feeding ~35% in old females and increased lifespan by ~18%. Similarly, reduced diet (i.e., ~30% less than that consumed by intact individuals fed ad libitum) reduced egg production about 30% and increased lifespan ~18%. Females upon ovariectomy and females on dietary restriction had similar total anti−oxidant activities in the hemolymph and muscle, similar numbers of mitochondria in the fat body and muscle, and similar mRNA expressions of vitellogenin and storage protein in the fat body. In stark contrast to these similarities, ovariectomy doubled fat body mass and hemolymph volume, while dietary restriction did not. In addition, we tracked ingested macronutrients to somatic tissues using stable isotopes. Ovariectomy, despite increasing somatic storage, does not alter allocation of ingested nutrients to muscle, storage proteins, or fat body (i.e., the metabolic organ). A parallel experiment testing allocation of ingested nitrogen upon dietary restriction is underway, and its results will be compared to ovariectomy. Last, we are measuring metabolic rates upon ovariectomy or matched−fed controls (which are thereby under dietary restriction). Overall, these data suggest that life−extending reductions in reproduction and diet result in similar feeding rates but greatly different investments in storage.

30.7 HAU, M; Max Planck Institute for Ornithology, Seewiesen and University of Konstanz; *mhau@orn.mpg.de*
From environmental endocrinology to hormone evolution: adaptations to a changing environment
Seminal empirical and conceptual work by John Wingfield, Marilyn Ramenofsky and collaborators helped establish the field of environmental endocrinology by providing a wealth of knowledge on how environmental and social conditions influence hormonal responses of individuals, populations and species. One of John Wingfield's stimulating approaches included studying species that diverge in their life style from that of most well−studied temperate zone birds. For example, in my own work with John we could elucidate some ways in which the hormonal organization of a tropical bird diverges from that of many temperate zone species. This work and subsequent comparative studies spurred my interest in unraveling the evolutionary patterns that shape hormonal organization. Focusing on our current model system, the great tit (Parus major), I will review recent findings on the fitness relevance of and the selection pressures on hormonal phenotypes. Specifically, I will present data from a multi−year study in which we determined baseline and stress−induced corticosterone concentrations in free−living great tits at different times of year and relate it to measures of fitness − reproductive success and survival. I will discuss our findings on selection pressures, direction of selection, and seasonal variation in light of concepts on the evolution of hormonally regulated traits. Furthermore, I will put our data into context with findings on the repeatability and heritability of hormonal traits and highlight possible ways to improve our understanding of the speed at which hormonally regulated traits evolve. As pointed out by John Wingfield, such knowledge may become crucial in helping us to evaluate the threat that changing environments pose to wild populations.

79.4 HAVIRD, JC*; HENRY, RP; SANTOS, SR; Auburn University; *jhavird@auburn.edu*
Taking their breath away: Metabolic adaptations to low−oxygen levels and salinity transfer in anchialine shrimps (Crustacea: Atyidae)
Invasion of extreme or stressful environments is often a result of, or results in, metabolic adaptations that allow the invaders to thrive in conditions where closely related species may perish. Shrimps from anchialine habitats (coastal ponds and caves) represent good candidates for studying these processes, since such habitats have fluctuating oxygen levels/salinity, and at least 3 shrimp lineages have independently colonized this niche. Here, we compared the metabolic rate (MR) of the Hawaiian anchialine shrimp *Halocaridina rubra* and four other anchialine shrimp species from across the Ryukyus Islands, Japan. Using closed−cell respirometry, we investigated: 1) if salinity transfer influenced MR; 2) if an oxygen debt must was paid following hypoxia/anoxia and; 3) if lactate and lactate dehydrogenase (LDH) levels responded to hypoxia or anoxia. Salinity transfer did not influence oxygen uptake rates in any of the species. However, oxygen uptake declined for *H. rubra* as environmental oxygen concentration decreased (or with experimental duration), while it remained constant over time for the other species. Furthermore, *H. rubra* survived in anoxia (0 torr) for > 7 days and paid an oxygen debt. In contrast, the other species perished quickly in anoxia and did not pay oxygen debts after either brief exposure to anoxia or prolonged exposure to hypoxia. For *H. rubra*, lactate increased during anoxia while levels of LDH remained high and constant. Taken together, these results suggest responses to low−oxygen conditions are not uniform across anchialine shrimp lineages and may be related to the evolutionary history of the species and/or the geographic/geologic context of the environments they inhabit.

9.5 HAYFORD, H.A.*; CARRINGTON, E.; Univ. of Washington, Friday Harbor Labs; *hayford@uw.edu*

Slowly but surely: Avoiding heat stress at a snail's pace

The regulation of temperature through behavior is often overlooked when predicting the effects of climate change. Ectotherms use behavior to cope with environmental temperature shifts, while meeting nutritional demands. These needs conflict when a mobile predator feeds upon immobile prey of higher thermal tolerance. *Nucella ostrina*, an intertidal snail of the Eastern Pacific, risks aerial exposure at low tide to feed on the barnacle, *Balanus glandula*. We hypothesized that *N. ostrina* foraging in the San Juan Islands, Washington, would be constrained by low tide exposure. We added *N. ostrina* to concrete islands in the intertidal and forced snails to choose between feeding in exposed areas and taking refuge. Snail behavior and barnacle consumption were monitored daily for two months. *N. ostrina* foraging peaked during neap tides, when aerial exposure time and temperature were consistently minimized. Barnacle consumption mirrored foraging behavior. To determine if experimental patterns held true for organisms in their natural habitats, we marked free−ranging snails with radio frequency identification (RFID) tags and tracked using a hand−held tag reader. We observed periodic abundance on exposed high shores that followed the 14−day lunar tidal cycle. RFID allowed us to track small animals over large stretches of shoreline and to confirm that non−feeders were retreating to refuges. These results suggest that *N. ostrina* alters its behavior to capitalize on differences in microclimate, maintaining a foraging pattern that consistently minimizes its exposure to hot aerial temperatures. Consequently, predation pressure on barnacles is dynamic through space and time. Mechanistic climate change models should include ameliorative behavior when predicting changes in both population distributions and dynamics of species interactions.

S1.3−4 HEAD, JA*; BASU, N; McGill University; *niladri.basu@mcgill.ca*

Epigenetics in Ecotoxicology

An enormous amount of biomedical research has been focused on epigenetics in recent years. This wave is just beginning to hit the field of ecotoxicology, and the potential is exciting. The concepts behind epigenetics will generate ideas in many areas of ecotoxicology from basic scientific understanding of mechanisms of action, to risk assessment and policy. Similarly, ecotoxicology has a lot to offer the field of epigenetics, including opportunities to test hypotheses under real−world conditions, and a wealth of organisms to study with wide−ranging physiologies and ecological adaptations. In this presentation we will highlight what we consider to be some of the most interesting and promising implications of epigenetics for ecotoxicology (and vice versa). A theoretical discussion as well as specific examples (when available) will focus on the role of epigenetics in ecotoxicology, including the temporal disconnect between exposure and disease, tracking the efficacy of bioremediation efforts, and epigenetic endpoints as generalized or even stressor−specific biomarkers.

72.1 HEDGECOCK, D.*; MANAHAN, D.T.; U of Southern California; *dhedge@usc.edu*

Controlling Nature & Nurture: Why experiments with wild type are insufficient for understanding adaptation to environmental change

Underlying Darwin's theory of evolution by natural selection are two observations: (1) organisms have excess reproductive capacity and (2) individuals of the same species vary extensively. Some of this phenotypic variation, we now know, is heritable (Phenotype = Genotype + Environment + G×E Interaction), so that, as environment changes, natural selection modifies gene pools and generally improves adaptedness. Unfortunately, these principles of Darwinian biology often appear to be missing from research directed at understanding the potential impact of global change on organisms. Experiments that put wild−caught organisms into different environments, in order to observe physiological or functional genomic responses, have limited power because G and G×E components of phenotypic variance are uncontrolled and poorly sampled. This is a particularly challenging issue for studying how highly fecund marine organisms will respond to ocean change, for example, because (1) the genomes of such organisms are extremely polymorphic, with redundant sets of genes responding to environmental stress; (2) genetic components of variance in complex traits, such as survival and growth, are large and non−linear; and (3) small numbers of wild−caught experimental subjects under−sample the true range of population responses. Well−conceived experiments that manipulate G and most importantly G×E, as well as E, to produce phenotypic contrasts and that integrate genomic, transcriptomic, proteomic, and metabolomic with classical biochemical and physiological approaches are going to be required to understand and to predict the Darwinian biological responses of organisms to global change. A focus on model species with well−developed genetic, genomic, and physiological resources is indicated.

P2.141 HEDRICK, MS*; MCNEW, KA; Univ. of North Texas, Univ. or North Texas; *michael.hedrick@unt.edu*

Does baroreflex gain vary with habitat in anuran amphibians?

Anurans from different environments vary with respect to lymph mobilization capacity which is linked to blood pressure/volume status. We hypothesized that anurans from different environments might also vary in their ability to regulate blood pressure and heart rate through the baroreflex. We altered mean arterial blood pressure (MAP) pharmacologically and measured changes in heart rate (HR) to determine baroreflex gain. Experiments were conducted at 20 °C with three species of anurans from terrestrial (cane toad, *Rhinella marina*), semi−aquatic (North American bullfrog, *Lithobates catesbeianus*) and aquatic (African clawed frog, *Xenopus laevis*) environments. MAP was increased with phenylephrine (Phe; 20−200 µg/kg, i.v.) and decreased with sodium nitroprusside (SNP; 20−200 µg/kg, i.v.). Heart rate ranged from 27 ± 3 to 31 ± 2 beats min^{-1} (P>0.05), but MAP was significantly higher in *R. marina* (5.3 ± 0.2 kPa) compared with *X. laevis* (3.6 ± 0.2 kPa) or *L. catesbeianus* (4.2 ± 0.2 kPa). The baroreflex gain (ΔHR/ΔMAP) ranged from was −6.5 ± 0.5 to −7.2 ± 0.8 beats min^{-1} kPa^{-1} but was not significantly different. These data indicate that baroreflex gain does not vary in three species representing a wide environmental range, but the more terrestrial species (cane toad) operates at a higher arterial blood pressure suggesting that baroreflex resetting has occurred in this species. Supported by NSF−IOS 0843082 and HHMI.

P2.44 HEFFNER, K*; CAPPER, R; DAVIES, S; MATZ, M; University of Texas, Austin; *katharine.heffner@gmail.com*

Estimating the amount of genetic load in a reef−building coral

High amount of deleterious mutations existing in a heterozygous state (genetic load) can affect reproductive success, lower the fitness of offspring and dampen the response to selection. Estimating genetic load in corals is therefore important to evaluate their capacity to adapt to the effect of global climate change. To evaluate the frequency of strongly deleterious alleles among heterozygotes in the coral *Acropora millepora*, we have examined 96 single nucleotide polymorphisms (SNPs) in the larval offspring cohorts of different age, looking for deviations of allele frequencies from the expected values based on parental genotypes. We have observed allele frequency shifts at several SNPs, to the point where an allele was completely eliminated from the larval population. Still, the majority of SNPs did not demonstrate a dramatic signal. Our observations indicate that, although corals do harbor some genetic load, it appears to be relatively low and does not noticeably affect the rate of larval survival.

107.4 HEIDINGER, BJ*; HERBORN, KA; BONER, W; NOGUERA, JC; ADAM, A; DAUNT, F; MONAGHAN, P; North Dakota State University, University of Glasgow, Center for Ecology and Hydrology; *britt.heidinger@ndsu.edu*

Long−term costs of early stress exposure: are telomeres an important link?

Developing vertebrates often respond to environmental stressors by elevating glucocorticoid (CORT) stress hormones. In young animals, a stress−induced rise in CORT is expected to enhance short−term survival, but to simultaneously shift resources away from growth. Exposure to CORT during early life can result in a more stress responsive' phenotype in adulthood, which might be adaptive under certain environmental conditions, but can also result in long−term costs such as reduced lifespan. The mechanisms linking early stress exposure and longevity are poorly understood, but telomere dynamics might be important. In this study, we experimentally manipulated stress exposure during the early post−natal period in a long−lived seabird, the European shag (*Phalacrocorax aristotelis*) and examined the effect on growth rate, CORT, and telomere dynamics. We found clear evidence that early stress exposure increased stress responsiveness and accelerated telomere loss, resulting in shorter telomeres at the time of fledging.

97.6 HEINBOCKEL, T.*; WANG, Z.−J.; SUN, L.; Howard University, Washington, DC; *theinbockel@howard.edu*

Cannabinoid Receptor−Mediated Changes of Mitral Cell Activity through Modification of Synaptic Input in the Main Olfactory Bulb

Marijuana (cannabis) is the most commonly abused illicit drug in the USA. Its bioactive ingredient, Δ9−tetrahydrocannabinol, THC, activates cannabinoid receptors (CB1R) in the brain in the same manner as brain−produced endogenous cannabinoids (endocannabinoids, eCBs). The eCB system has emerged as an important neuromodulatory system during normal brain function and involves CB1R and eCBs. Neurons in the main olfactory bulb (MOB) express high levels of CB1R. Our understanding of the functional role of CB1R for olfactory processing is in its infancy. In mouse brain slices, we used whole−cell patch−clamp recordings to study how CB1R regulates the activity of mitral cells (MCs), key MOB output neurons. Our data shows that eCBs mediate strong effects in MCs. We hypothesize that eCBs are modulators of feedforward inhibition of MCs. CB1R agonists evoke membrane depolarization, increased action potential firing, and an inward current in MCs, while CB1R antagonists reduce firing and evoke an outward current. CB1R actions on MCs are eliminated in slices in which the olfactory nerve layer and glomerular layer are microsurgically removed showing that the glomerular layer is the site of CB1R action. Periglomerular cells (PGCs), GABAergic interneurons, show an inverse response pattern to CB1R activation compared to MCs, suggesting that CB1R indirectly regulates MC activity as a result of PGC activation. This hypothesis is supported by our data showing that cannabinoids modulate synaptic transmission from PGCs to MCs. We propose that CB1R directly regulates PGC activity to control GABA release and, in turn, regulates MC activity. Support: Whitehall Foundation, U.S.−PHS grants GM08016, MD007597.

90.5 HEINRICH, EC*; GRAY, EM; VORHEES, AS; MEIGHER, SG; BRADLEY, TJ; Univ. of California, Irvine, Colorado College; *eheinric@uci.edu*

Post−mortal CO_2 release by insects at high temperatures

Researchers utilizing thermolimit respirometry to study insect thermal tolerance have previously reported an unexplained surge of carbon dioxide release by insects following death at high temperatures. This phenomenon has been referred to as the "post−mortal peak" (PMP) (Lighton and Turner, 2004). In some insects, the CO_2 release rate during the PMP may be up to 50% higher than the maximal rate achieved in the live insect. We have observed the PMP in fruit flies, mosquitoes, crickets, cockroaches, and beetles. While it has been verified that the PMP occurs after death, the cause of death does play a role in the appearance of the PMP. We have observed the PMP only when an insect dies due to high temperature stress. Furthermore, the PMP does not occur in the absence of atmospheric oxygen, or if the dead insect is subjected to cyanide prior to the initiation of the peak. On the basis of these results, we hypothesize that the CO_2 released in the PMP derives from the insect's mitochondria. We are currently simultaneously measuring CO_2 release and oxygen uptake during thermal ramping to clarify the source of the PMP. Understanding this event may provide insights into the physiological implications of heat stress in insects and the timeline of biochemical events before and after death at high temperatures.

128.2 HELM, RR*; DUNN, CW; Brown University; *rebecca.rae.helm@gmail.com*

Development and life cycle evolution in the sea nettle jellies (Pelagiidae)

Life cycle evolution is difficult to study because many instances of life cycle transition occur at the base of diverse lineages. One exception is the mauve stinger jelly *Pelagia noctiluca*, which has evolved direct development, despite being nested within a clade of indirect developing species. There are three possible ways that *P. noctiluca* has achieved this: 1. a heterochronic shift to develop jellyfish (termed medusae) prematurely, thus skipping the intermediate polyp stage, 2. by incorporating a pelagic, reduced polyp stage in development or 3. through novel developmental mechanisms for developing medusae. To investigate these alternate hypotheses, I examined morphological development of *P. noctiluca* and its indirect developing sister species *Chrysaora fuscescens*. Here I present my findings, focusing particularly on muscle development, and their implications for understanding life cycle evolution in this clade.

70.2 HELM, BR*; DAVIDOWITZ, G; North Dakota State University, Fargo, ND, University of Arizona, Tucson, AZ; *bryan.r.helm@ndsu.edu*

Trade−offs amongst growth, storage and metabolic rate during the 5th instar of the tobacco hornworm, Manduca sexta

Juvenile organisms must invest incoming nutritional resources among growth, storage and maintenance, and tradeoffs among these traits will occur because incoming resources are limited. As a consequence, resources must be allocated so that survival and future reproduction are optimized both within a single growth trajectory and in light of environmental conditions experienced. In this study, we asked how the relationships among these traits change during ontogeny and in response to different environmental conditions. We examined growth rate, storage rate, and resting metabolic rate relative to increasing body size in last instar larvae of the tobacco hornworm, *Manduca sexta*. We measured these traits in individuals that had been reared at 30C, 25C, or 20C and on either a standard high quality or reduced low quality artificial diet. We found that the tradeoffs among these traits varied along ontogeny as the organism grew. During early growth of the last instar, growth rate, storage rate and metabolic rate were positively correlated. However, growth rate declined approximately half−way through the instar and became negatively correlated with increasing storage and metabolic rates. Environmental conditions affected growth, storage and metabolic rate, but the relationships among traits shared a common pattern across environmental conditions. We conclude that dynamic changes in the allocation scheme between these traits reflect evolved strategies for optimizing survival and future reproduction based on both developmental status and varying environmental conditions.

127.5 HEMINGWAY, CT*; SARGENT, RC; St. Edward's University, University of Kentucky; *cheming@stedwards.edu*

Female Personality Depends on Body Size, Reproductive State, and Social Context in the Invasive Western Mosquitofish

The western mosquitofish (*Gambusia affinis*) is one of the top 100 invasive species worldwide. Native to North America, this fish has been expanding its range naturally up the Mississippi River drainage. They are native to western Kentucky, and over the last 50 years have expanded their range eastward throughout the entire Commonwealth. We study the ecological and social determinants of microhabitat choice, dispersal and range expansion in this species. Predation, body size, sexual conflict, and personality of the focal fish and its shoal mates are all known to affect microhabitat choice and dispersal in this species. We focused on the interaction between personality and body size. Personality in animal behavior is a multivariate behavioral phenotype that consists of repeatable individual behaviors (e.g. shoaling, predator inspection), and is thought to be fixed over an individual's lifetime. We found, however, that female personality is plastic rather than fixed. Larger females are less likely to shoal and more likely to inspect predators than smaller females. Females about to give birth are also less likely to shoal and more likely to inspect predators than are females earlier in their reproductive cycle. These results suggest that female personality changes as she grows, and with stage of her reproductive cycle. We also examined these fish in social groups. Both predation and sexual conflict disrupt female social networks and result in smaller shoals. Predator inspection in solitary trials positively correlates with predator inspection and negatively correlates with shoal size in social groups.

34.3 HENRY, E. R.*; BUTLER, M. A.; Univ. of Hawaii at Manoa; *erh@hawaii.edu*

Important Resources of a Native Hawaiian Damselfly

The blackline Hawaiian damselfly (*Megalagrion nigrohamatum nigrolineatum*) is a native Hawaiian damselfly that is endemic to upland streams on the island of Oahu. It is part of an ecologically diverse adaptive radiation that is spectacular with body color and ecological variation. The only significant scientific work on this genus, however, is the construction of a robust phylogeny. Unfortunately, very little is known about the natural history and behavior of any *Megalagrion* species. Moreover, *M. n. nigrolineatum* has been added onto the federal endangered species list based on concerns over habitat loss and invasive predators, although little is known about its populations. In this study, *M. n. nigrolineatum* was observed in the field to describe its daily and seasonal activity patterns and to gain a deeper understanding of their behaviors, microhabitat selection, and habitat use. The seasonal differences in behavior that were observed include: higher abundance, more tandem pairs, and less male−male interactions in the spring than in the fall. Daily fluctuations in damselfly abundance and perch selection remained constant regardless of the season. *M. n. nigrolineatum* were significantly more likely to be facing away from the stream and would select perches that were in the shade as opposed to areas in the sun. However, males were more likely to defend territories in the sun. Knowledge about their activity patterns are important for future ecological studies and conservation efforts, and the differences in behavior found in *M. n. nigrolineatum* leads one to wonder what other unique behavioral attributes can be found among this extremely diverse genus.

7.7 HERBST, ZL*; CHANG, J; ALFARO, ME; Chadwick High School, University of California Los Angeles; *zherbst@chadwickschool.org*

Many−to−one mapping and Controls on Phenotypic Convergence

Convergence represents a fundamental concept in organismal biology, yet the evolutionary dynamics of convergence have been studied in a surprisingly small number of systems. Many−to−one mapping, in which multiple underlying parts interact to produce an emergent functional trait, provides a conceptual framework for understanding how and when morphological and functional convergence may evolve. We tested whether the number of possible morphological solutions to a functional demand influences the potential for morphological convergence using a genetically explicit evolutionary simulation based upon the Suction Index for centrarchid fishes. Our simulations revealed that centrarchid fishes populations evolving towards Suction Index values with higher numbers of morphological solutions display a much greater level of morphological variation over the duration of the simulation and after reaching the target value than populations evolving towards Suction Index values with less morphological solutions. In particular, more morphological solutions exist for low suction index values than high indices, and centrarchid populations that evolved to a low suction index value possessed more morphological diversity than populations that targeted high values. Our results suggest that morphological convergence is shaped by the level of phenotypic redundancy possibly for functional systems. Furthermore, our simulations suggest that functional convergence may be obscured morphological diversity.

P2.78 HERDINA, A.N.*; HULVA, P.; HORÁ EK, I.; BENDA, P.; MAYER, C.; HILGERS, H.; METSCHER, B.D.; University of Vienna, Austria, Charles University, Prague, Czech Republic; *annanele.herdina@univie.ac.at*

Individual and Phylogeographic Variation in the Pipistrellus Baculum

With the discovery of further cryptic diversity in the genus *Pipistrellus*, it is critical to find morphological differences and to understand the phylogeographic distribution of species, subspecies and linages. *Pipistrellus pipistrellus* and *P. pygmaeus* have been recognized as separate species since 1997, but we have only now found a reliable morphological species discriminating character. *P. pipistrellus* and *P. pygmaeus* specimens can be discriminated by measuring the projected length, height, and width of the baculum. The baculum (os penis) has long been used successfully in species discrimination. In this study individual and phylogeographic variation of the *Pipistrellus* baculum were quantified. Using museum specimens (Národní Muzeum, Prague) of these two species and of *P. hanaki*, all of which had already been identified by molecular genetic methods, we imaged the bacula with high−resolution microCT. Geometric morphometrics was used to quantify and locate variations in baculum shape. Variation in baculum shape (alone) cannot be used to separate these species, and *P. hanaki* cannot be separated from the other two species by baculum shape using geometric morphometrics. Most of the interspecific variation in baculum shape can be found in the proximal third (the base) of the baculum. Most individual variation can be observed in lateral view, especially in the shape of the curve. Quantitative details of morphology are becoming more important to distinguish cryptic species and subspecies and to understand their phylogeographic distributions.

52.5 HEREDIA , S. M.*; RIESEBERG, L. H. ; ELLSTRAND, N. C. ; University of British Columbia, University of California−Riverside; *sylviah@biodiversity.ubc.ca*

Within−Fruit Seed Characteristics and Paternal Fitness of a Hybrid Plant and its Two Progenitor Lineages, Genus Raphanus

The hybrid−derived California wild radish has outcompeted and replaced its two progenitor lineages in California. All three plants have pod−like fruits but in the hybrid, these are sired by multiple fathers in a non−random position. These unusual seed characteristics may be a key feature in explaining the competitive superiority of the hybrid. Here we address this hypothesis by directly comparing patterns of seed size, paternity, fitness, phenology and fruit structure from both progenitors and the hybrid. Our experiments revealed that the two progenitor lineages also have multiple paternity and that plant phenology patterns are influenced by maternity. However, only in the hybrid do fitness and fruit structure vary along the fruit consistently. These results indicate that multi−seeded *Raphanus* fruits provide an advantage of enclosing seeds with various genotypes maintaining high polymorphism. In the hybrid's case the fruit provides additional protection to enhance fitness in stressful and competitive environments.

P1.26 HERMANSON, JW*; MACAYEAL, LC; MCDONALD, C; GARY, G; WAXMAN, L; ROONEY, P; STONE, M; BUCKLES, E; CURTIS, PD; LANIEWICZ, BR; Cornell Univ., Ithaca NY, NYS Dept. of Health,CCH,BCDC, Albany NY; *jwh6@cornell.edu*

Summer bat populations in the White−nosed era: implications for future survival.

Bat populations in the northeastern United States have declined dramatically since the recognition of White−nosed Syndrome (WNS) in a hibernation roost in 2006. Little brown bats (*Myotis lucifugus*) were the most common bat species in New York, but have declined precipitously. Because of the economic and biologic impact of bats, biologists have worked to document the spread of WNS and to address its mode of transmission. The causative agent of WNS is a cold−loving fungus, *Pseudogymnoascus destructans*. Nearly 7 million bats have died as a result of WNS. High mortality has been documented at numerous winter hibernation sites and there has been a progression of the disease to other hibernation sites across the United States. Maternity roosts populations were studied with direct visual counts and infrared illuminated video counts of the evening outflights. We have assessed summer populations of little brown bats at traditional hibernation sites in central New York and have documented a 80%, 90% and a 93.4% reduction (in the past three summers, respectively) in the expected number of female bats occupying 8 maternity roosts in the central New York region. Differences in stability of populations between roosts suggest that some populations have been isolated from, or are somewhat resistant to the impacts of WNS. Two of our study sites retained at least 20% of the population size seen in the pre−White nosed era, while one of our study sites experienced a total loss of little brown bats, and two others at least a 99% reduction of population size. We assess the use of human−built structures such as barns and out−buildings, as well as bat boxes in population stability. Supported in part by a grant from Hatch funds (NYC−435482).

P1.109 HERNANDEZ, LP*; CHEN, AH; RADE, CM; COSTANTINI, K; OBERG, F; STAAB, KL; GEORGE WASHINGTON UNIVERSITY, MCDANIEL COLLEGE; *phernand@gwu.edu*

Interspecific variation in muscle fiber type composition and histological architecture characterizes cypriniform palatal organ

Cypriniform fishes are characterized by a number of trophic novelties that have likely played an important role in the evolutionary success of this group. The palatal organ is a dorsal mass of exceedingly thin, complexly arranged muscle fibers within the roof of the buccopharyngeal cavity. Tied laterally to the branchial arches and caudally to the chewing pad it is coated in a taste bud−studded epithelium. In goldfish and carp this muscular pad is incredibly well innervated and produces localized protrusions that are used to trap edible items while bottom feeding. Thus far the palatal organ has only been investigated in those species with either a greatly hypertrophied vagal lobe or species with a greatly hypertrophied palatal organ. There is little comparative data on histological structure of the palatal organ across the whole of Cypriniformes. Moreover there is no data on the specific myosin isoforms that comprise the palatal organ. The general assumption has been that the function of the palatal organ is conserved across cypriniforms, and requires the careful sensory control of the vagal lobe to function properly. Few have considered the possibility that the palatal organ may have become adapted for different trophic functions during the course of cypriniform evolution. Here we present data on the histological structure and myosin identity of species within several major clades within Cypriniformes. Palatal organs from different species showed subtle but significant differences in both histological architecture and myosin profiles. Such differences suggest that the palatal organ may have become coopted for different functions during the course of cypriniform evolution.

110.2 HERREL, A.*; VIDELIER, M.; CORNETTE, R.; BONNEAUD, C.; CNRS/MNHN, MNHN, University of Exeter; *anthony.herrel@mnhn.fr*

Should I stay or should I go: exploration behavior in the frog Xenopus tropicalis

Habitat fragmentation of natural habitats takes place at an ever increasing rate. This likely imposes strong selection on the mobility of animals living in fragments in order to find mates and assure gene flow. Mobility is a complex trait involving variation in locomotor performance and exploration behavior. Yet, whether behavior and performance are coupled remains unknown for many taxa. Here we study exploration behavior and locomotor performance in an aquatic frog, *Xenopus tropicalis*, who's natural habitat is being strongly fragmented. Our results show strong variation in performance and locomotor morphology between sexes and among individuals. Behavior was also variable with some individuals moving up to 76 m in one hour. Moreover, exploration behavior was highly repeatable within an individual for most variables analyzed. A Gaussian mixtures analysis of the behavioral data detected three distinct behavioral strategies varying in the degree and willingness of animals to explore a novel environment. However, these behavioral clusters were not different in overall levels of performance or underlying morphology. These data suggest that behavioral strategies may evolve independent of selection on performance and morphology providing multiple independent pathways for the evolution of high mobility.

131.5 HERSH, T.; LUPICA, J. ; RUTH , B.; LUTTON, B.V. *; Carnegie Mellon University, Pittsburgh, PA, Portland High School, ME, Endicott College, Beverly, MA, Endicott College, Beverly, MA ; *bram.lutton@gmail.com*

The skate, Leucoraja erinacea, as a novel model for understanding the cellular and molecular mechanisms of hematopoiesis and angiogenesis

In elasmobranchs, the epigonal and Leydig organs are the two primary sites of hematopoiesis (production and differentiation of blood cells). In this study, we have used hematoxylin and eosin staining to characterize the cyto−vascular architecture within these tissues of the skate, *Leucoraja erinacea*. For molecular analyses, primers for twenty genes involved in hematopoiesis and angiogenesis were designed using recently developed bioinformatics tools to acquire genome and transcriptome information in *Leucoraja erinacea*. Our observations indicate that the robust increase in angiogenesis and cellular proliferation we have seen may occur to activate hematopoietic stem cells (HSC) during the reproductive period. In addition, we have demonstrated expression of the chemotactic receptor and ligand pair, CXCR4 and CXCL12, known to be critical for HSC mobilization and homing in mammals. By studying the cyto−vascular architecture and developing a targeted knock−down approach to gene expression in these tissues, we hope to be able to gain a better functional understanding of the vascular relationship and HSC, which we believe to be directly linked. As characterization of the epigonal and Leydig organs continues, we intend to address questions that have not yet been answered due to limitations of current models.

25.1 HESSEL, A.L.*; NISHIKAWA, K.C.; Northern Arizona University, Flagstaff; *alh385@nau.edu*

How Do they Do That? Understanding how Plethodontid Salamanders get Lift Off .

Plethodontids have been observed to jump using a unique mechanism in which they bend and unbend their torsos laterally with such force that they hurl themselves into the air. Although the take off, performance and some kinematic data have been described elsewhere, no work to date has been done to fully understand how this behavior leads to propulsion. We have attempted to understand this mechanism by performing a more detailed biomechanical analysis and using a conservation of energy analysis to estimate total useful energy outputs. We further used the engineering application of cantilever beam techniques to find the relative static stiffness of the salamander's torso in bending and work contribution thereof to the jumping mechanism. We used this knowledge to model the salamander jump. Preliminary results show that energy stored in the torso is directed to the hips, which rotate. The inside hind−limb is anchored before the salamander begins to unbend its body. As the hips rotate and pull against the planted limb, the hips move towards and over the planted limb, catapulting the salamander into the air. Our work has shown that understanding the dynamic center of mass, which changes drastically throughout the bend cycle, is critical to fully understand the mechanical efficiency of this unorthodox jumping mechanism. Further, static stiffness of the salamander's lateral bend has a major influence on the total work output of the jump mechanism. The jump mechanism may be a link between fish axial stiffness and jumping/walking mechanics of reptiles and mammals, as components from both are visible. Therefore, we encourage further comparative studies. The salamander data has allowed us to build a jumping model based on catapult mechanics and testing of this model against the available data will be pursued.

P2.58 HIEBERT, T.C.*; BURGESS, A.K.; LABELLA, A; YOUNG, C.M.; MASLAKOVA, S.A.; Oregon Institute of Marine Biology, Univ. of Oregon, Duke University; *terrah@uoregon.edu*

Genetic identification of bivalve larvae from deep−sea seep communities

Most marine invertebrates exhibit a biphasic life history with planktonic larvae and benthic adults. Larvae typically have greater dispersal potential than adults, and thus connect populations both in time and in space. Genetic data on adults suggest contemporary gene flow among small and isolated populations of deep−sea cold−seep bivalves within the Intra−American Sea (IAS) that could be facilitated by larval dispersal. Some seep bivalves have long−lived planktotrophic larvae and one species has been found throughout the water column in the Gulf of Mexico. However, information on larval distribution of seep species in the water column is generally scarce. Here, we identify larvae of several species of deep−sea bivalves collected from the water column at various depths near seep systems within the IAS using DNA sequences of the 5' region of the mitochondrial gene Cytochrome Oxidase I. Larvae identified to species level include those of the deep−sea seep mussel *Bathymodiolus mauritanicus*, an amphi−Atlantic species found in West Africa, Gulf of Cadiz and Barbados Accretionary Prism (BAP). Larvae of this species were found in the water column as deep as 1250 m and as shallow as 200 m near BAP, suggesting that they may disperse with deep or surface currents. Additionally we identified larvae of two vesicomyid clams − *Laubiericoncha myriamae*, and an undescribed species found at BAP, both collected in plankton samples taken between 1250 m and 900 m near BAP.

116.4 HIEBERT, T.C.*; MASLAKOVA, S.A.; Oregon Institute of Marine Biology, Univ. of Oregon; *terrah@uoregon.edu*

A life−history approach to describing species diversity of nemerteans in the NE Pacific

Recent estimates suggest that between one third and nine tenths of marine eukaryotic diversity is undescribed. Although most marine invertebrates have biphasic life cycles with planktonic larvae and benthic adults, larval stages are rarely part of biodiversity assessments. We have evaluated the nemertean diversity of the Oregon coast based on regular surveys of both the adults and larvae since 2008, connecting the two life history stages with DNA sequence data. About 65 intertidal species are reported from central California to Oregon, and the nemertean fauna of this region is thought to be well characterized. Surprisingly, our results suggest that the local diversity of this phylum is at least double what is currently known. We found many species new to science, and detected (mostly as larvae in the plankton) species previously known only from other parts of the world. About half of all larval types we have collected remain unidentified because we have not yet encountered their adults. This illustrates an important point for biodiversity studies of other groups of marine invertebrates worldwide: certain species are likelier to be encountered as larvae in the plankton than as adults. Sampling both adults and larvae may reveal a much greater diversity than if only one of the life history stages is surveyed. Additionally, we discovered several new types of nemertean larvae, which is relevant to our understanding of larval evolution. Finally, while nemertean larvae often have species−specific morphology, the general morphotypes appear to characterize clades of closely related species. This means that larval identification not only reveals hidden diversity, but may also help to revitalize the systematics of the group by infusing larval characters into an adult−centric taxonomy.

128.1 HIEBERT, LS*; MASLAKOVA, SA; Oregon Institute of Marine Biology, Univ. of Oregon; *lhiebert@uoregon.edu*

How the pilidium larva uses the Hox genes

The pilidium larva is a novelty of a single group of nemertean worms called the Pilidiophora. Uniquely for this group the juvenile body develops from a series of isolated rudiments called imaginal discs. The larval and juvenile bodies have entirely different plans, though they share the same stomach. In order to understand the origins of this novel larval body plan and developmental mode, we examined patterns of expression of Hox genes in pilidial development. These conserved genes pattern major body regions and also certain evolutionarily novel structures in animals. Several nemertean Hox genes have been identified but their developmental expression has not been studied. Here we report for the first time the expression patterns of nine Hox genes during development of the pilidiophoran *Micrura alaskensis*, including two anterior, a PG3 gene, five central, and one posterior gene. Surprisingly, there is no Hox gene expression at any time anywhere in the pilidial larval body. And even more surprisingly, all nine are expressed in localized partially overlapping domains in the trunk imaginal disks − a pair of rudiments that gives rise to the juvenile trunk, and none in the cephalic or the cerebral organ discs, which form the juvenile head. Our findings suggest that Hox genes pattern the antero−posterior axis of the juvenile, but not the larva. Thus, a novel, apparently Hox−free mechanism must account for the patterning of the pilidium. Furthermore *M. alaskensis* orthologues of the more anterior genes have a broader domain of expression compared to the more posterior genes. Also, the more anterior genes begin to be expressed earlier in development than the more posterior genes, hinting at temporal and spatial colinearity, a hallmark of Hox expression in other animals.

104.4 HIERONYMUS, TL*; SIMONS, ELR; NEOMED, Midwestern University; *thieronymus@neomed.edu*

From wing to bone: Anatomy and microanatomy of skeletal correlates for whole wing shape in Neornithine birds

Bird wings display a remarkable variation of shape and size, ranging from small, rounded wings in sparrows to long, narrow wings in albatross. This variability occurs hand−in−hand with adaptive differences in flight behavior. Our ability to reconstruct the evolutionary history of wing shape in birds is hampered by this same variability. The high rate of change that underpins variability also leads to ambiguous ancestral character state reconstructions for the Paleogene stem lineages of extant neornithine birds. Understanding trends and patterns in the evolution of bird flight requires reliable skeletal correlates of wing shape, which will allow fossils to anchor ancestral character state reconstructions in deep time. We examined skeletal correlates for the attachment of remiges, which determine the majority of wing area and shape, by dissection and ¼ CT (n=35 species), coupled with histological preparations of skeletal elements and associated soft tissues (n=6 spp). We found six skeletal characters to be directly related to ligaments of feather attachment. We examined the relationship between these characters and aerodynamically relevant wing shape variables (body mass, wing span, and wing area) in extant birds (n=71 spp) using a phylogenetic adaptation of Distance−Based Redundancy Analysis (db−RDA). The resulting ordination defines a morphospace of skeletal correlates, which is constrained by robust relationships to aspect ratio and wing loading. The Cretaceous stem ornithurine *Ichthyornis* shows skeletal correlates of high aspect ratio and low wing loading, in sharp contrast to the "average" values inferred for the neornithine crown node from extant data alone. Our results highlight how quantitative models of soft−tissue morphology that include fossil data can dramatically influence reconstructions of evolutionary pattern and process.

25.6 HIGHAM, TE*; RUSSELL, AP; BIRN−JEFFERY, A; COLLINS, CE; HULSEY, CD; Univ. of California, Riverside, Univ. of Calgary, Univ. of Tennessee; *thigham@ucr.edu*

Use it or lose it: locomotor evolution associated with the loss of adhesion in geckos

Geckos are known for their remarkable ability to adhere to smooth and/or inclined surfaces using adhesive toe pads. As well as the multiple instances of the acquisition of adhesive capabilities, the secondary loss of the morphological modifications associated with adhesion has been reported for several lineages. The *Pachydactylus* clade exhibits two unequivocal losses of the adhesive apparatus (*Chondrodactylus angulifer* and *Pachydactylus rangei*), and several other reductions (e.g. *Rhoptropus afer* and *Colopus wahlbergii*). This clade occupies both sandy and rocky habitats in southern Africa, and the secondary loss (or reduction) of adhesion appears linked to shifts in habitat use, from climbing to ground dwelling. Although the gain and loss of adhesion has been documented, little is known of the resulting functional consequences. Utilizing 25 species from the *Pachydactylus* clade, we examined the morphometric changes associated with the reduction and loss of adhesion. We also explored the three−dimensional hindlimb kinematics of pad−bearing and secondarily padless taxa (14 species), using high speed videography, to determine the functional consequences of the reduction and loss of the adhesive apparatus. To examine morphology and kinematics in a phylogenetic framework, we developed trees based on existing sequences from four genes. We then used both Brownian motion and Ornstein−Uhlenbeck models of character evolution to compare changes in the evolutionarily rates and lability of locomotory traits in clades where adhesion is retained versus in clades where adhesion is reduced and then lost. Supported by NSF IOS−1147043 (TEH) and NSERC 9745−2008 (APR).

S2.3−3 HILL, G. E.; Auburn Univ.; *ghill@acesag.auburn.edu*

Cellular respiration: the nexus of stress, condition, and ornamentation

Current theory suggests that females benefit by choosing highly ornamented males as mates because ornamentation is an honest signal of male condition. Empirical studies on a diversity of vertebrates and invertebrates have demonstrated associations between ornamentation and a host of parameters associated with condition including adiposity, immunocompetence, oxidative state, neuromuscular function, and cognition. From this literature, there appears to be no core aspect of system function revealed by ornamentation. Here I propose that the primary determinant of individual condition is cellular respiration and in particular oxidative phosphorylation (OXPHOS). Dysfunction of OXPHOS leads to reduced production of ATP and oxidative stress via the release of free radicals. Oxidative stress and reduced energy production, in turn, negatively affect ornament production while at the same time inhibiting immune responsiveness, restricting protein production, reducing fat stores, and depressing behavioral activity. Thus, a fundamental link between OXPHOS and ornamentation explains the commonly observed associations between ornamentation, oxidative state, and energy−demanding processes such as immune defense. Environmental stress affects ornamentation largely through negative effects on cellular respiration. Because OXPHOS efficiency lies at the core of system functionality, it is the property that females should assess most closely in prospective mates. I propose that condition−dependent ornaments evolve via female mate choice as uncheatable signals of OXPHOS efficiency. I use carotenoid pigmentation as an example of a condition−dependent trait for which production is intimately linked to OXPHOS through sensitivities to the oxidative state of the mitochondria.

21.6 HILLARD, H*; CARPENTER, R.C.; California State University, Northridge; *heather.hillard.358@my.csun.edu*

Acidification and Algae: Do they have interactive effects on corals?

Ocean acidification, the decrease in the pH and carbonate ion concentration due to the uptake of anthropogenic CO_2, threatens coral reefs worldwide as studies predict the decline of calcifiers and increasing growth of non−calcified macroalgae. However, the flux of carbonate species partly depends on the benthic community composition. On the north shore of Moorea, French Polynesia, SeaFETS, ocean pH sensors, were placed at 5 locations across the reef. The pH was relatively stable on the fore reef while large diel fluctuations were recorded directly behind the reef crest, which is dominated by the macrophyte *Sargassum pacificum*. The fleshy alga, through photosynthesis and respiration, may be driving the pH fluctuations on the back reef. Previous studies explore the negative effects of coral algal interactions from shading, abrasion or allelopathy. In future elevated CO_2 conditions, macroalgae could indirectly alleviate some of the effects of ocean acidification on associated corals by increasing the pH. I tested the combined and potentially interactive effects of algae and ocean acidification on the coral, *Acropora pulchra*, in a fully factorial field and mesocosm experiment. At the Richard B. Gump South Pacific Research Station, I exposed *Acropora* fragments to a mesocosm experiment crossing 3 CO_2 treatments (ambient, high and fluctuating) with 2 light levels (shaded and unshaded) mimicking the light environment in *Sargassum* canopies. Future recovery of coral reefs may depend on the ability of corals to survive in association with macroalgae. Through this research, I hope to elucidate any interactive effects of macroalgae and ocean acidification on coral calcification, growth and survival.

96.7 HIRAMATSU, L.*; WOLAK, M.; GARLAND, T.; Univ. of California, Riverside; *lhira001@ucr.edu*

Genetic modeling to study limits in selection experiments for behavioral traits

Many behaviors can be viewed as composite traits because the total amount of expression is the product of intensity and duration. Each of these two components is, in turn, potentially limited by either the organism's physical ability or its level of motivation. Therefore, even if all alleles at every locus affecting physical ability and/or motivation have purely additive effects, the way they interact to determine intensity or duration of a behavior is non−additive. If selection is performed on a composite behavioral trait with such properties, then non−additive interactions (dominance and/or epistasis) could be important in determining the response to selection. We created a simple model with purely additive effects and the above interactions to simulate long−term selection experiments. Population sizes were chosen to mimic typical selection experiments with rodents (Ne=40/generation) and 40% of individuals were selected per generation. Overlap in the phenotypic effects of the loci on the four lowest−level traits was varied, as were starting allele frequencies. Values for allelic effects, environmental effects, and population means in the base population and when a limit might be reached were chosen to mimic a long−term selection experiment that targeted voluntary wheel running in mice (Swallow et al. 1998; Careau et al. 2013). Similar to results from the wheel−running selection experiment, the model reached a selection limit after ~20 generations, but the limit coincided with depleted additive genetic variance, unlike the selection experiment. These results suggest that the maintenance of additive genetic variance in the selection experiment cannot be explained by purely additive effects, even with complex interactions among behavioral components. Supported by NSF IOS−11212732.

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Epigenetics in Cardiovascular Development

The field of epigenetics has gained much attention in the past few decades due to the fact that, in many instances, epigenetic processes outweigh direct genetic processes in the manifestation of aberrant phenotypes. Maternal effects, or the influences of maternal environment, phenotype and/or genotype on offspring phenotype that are independent of offspring genotype, are a subcategory of transgenerational epigenetic effects. Due to the intimate role of the mother during early development in animals, there is much interest in investigating the means by which maternal effects can shape the individual. Maternal effects are responsible for cellular organization, body axis determination, initiation and maturation of organ systems, and physiological performance of a wide variety of species and biological systems. The cardiovascular system is the first to become functional and can significantly influence the development of other organ systems. Thus, it is important to elucidate the role of maternal effects in cardiovascular development, and understand its impact on adult cardiovascular health. Topics to be addressed include: (1) how and when do maternal effects change the developmental trajectory of the cardiovascular system to permanently alter the adult cardiovascular phenotype, (2) what molecular mechanisms have been associated with maternally−induced cardiovascular phenotypes, and (3) what animal models (i.e. the chicken and the rodent) can help to better understand the role of maternal effects in the transgenerational transfer of cardiovascular phenotype.

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Changes in androgen receptor expression in a brain region controlling communication behavior across populations of black ghost knifefish (Apteronotus albifrons)

Rapid evolutionary shifts in the magnitude and direction of sexual dimorphism of behavior can result from changes in responsiveness of behavior to gonadal steroids. In the South American ghost knifefish (Apteronotidae), evolutionary shifts in the sexual dimorphism of electrocommunication behavior are accompanied by changes in androgen sensitivity across species and populations. In this study, we tested the hypothesis that variation in sexual dimorphism and androgen sensitivity in the black ghost knifefish (*Apteronotus albifrons*) is mediated by changes in the expression of androgen receptors (AR) in the brain. Black ghosts communicate using weak electric signals (electric organ discharges, EODs) fired at a characteristic frequency (EODf). The magnitude of sexual dimorphism in EODf varies across populations and is correlated with changes in the sensitivity of EODf to the main fish androgen, 11−ketotestosterone (Ho et al. 2013). We compared fish from populations that were either strongly or weakly sexually dimorphic in EODf and used qPCR to quantify the relative expression of AR mRNA transcript in a region of the brain responsible for setting EODf, the pacemaker nucleus (Pn). AR mRNA expression was also quantified in the gonads. We found that AR abundance in the Pn was significantly higher in fish from the strongly sexually dimorphic populations than in the less sexually dimorphic population. Our data show that changes in AR abundance within specific brain regions can underlie population−level variation in sexually dimorphic behavior.

P2.146 HOBENSACK, M.J.*; HOOD, W.R.; Auburn University; *mjh0026@auburn.edu*

Increasing mechanical strain on the skeleton during reproduction does not reduce bone mobilization during reproduction in the mouse

Bone is a dynamic tissue with minerals being deposited or withdrawn according to the demands of the body. During late pregnancy and lactation, female mammals mobilize mineral from bone to support the ossification of offspring skeleton(s). Conversely, in response to mechanical loading, minerals are deposited in bone enabling it to develop a stronger architecture. Despite their central importance to the functionality of vertebrate individuals, the interactions between these potentially opposing forces of mineral deposition in response to mechanical strain and mineral mobilization in response to reproduction remains poorly understood. It is possible that inter−individual differences in the loading imposed by different forms of locomotion may alter the amount of mineral mobilized during reproduction. Here, the impact of climbing on bone mobilization was examined during reproduction in the laboratory mouse. Mice were divided among treatment groups. The climbing group had access to a 60−cm tower, increasing strain on their appendicular skeleton. The tunnel group had access to a 100−cm tunnel, which encouraged movements within the horizontal plane. Mothers' in the climbing group displayed changes in femoral trabeculae that reflected net gain in bone, whereas changes in the mid−shaft cortical bone reflected a net loss of bone. The mineral content of mothers' femurs and body did not differ between groups. The total body mineral content of individual offspring and the cumulative amount of mineral invested in the full litter, corrected for litter size, was also similar between treatment groups. These results suggest that a redistribution of femoral bone may allow mothers to resist strain while maintaining high calcium output to suckling young.

P2.114 HOCHBERG, A*; HOCHBERG, R; Univ. of Massachusetts, Lowell; *adele_hochberg@student.uml.edu*

Larviparity, metamorphosis, and neural architecture in species of Gnesiotrocha (Rotifera: Monogononta)

Sessility is a rare lifestyle among species of Rotifera and one that demands unique adaptations relative to the more common freeliving (planktonic and benthic) lifestyle typical of rotifers. One exceptional adaptation is indirect development, which leads to the production of a short−lived larval stage that functions in dispersal. Indirect development is common among species in the superorder Gnesiotrocha, which includes sessile rotifers that produce larvae that undergo one of two forms of metamorphosis: 1) gradual metamorphosis that involves only allometric growth of the larva, and drastic metamorphosis that involves precocious development of the adult head with eventual replacement of the larval corona. In this study, we examine the neural architecture of two sessile species that display each of these conditions (gradual: *Floscularia conifera*; drastic: *Stephanoceros fimbriatus*) to determine how metamorphosis affects the serotonergic nervous system. As serotonin is likely to play a significant role in ciliary locomotion (as larvae) and ciliary feeding (as adults), we hypothesize that both species will show changes in the number and distribution of serotonergic neurons (and their connections) from larva to adult. We also hypothesize that neural patterns will differ between the species as a result of their considerably different adult body plans and feeding styles. We test these hypotheses using immunohistochemical protocols and confocal laser scanning microscopy. Our results show that all larvae have broadly similar neural patterns, but metamorphosis leads to a reorganization of serotonergic elements that produces distinctly different adult topologies.

P3.184 HODA, A.B.*; BALTZLEY, M.J.; Western Oregon University; *ahoda10@wou.edu*

Intraspecies variability in GABA−immunoreactive neurons in the central nervous system of Helix aspersa

While the central nervous systems of closely related species are generally conserved, there are many examples of variability in the size, number, and location of homologous neurons. We examined the nervous system of Helix aspersa to investigate whether there is similar intraspecific variability between different populations of the same species. We used immunohistochemistry to identify GABA−immunoreactive cells in the H. aspersa central ganglia. Overall, our results are similar to previously published studies. We found 4 GABA−immunoreactive neurons in the buccal ganglia, as well as several clusters of GABA−immunoreactive neurons in the cerebral and pedal ganglia. We did not identify any GABA−immunoreactive neurons in the visceral, parietal or pleural ganglia. We are in the process of quantifying the number of neurons in each of the cell clusters found in the pedal and cerebral ganglia.

P1.165 HOFFMAN, J.*; SYLLA, M.; GRAY, E.M.; Colorado College, Colorado State University; *jacob.hoffman@coloradocollege.edu*

Effects of desiccation stress on gene expression in the mosquito Aedes aegypti

Aedes aegypti (Diptera: Culicidae) is the primary disease vector for both Dengue and Yellow Fever. Climate change is likely affecting the distribution of these mosquitoes, yet the extent to which individuals and populations can respond physiologically to the environmental change is unknown. Increasing our understanding of how *A. aegypti* responds to environmental stressors is an important step in predicting the future distribution of the diseases these mosquitoes transmit. In this research, we investigate the response of individual adult mosquitoes to dehydration stress. Homologs of four genes identified as being differentially expressed in response to desiccation stress (Frost, Desat2, HSP70 and Pepck) in *Drosphila* and other species are examined in *A. aegypti*. *Aedes* mosquitoes are subjected to both chronic and acute desiccation stress and then analyzed via qRT−PCR to determine the extent to which these genes are differentially expressed. These results provide clues as to which physiological mechanisms are likely to mediate survival in desiccating environments.

46.3 HOLDEN, W.M.*; ROLLINS−SMITH, L.A.; Vanderbilt University School of Medicine; *whitney.m.gammill@vanderbilt.edu*

Skin bacteria protect newly metamorphosed Rana sphenocephala from the emerging fungal pathogen Batrachochytrium dendrobatidis.

Recent evidence suggests that the assemblage of amphibian skin microbes play a role in protection of hosts against the lethal chytrid fungus, *Batrachochytrium dendrobatidis*. This emerging pathogen causes chytridiomycosis, a disease linked to catastrophic global amphibian declines. Newly metamorphosed frogs are especially vulnerable to this pathogen. Most studies examining the role of skin bacteria in defense against this pathogen have focused on correlations between amphibian population persistence and antifungal metabolites secreted by the bacteria or on the presence or absence of inhibitory bacterial isolates. Our goal was to explore the role of the entire microbial community in defense against this pathogen. Thus, we developed a robust bacterial depletion protocol using an effective antibiotic cocktail to significantly deplete amphibian skin bacteria. Using the southern leopard frog (*Rana sphenocephala*), we show that such reduction of skin bacteria results in higher *B. dendrobatidis* infection levels compared to control frogs with their skin bacteria intact. By using *R. sphenocephala* juveniles at one week post−metamorphosis, we examined this innate skin defense in frogs that do not yet express skin antimicrobial peptides. Additionally, we identify a number of individual skin isolates from this species that are capable of constitutively secreting compounds that inhibit *B. dendrobatidis* growth *in vitro*, helping to protect this species at a critical developmental juncture. *Support: NSF grants 0843207 and 1121758 to LR−S.*

P1.8 HOLLAND, C*; SCHWALBE , M A.B; WEBB, J.F; University of Rhode Island; *cholla881@gmail.com*

Aggression and reproductive behavior in two cichlid fish species that differ in their sensory biology

Tramitichromis sp. (*TRA*) and *Aulonocara stuartgranti* (*AUL*) are mouth brooding cichlids in Lake Malawi, but use different sensory strategies to find their benthic invertebrate prey. *TRA* uses visual inputs, while *AUL* depends on its modified lateral line system, especially in the dark. Thus, we asked if aggressive and reproductive behaviors in *TRA* depend more on visual input than those in *AUL*. Interactions between male and female *TRA* and *AUL* were recorded using HD video and hydrophone to correlate body movements and sound production. Reproductive behavior in *TRA* and *AUL* was defined by quivers, sound production (male *TRA* only; 161−581 Hz; correlated w/quivering), chasing, guarding, circling, and color pattern changes. Aggression was defined by fin erection/depression, mouth displays, quivers, bites, sound production (male *TRA* only; correlated w/quivering behavior), circling, and color pattern changes (*TRA* only). In both behaviors, male *TRA* exhibited a higher frequency of fin movements, dramatic color pattern changes, and faster escalation to mouth displays − all visual signals. Female *TRA* oriented visually to the egg spots on the male's anal fin in contrast to female *AUL*, which maintained a parallel orientation to the male during mutual quivering. In both behaviors, male *AUL* started quivering sooner and at a higher frequency, but demonstrated little or no color change. Thus, *TRA* uses sound production and an array of visual signals, but *AUL* does not produce sound, and depends more on quivers that likely produce lateral line stimuli during aggression and reproductive behavior. Thus, differences in sensory structure and function may play a role in a wide range of critical behaviors in closely related species. NSF grant IOS−0843307 to JFW and NSF EPSCoR contract EPS−1004057.

P1.116 HOLLIDAY, CM*; TEA, J; SELLERS , KC; WITMER, LM; DAVIS, JL; University of Missouri, University of Houston, Ohio University , University of Southern Indiana; *hollidayca@missouri.edu*

Estimating Bite Force in Fossil Vertebrates Using 3D Computational Methods

Accurately predicting bite forces in extinct vertebrates remains a challenging yet important tool for ecologists, functional morphologists, and paleobiologists. Only recently have three−dimensional computational methods offered more informed methods for reconstructing the anatomy and cranial biomechanical environment compared to previous 2D methods. Despite being one of the most studied non−avian dinosaurs, estimates of bite force in Tyrannosaurus rex range orders of magnitude (5,000N−150,000N) suggesting more refined analyses are needed. Here we review previous estimates of bite force in the T. rex complemented with a new model. Jaw muscles were digitally mapped using Strand7 software, and muscle resultants and bite forces were calculated using the Boneload program. Using areas of muscle attachment, muscle length, and modeled physiological parameters, we calculated the force exerted by each individual muscle, then used geometric relationships to sum each muscle force to yield total bite force at particular bite points. A sensitivity analysis was employed to test the behavior of the model using different physiological cross sectional areas of muscles and bite points. Our model found bite forces of *T. rex* to range from 5,000N to 30,000N, which are forces substantially lower than most previous estimates but fall near estimates derived from dental data. This model and others like it indicate that anatomically−informed, 3D lever−based computational models are more accurate than many previous methods for estimating bite force and will be useful for testing functional and ecological hypotheses pertaining to the evolution of feeding in vertebrates.

2.2 HOLMES, Z.C.*; BYERS, J.E.; MALEK, J. ; The University of Georgia; *zholmes9@uga.edu*

Top−down Control by Bonnethead Sharks in Oyster Reef Communities Through Consumptive and Non−Consumptive Effects.

The eastern oysters (Crassostrea virginica) along the Atlantic coast are an important foundational species upon which many estuarine species are dependent for food and structure. Bonnethead sharks (Sphyrna tiburo) are the most abundant fish by biomass within some southeastern estuaries and are known to be voracious predators of blue crabs. We conducted a replicated mesocosm experiment to examine how bonnethead sharks influence crab mortality and foraging behavior and how these effects on the crabs trickled down to affect species lower on the food chain, especially juvenile oysters. Our mesocosm study showed that sharks significantly impact juvenile oyster survival, by reducing blue crab abundance and foraging. Bonnetheads however had little effect on mud crab predation of oysters, with substantial quantities of oysters eaten even in the presence of sharks. We also quantified predation rates of crabs in field settings both on and away from oyster reefs. Our results indicate that crab loss is extremely high away from oyster reefs, often approaching 100% in a 12 hour period. These results indicate that bonnethead presence in oyster reef communities is a significant driver of blue crab behavior, with likely implications for other oyster reef community species.

39.2 HOLT, NC*; ABBOTT , EM; AZIZI, E; Univ. of California, Irvine; *natalie.c.holt@gmail.com*

Compliance, activation and the force−length relationship in skeletal muscle

In vivo muscle performance is modulated by varying the level of muscle activation, both by changing activation frequency and the number of motor units recruited. However, much of our understanding of muscle physiology comes from studies using maximal activation. This discrepancy limits our understanding of *in vivo* muscle function. A muscle's optimal length (L_0) has been shown to increase when activation level is reduced by decreasing stimulus frequency. Length−dependent calcium effects have been implicated as a potential mechanism to explain this increase in L_0. However, this pattern may also be explained by the fact that the effects of in−series compliance will vary with the muscle's level of force. We distinguish between these alternate mechanisms by examining how different stimulation conditions affect L_0 in a single muscle. Isometric force−length curves were constructed for frog plantaris muscles using: 1) a tetanic stimulus of supra−maximal amplitude (high activation, high calcium in all fibres and high whole muscle force); 2) a tetanic stimulus of sub−maximal amplitude (low activation, high calcium in a sub−set of fibres and low whole muscle force) and; 3) a twitch stimulus (low activation, low calcium in all fibres and low whole muscle force). If the optimal length increases solely with decreasing maximum force, compliance would be the most likely candidate to explain shifts in L_0. If however, L_0 was independent of maximum force, and only varied between supra−maximal tetanic and twitch contractions, calcium−dependent mechanisms would be implicated. Our findings suggest that compliance has a greater role than calcium in determining the optimal length of the force−length relationship and imply that the interaction between compliance and activation level may affect *in vivo* muscle performance more than is currently appreciated. Supported by NIH AR055295.

91.1 HOLZMAN, RH*; CHINA, V; ZILKA, M; YANIV, S; ELAD, D; Tel Aviv University; *holzman@post.tau.ac.il*

Hydrodynamic starvation in first−feeding larval fishes

Larval fishes suffer prodigious mortality rates, typically eliminating 99% of the brood within a few days after first feeding. Hjort (1914) attributed this "critical period" of low survival to the larvae's inability to obtain sufficient food. Larvae feed by generating suction flows that carry the prey into their mouth. This feeding mechanism is conserved across life stages, despite a dramatic transition of larvae from a viscosity−dominated low Reynolds at first feeding to an inertia−dominated high Reynolds regime at larger sizes. Using numerical simulations, hi−speed filming, and feeding experiments we examine suction performance in larval fishes. Our data shows that hydrodynamic constraints on the suction mechanism in first−feeding larvae strongly affect larval feeding rates. We manipulated water viscosities to quantify age−independent effects of the hydrodynamic regime on feeding performance. These dynamic−scaling experiments revealed that larvae size is the primary determinant of feeding rates, independent of other ontogenetic effects. We conclude that first−feeding larvae experience "hydrodynamic starvation" in which low Reynolds numbers mechanistically limit their feeding potential. Thus, starvation of first−feeding larvae may occur even under apparent high densities of high−quality food, providing a likely mechanism for Hjort's "Critical Period".

P1.40 HONG, P.*; HATCH, K.; Long Island University: Post Campus; *honginhui@gmail.com*
Analysis of Carbon and Nitrogen Stable Isotope Ratios Between Trophic Levels in Mealworms and Crickets
The change in the $^{15}N/^{14}N$ ratios of animal tissues is a powerful tool for determining an animal's trophic level. Although much field research has been done on ^{15}N enrichment with increased trophic level, it has largely been correlative and there have been few controlled laboratory studies. It is often assumed that an increase in $\delta^{15}N$ of about 3.4 ppm indicates an increase of one full trophic level, but this value is actually quite variable among different species and diets. We aimed to better understand the relationship between shifts in trophic levels and see what the actual values for the changes in stable isotope ratios are and whether, and whether those values are consistent among different diets. To do this, we conducted a controlled laboratory experiment using crickets and mealworms and compared the changes in isotopic ratios, specifically $\delta^{15}N$ and $\delta^{13}C$ among their trophic levels. The results showed that for the mealworms, there was a significant difference in $\delta^{15}N$ and $\delta^{13}C$ ratios between those fed on wheat germ and those that were fed on other mealworms or crickets.

107.3 HOOD, W.R.; Auburn University; *wrhood@auburn.edu*
Maternal diet, developmental plasticity, and reproductive fitness in the house mouse
The early environment of an individual can alter processes responsible for long−term or permanent changes in phenotype. There is good evidence that individual differences in glucose, lipid, and bone metabolism, to name a few, are partially attributable to the supply of nutrients made available to the young as they develop. It has been argued that developmental plasticity matches offspring physiology to maternal diet and that this process is adaptive. Adult offspring that live in an environment comparable to their mother are expected to have greater fitness than those that live in a different environment. Despite the ubiquity of this hypothesis, there is little empirical evidence to support it. The goals of this work are to 1 − confirm that an individual's physiological phenotype is programmed during early development under natural conditions, and 2 − determine if adult offspring consuming diets comparable to their parents have greater fitness than those that have a mismatched diet. This work was conducted in 10 wild−derived populations of house mice (*Mus musculus*) maintained at a population density and conditions that mimic demes of mice living in barns. The parental generation was maintained on 10% or 20% protein diet. After weaning, F1 offspring were kept on the same diet as their parents or switch to the alternate diet. Treatment impacted male and female mice differently with male offspring on the matched treatment depositing more abdominal fat than those on the mismatched diet and females on the matched diet displaying less abdominal fat than those on a mismatched diet. The impact of treatment on male and female survival, male dominance, and female reproductive output will be discussed.

128.6 HOOKHAM, B.K.*; PAGE, L.R.; University of Victoria; *bhookham@uvic.ca*
Foregut development in predatory caenogastropods: Common developmental trajectories despite changing life histories
Caenogastropods experienced an impressive adaptive radiation, with the evolution of new feeding strategies a prominent theme. The ancestral feeding condition is herbivorous grazing, whereas the derived condition is predatory feeding with a proboscis and complex foregut, as shown by neogastropods. Previous research has looked to development to explain how the proboscis and derived foregut of predators evolved. In species with indirect development, the definitive foregut arises from an anlage of undifferentiated cells embedded within the ventral wall of the larval foregut. At metamorphosis, the larval mouth and distal foregut are destroyed, the definitive foregut takes its place, and a new mouth is formed. These developmental novelties allow for development of the adult foregut without disruption of larval feeding and ensure the adult foregut is ready for use immediately after metamorphosis. The developmental pattern observed in indirect developing species (*e.g. Nassarius mendicus*) suggests how predatory feeding may have evolved; however, a similar developmental pattern was not identified in a direct developing caenogastropod (*Nucella lapillus*). By means of histological sectioning and 3D reconstructions, I identified a larval foregut and anlage of the definitive foregut in the direct developing species *Nucella lamellosa*. In *N. lamellosa*, like the indirect developing species, the anlage gives rise to the definitive foregut and at metamorphosis the distal larval foregut is destroyed. The developmental innovation that facilitated the evolution of predatory feeding in indirect developing caenogastropods is also apparent in a direct developing species, which strongly suggests that the proboscis and complex foregut of predators evolved in a common ancestor with indirect development.

6.2 HOOVER, A.*; MILLER, L.; University of North Carolina at Chapel Hill; *hooverap@email.unc.edu*
Do resonating bells increase jellyfish swimming performance?
A current question in swimming and flight is whether or not driving flexible appendages at their resonant frequency results in faster or more efficient locomotion. It has been suggested that jellyfish swim faster and/or more efficiently when the bell is driven at its resonant frequency. Previous work has modeled the jellyfish bell as a damped harmonic oscillator, and this simplified model suggests that work done by the bell is maximized when force is applied at the resonant frequency of the bell. We extend the idea of resonance phenomena of the jellyfish bell to a fluid structure interaction framework using the immersed boundary method. We first examine the effects of the bending stiffness of the bell on its resonant frequency. We then further our model with the inclusion of a "muscular" spring that connects the two sides of a 2D bell and drives it near its resonant frequency. We use this muscular spring to force the bell at varying frequencies and examine the work done by these springs and the resulting swimming speed. We finally augment our model with a flexible, passive bell margin to examine its role in propulsive efficiency. We also compare resulting swimming motion and flow to Aurelia aurita recordings and PIV.

P2.13 HOPE, S.F.*; ABOLINS−ABOLS, M.; KETTERSON, E.D.; The College of New Jersey, Indiana University; *hopes1@tcnj.edu*

Stress affects the behavior of urban and montane populations differently

The trade−off between self−maintenance and reproduction is important for animals that must partition limited resources to maximize fitness. Stress, reproductive opportunities, and resource availability often differ between habitats and populations, thus individuals are required to alter their resource allocation to competing functions. Behavior can serve as a mechanism to enable allocation decisions and as an indicator of altered allocation. We experimentally compared birds for their territorial behavioral response to an acute stressor in two Oregon junco (*Junco hyemalis thurberi*) populations living in two different habitats − urban and montane. Urban birds are known to be less responsive to stress and to allocate more to reproduction. On day 1, birds from both experimental and control groups in both habitats experienced a simulated territorial intrusion (STI). In the experimental group, the STI was followed by capture and handling; in the control group there was no capture or handling. On day 2 both groups experienced a second STI. If stress on day 1 has a negative impact on reproduction (aggression), we predicted that birds from the experimental group would be less aggressive than controls on day 2. If the impact of stress varies with habitat, we predicted a greater effect in the montane population, since montane junco populations are known to be more responsive to stressors. We found that stress on day 1 negatively affected activity and distance to the intruder on day 2 in the montane population but not in the city population, indicating that acute stress can vary in its effect on behavior in populations inhabiting different habitats. We conclude that variation in the trade−off between stress and reproduction may be manifested in a behavioral mechanism related to allocation decisions.

55.6 HOPKINS, G.R.*; BRODIE, JR., E.D.; FRENCH, S.S.; Utah State University; *gareth.hopkins@usu.edu*

Salt and the Rough−skinned Newt: Investigations of Adaptation to a Natural and Anthropogenic Stressor

Amphibians are osmotically sensitive organisms, and tolerance of saline environments is rare (some coastal species have adapted to natural sources of salt). Due to anthropogenic factors, freshwater habitats are becoming increasingly saline, and osmotically sensitive organisms will be forced to adapt. We investigated the ability of the rough−skinned newt (*Taricha granulosa*) to adapt to natural and anthropogenic sources of salt. Increasing salt concentrations resulted in higher newt egg mortality, incidence of developmental deformities, reduced size and developmental stage at hatching, and significantly compromised post−hatching larval survival. Survival was also dependent on the type of salt used, and whether or not newts had an evolutionary history of regulating it. $MgCl_2$ was more toxic to larvae than NaCl, which larvae were able to regulate with Na^+ pumps. We also found in a salt−naïve population of newts there exists significant interfamily variation in salt tolerance, providing the raw material for natural selection and evolutionary change. We have discovered that newt populations along the Oregon coast have adapted to naturally elevated sources of NaCl. Newts located in the tidal area of a stream were significantly less stressed (lower corticosterone levels) and their immune system (bacterial killing ability) less affected by NaCl than newts located upstream. Thus, adaptation to salt can occur in this amphibian species, and such adaptive potential may be more common than originally thought. We provide some preliminary evidence, however, that the affect of salt on newts may interact with other environmental factors, namely temperature, with possible consequences for the adaptive potential of amphibian populations in a warming world.

13.6 HOPKINS, WA*; DURANT, SE; MOSER, WE; DAVIS, AK; ROMERO, LM; Virginia Tech, Oklahoma State, Smithsonian, Univ of Georgia, Tufts Univ; *hopkinsw@vt.edu*

Incidence of endo− and ecto−parasitism and its influence on the physiology of eastern hellbenders

The hellbender (*Cryptobranchus alleganiensis*) is one of the largest amphibians in the world and among the most imperiled amphibians in North America. Although habitat degradation is probably the biggest threat to hellbender populations, recent evidence suggests that pathogens including chytrid fungus and flesh−eating bacteria may also contribute to declines. Leeches, which are very common in Ozark hellbenders, have recently been implicated as possible vectors of disease among Ozark hellbenders but have not been described in eastern hellbenders. While conducting surveys in southwest VA, USA we recently discovered a new species of leech (*Placobdella* sp.) on hellbenders in one of our study streams. We also described an unknown species of trypanosome to be widespread within this same hellbender population. To determine whether there are physiological consequences of parasitism in hellbenders, we measured corticosterone and white blood cell counts in response to capture, handling, and injection with ACTH or saline for up to 50 h post capture. The presence of leeches significantly dampened corticosterone responses to capture. Injection with ACTH restored the normal interrenal responses of hellbenders suggesting that leeches cause down−regulation of corticosterone release at the level of the pituitary or higher. Hellbenders with leeches also had a higher percentage of eosinophils than hellbenders without leeches. In contrast to leech infection, trypanosome infection did not affect any aspect of hellbender physiology we measured. Our findings reveal an important physiological consequence of leech infection that has have not previously been documented in animals.

S3.1−2 HORNE−BADOVINAC, Sally; The University of Chicago; *shorne@uchicago.edu*

Mechanisms of egg chamber elongation in Drosophila

During development, discrete organs and entire body plans emerge from the coordinate actions of individual cells. These complex morphogenetic events require dynamic regulation of cell shape, polarity, and adhesion across cell populations. My lab seeks to understand how these diverse cellular behaviors are orchestrated to produce an organ's functional shape. To this end, we are using the Drosophila egg chamber as a highly tractable system to investigate the cellular control of morphogenesis. Egg chambers are multicellular structures within fly ovaries that will each give rise to a single egg. They are composed of an inner germ cell cluster surrounded by an outer epithelial layer of follicle cells. The follicle cells secrete a basement membrane ECM that forms the egg chamber's outer most layer. Though initially spherical, egg chambers lengthen as they develop. This morphogenesis depends on an unusual form of planar polarity, in which linear actin bundles at the basal follicle cell surfaces become aligned orthogonal to the elongation axis. Once oriented, the follicle cells undergo a directed migration along the inner basement membrane surface, a process that causes the entire egg chamber to rotate inside the stationary matrix. Importantly, the migrating follicle cells also secrete new basement proteins. Through a process that is still poorly understood, the combination of cell movement and matrix secretion creates fibril−like structures in the BM, perpendicular to the elongation axis. It has been proposed that this fibrillar matrix then constrains isometric egg chamber growth to promote axial elongation. In this talk, I will explore the relationship between follicle cell planar polarity, the fibrillar basement membrane and collective cell migration.

39.6 HORNER, AM*; MOURADIAN, G; GROGAN, S; ROBERTS, TJ; Cal State San Bernardino, Brown University; *anghorner@gmail.com*

Does advanced age alter in vivo muscle operating length?

Advanced aging is associated with muscle weakness, stiffness, and decreasing joint range of motion. The operating lengths used by aged muscle *in vivo* may be impacted by these sarcopenic changes. Because the proportion of passive force to total force increases in aged muscle, muscles operating at relatively longer lengths may mitigate the loss of active force by contributions of passive force. In order to test this we 1) characterized the *in vivo* length behavior of aged (30−32 mos) and young adult (7 mos) rat medial gastrocnemius muscles, and 2) compared *in vivo* lengths to *in situ* force−length properties of the isolated muscle. *In vivo* muscle lengths were measured via small (< 1.0 mm) radio−opaque beads surgically implanted into individual muscle fascicles in the medial gastrocnemius. The bead positions were determined using high−speed x−ray videography (fluoromicrometry) during locomotion across a range of speeds on level, 30 degree inclined, and 30 degree declined trackways. Directly following locomotor measurements, animals were anesthetized and the passive and active force−length properties of the muscle were recorded *in situ* via fluoromicrometry synchronized with a muscle ergometer. Rats in both age groups demonstrated operating lengths that crossed the plateau region of the active force−length curve.There was considerable variation in passive muscle stiffness but rats of both age groups consistently demonstrated *in vivo* operating lengths shorter than lengths at which passive stiffness would contribute significant force

P3.152 HORNS, J.J.*; JUNG, R.; CARRIER, D.R.; Univ. of Utah, Salt Lake City; *jjhorns@gmail.com*

Testing the protective buttressing hypothesis of hominin hand proportions.

In comparison to other apes, hominins have short palms and fingers (i.e., digits 2−5), but long, strong and mobile thumbs. These characters are thought to have evolved in response to selection for enhanced manual manipulation. Recently, we have suggested that another factor that may have influenced the evolution of hominin hand proportions is sexual selection for improved striking performance during hand−to−hand combat by males. The bones of hominin hands are proportioned in a way that may provide supportive buttressing that protects the hand from injury when striking with a fist. To test the hypothesis of protective buttressing we measured the strain experienced by the second metacarpal of 3 human cadaver arms during striking with buttressed (normal) and unbuttressed fist postures. Cadaver arms were mounted on a frame that allowed adjustment of the tension of the various muscles of the hand and wrist. This allowed us to modify the posture of the hand. The frame on which the arm was mounted swung as a pendulum and the hand struck a mass instrumented with an accelerometer; providing a measure of the impact force. These recordings show that the dorsal surface of the second metacarpal undergoes tensile strain during the impact of a punch. This is consistent with the bone being loaded primarily in bending, rather than compression. Most importantly, striking with a buttressed fist decreased the strain experienced by the metacarpal. At the highest striking forces, peak principle strains were 50 to 80% greater in the unbuttressed posture than in the buttressed posture. These results are consistent with the hypothesis that the human fist provides protective buttressing of the musculoskeletal elements of the hand.

29.2 HOWARD, CM*; LUTTERSCHMIDT, DI; Portland State University; *chow@pdx.edu*

Sex and seasonal differences in the effects of melatonin on brain arginine vasotocin: Relationship to melatonin receptor type 1a immunoreactivity in green treefrogs (Hyla cinerea)

Melatonin (MEL) modulates arginine vasotocin (AVT) immunoreactive (ir) cell number in the brain of green treefrogs (*Hyla cinerea*) during the summer breeding season, and this modulation is sexually dimorphic. In this study, we asked if MEL's influence on AVT varies seasonally. We show that treatment of nonreproductive frogs with MEL−filled silastic implants for 4 wks during the winter does not alter AVT−ir cell number in any brain region (i.e., nucleus accumbens, amygdala, preoptic area, hypothalamus, or suprachiasmatic nucleus). These results suggest that MEL's influence on AVT is associated with sex and seasonal variation in melatonin receptor expression. We tested this hypothesis by using immunohistochemistry to characterize the distribution of MEL type 1a receptor (MEL1a−R) in the brain of reproductive and nonreproductive male and female frogs. We quantified MEL1a−R−ir cell number in regions known to contain AVT cell populations. When boundaries between regions were unclear, they were combined for statistical analysis. During the breeding season, frogs had significantly more MEL1a−R−ir cells than nonreproductive frogs in all brain regions, including the combined nucleus accumbens, diagonal band of Broca and septum ($p = 0.031$), striatum ($p = 0.020$), amygdala ($p < 0.001$), pre−optic area and suprachiasmatic nucleus ($p < 0.001$), and caudal hypothalamus ($p < 0.001$). In the accumbens region, where MEL's effect on AVT is known to be sexually dimorphic, males had significantly more MEL1a−R−ir cells than females during the summer breeding season ($p = 0.014$). These results suggest that variation in MEL1a−R expression mediates both sex and seasonal differences in the sensitivity of AVT neurons to MEL signaling.

P3.123 HOWARD, C.A.K*; HOLLAND, B.S.; University of Hawaii at Manoa; *cierrah@hawaii.edu*

Comparative Performance of an Endemic Oahu snail (Auriculella sp.) in Native versus NonNative Host Plants

Although Hawaiian snails generally occur only on native plants, a single population has been observed in nonnative ginger and jasmine. We tested laboratory performance (survival and reproduction) on different plant species for an endemic Hawaiian snail, in 3 phases, each run for a period of 3 months. In *Phase I*, groups of 10 *Auriculella* sp. were placed in five cages. In two (native cages) we placed native plants, ohia (*Metrosideros polymorpha*) and i'e i'e (*Freycinetia arborea*), while the other two treatment cages (nonnative cages) contained nonnative plants white ginger (*Hedychium coronarium*) and jasmine (*Cestrum nocturnum*). A fifth cage was set as a control with both native and nonnative plants plus cultured leaf fungus. Cages were regularly cleaned, vegetation replaced, and eggs counted. To compare reproduction and survival of juveniles from different host plants, eggs were collected, and incubated at two different temperatures. Incubation time, hatch rate, and survival of juveniles from native versus nonnative cages were recorded. In *Phase II*, host plant composition of native and nonnative cages was reversed, to account for variation in fecundity. In *Phase III* we tested performance on different individual host plants by separation into four cages, each with a single host plant (ohia, i'e i'e, ginger, or jasmine). We then tested for statistically significant differences among treatments. Preliminary results suggest that snails in native cages produced about 20 times more eggs than those in nonnative cages, innate variation in fecundity did not account for differential reproductive output observed, and jasmine is a superior host plant than ginger. Our results have implications for conservation of rare Hawaiian snails, including captive propagation strategies.

P1.27 HRISTOV, NI*; ALLEN, LC; Center for Design Innovation, Winston−Salem State University;
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Bats and Caves in Three Dimensions: Advanced Methods for the Study of Bat Roost Biology
Organisms do not exist in isolation; rather, they are immersed in and constantly interact with their surroundings. Understanding the physical properties of the environment is thus important because such data provide useful understanding of the complexity of the natural world and the spatial arrangement of organisms in it. In studying cave roosting bats, much effort to date has been dedicated to recording cave conditions, colony size or physiological responses of the bats to infer roost suitability. Currently, there is little understanding of how these and other variables may be affected by the morphology of the caves. Existing survey techniques are tedious, slow and can pose a disturbance risk to bats or require extensive expertise in surveying that might not scale well to biological measures of interest. New methods, therefore, are needed for the effective collection, analysis and visualization of such data. Long−range laser scanning provides a promising solution to the challenges of traditional cave surveying by capturing the three−dimensional environment in stunning accuracy using non−contact measurements. The goal of this work is to reconstruct in detail the six largest natural roosts of Brazilian free−tailed bats in south−central US. Here we present preliminary results from three of the six sites. The data to date include the largest cave by size, largest colony and smallest cave and colony sizes. The preliminary analysis indicates that there is no relationship between the basic morphometric properties of the caves and the size of the bat colonies. These findings suggest that other variables such as proximity to food or other cave properties or conditions likely determine the size of the resident colonies.

S10.2−5 HU, David*; DICKERSON, Andrew; YANG, Patricia; Georgia Institute of Technology; *hu@me.gatech.edu*
To eject a drop, from wet−dog shaking to urination
Animals frequently expel fluids from both their surfaces and inside their bodies. Undesired fluids include include rain and dew, accumulated on their surfaces, as well as the products of metabolism from within their bladder. As animals decrease in size, the specific forces required becomes larger due to surface tension forces. In this presentation, we review the fluid−ejection methods used by animals across scale. We demonstrate mammals shake at tuned frequencies to dry their fur, generating 10 − 70 times earth's gravity. Smaller flying insects remove accumulated water drops by performing controlled falls or by vibrating their wings at twice the frequencies of in−flight flapping. To urinate, small animals such as rats use dripping, while large mammals such as elephants use jetting. We report urination duration is independent of animal size among animals that use jetting. We rationalize urination styles, along with the constant−time scaling, by consideration of the relative magnitudes of the driving forces, gravity and bladder pressure, and resisting forces including viscosity and surface tension.

123.3 HU, Y.*; ALBERTSON, R.C.; UMass−Amherst;
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Hedgehog signaling mediates adaptive variation in a complex functional system in the cichlid skull
Adaptive variation in the craniofacial skeleton is a key component of resource specialization and divergence in vertebrates, but the genetic mechanisms that underlie complex patterns of craniofacial variation are largely unknown. In this study we show that pleiotropic effects of the hedgehog pathway receptor Patched1 (ptch1) mediate variation in a complex functional system in Lake Malawi cichlids. The opercular 4−bar linkage apparatus is a well−known anatomical unit that participates in lower jaw depression in teleost fishes. In general terms, species that feed from the water column possess 4−bar systems characterized by high kinematic transmission (KT) and fast jaw movements, whereas species that forage from the benthos possess systems with relatively lower KT and slow but powerful jaw rotation. We demonstrate here that ptch1 influences the development of the retroarticular (RA) process and the interopercle (IOP) bone, which in turn alters three out of the four links in the opercular 4−bar system. Specifically, the evolutionarily derived ptch1 allele is associated with the development of a shorter RA and relatively narrower, longer IOP. In functional terms, these shifts in anatomy translate to a 4−bar system with a higher KT (fast and weak). Alternatively, the ancestral allele is associated with the development of a longer RA and relatively wider, shorter IOP that translates to a lower KT (slower and powerful). These results provide the first empirical support for genetic variation at a single locus mediating widespread variation in a complex functional system. Moreover, they offer Hedgehog signaling as a specific link between developmental and functional integration, shedding new light on the mechanisms that promote craniofacial variability in these fishes.

P3.125 HUANG, X.*; CHOW, M.H.; MANCIA, S.I.; MCMILLAN, B.; JACOBS, M.W.; McDaniel College, Bryn Mawr School;
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Effects of Hiking Trails on Soil Invertebrate Abundance, Taxonomic Richness, and Biodiversity
Hiking trails are often described as low−impact, but may significantly change the physical characteristics of soil habitats. Soil in and around hiking trails is more compacted, dryer, and has lower vegetative cover than surrounding soil, which may significantly impact communities of soil−dwelling organisms. We analyzed the effects of hiking trails on soil invertebrate abundance, taxonomic richness, and biodiversity by (1) comparing soil communities in the path to adjacent off−path communities, and (2) testing whether the presence of a path affected spatial change in soil community along a gradient away from a stream. We found that hiking paths strongly impacted soil invertebrate communities: invertebrate abundance, taxonomic richness, and biodiversity were significantly lower at path locations compared to adjacent off−path locations. This suggests that soil compaction in trails reduces habitat suitability for soil invertebrates. Although our results do not support the hypothesis that the hiking path acted as a barrier to the migration of soil invertebrates, we cannot reject the hypothesis because we also did not find evidence of any community gradient away from the stream. More research is needed to determine whether hiking paths act as barriers to the movement of soil invertebrates along environmental gradients.

110.3 HUBEL, TY*; CURTIN, NA; WOLEDGE, RC; WEST, T; WILSON, AM; Royal Veterinary College, London, UK; *thubel@rvc.ac.uk*

Muscle power in predator and prey species

Cheetahs and greyhounds are know for their ability to run at exceptional high speeds and manoeuvre for prey capture. But how exceptional is that performance and how does it compare to the prey species they hunt? Muscle power or ability to deliver that power to the center of mass (e.g. grip, musculoskeletal gearing or pitch stability) might be the prevailing factor in limiting acceleration. Here we focus on the acceleration performance and associated muscle power output of two predator species cheetah and greyhound and two prey species, rabbit and hare. We measure the acceleration performance of predators using a GPS−IMU wildlife collar and calculate stride and stance average muscle power from velocity and acceleration data and stance times. Equivalent data for prey are derived from video and force platform measurements. These are compared with measures of muscle power made in vitro in our laboratory. Pilot data for predator and prey acceleration performance and power were similar suggesting that the "performance arms race" might be mainly constrained by factors other than muscle power and acceleration and that grip, turning initiation and manoeuvring or other skills such as detection may be critical in determining hunt outcome.

122.2 HUBICKI, C*; SPROEWITZ, A; HURST, J; DALEY, M; Oregon State University, Royal Veterinary College; *hubickic@onid.orst.edu*

Ground−bird running in non−rigid terrain: deducing task−level priorities in locomotion

Terrestrial animals including ground birds regularly traverse terrain of irregular geometry and rigidity. We postulate that these diverse behaviors are unified at their foundation by task−level priorities based on the fundamental mechanical demands and functional limits of locomotion. We refer to these as *task−level goals* or *control priorities*. In prior work, behavior of ground birds in uneven rigid terrain suggested musculoskeletal injury avoidance and energy minimization as key task−level priorities. We also discovered a simple leg model that fits data across species. Building on these findings, we aim to quantitatively predict animal locomotor behavior in novel terrain scenarios. We probe the control priorities of running birds by leveraging both animal experiments and model analysis via optimal control. We run birds over a plannable perturbation, i.e. non−rigid ground, challenging hypothesized task−level priorities by provoking potential tradeoffs. To test for a stability−economy tradeoff, we collect motion−capture, force−plate, and high−speed video data of helmeted guinea fowl (*Numida meleagris*) running over non−rigid surfaces (sand, elastic foam, damped foam). We assess hypothesized priorities by comparing observed behavior to computed optimal trajectories. Our ongoing analysis aims to reveal deviations in strategy with differing ground properties, signaling tradeoffs between energy economy and stability (and not injury). Preliminary optimizations predict that work−optimal running on elastic terrain prolongs stance time, but maximally stable gaits do not. This work, combined with our prior analyses, will help reveal if steady and unsteady locomotion are governed by the same task−level priorities.

S7.3−1 HUGHES, DP; Penn State ; *dhughes@psu.edu*

Reconstructing the evolutionary history of behavioral manipulation

In this talk I will consider when parasites evolved the ability to manipulate behavior. It is a rare phenomenon when we recall that half of all life is parasitic and that only a few of them manipulate behavior. So, why did some evolve to do it? And do we have any hope reconstructing the evolutionary pathways? In this talk I suggest we can and detail our own work in fungi that control ant behavior

P1.209 HULETT, R.E.*; GOSLINER, T.M.; California Academy of Sciences/San Francisco State University, California Academy of Sciences; *rhulett@calacademy.org*

Rooting for Clarity: A Phylogenetic Reconstruction of the Nudibranch Family Tritoniidae

Nudibranchs are vibrant marine gastropods that have a muddled evolutionary history. Classifications were previously based on morphological characters; however, there are instances where physical features fail to correctly discern these organisms. Morphology does not always reflect true relatedness, as there are plenty of instances where nudibranchs look similar but vary genetically; however, these organisms can be resolved using mitochondrial and nuclear genes. Little is known about the evolutionary history of nudibranchs and it is important to tease out these relationships and clarify evolutionary lineages in order to assess the overall biodiversity in marine systems and to lay the foundation for future work with these organisms. The Nudibranch family Tritoniidae requires molecular data to accurately construct robust phylogenetic relationships. I will analyze the following gene fragments: COI (Cytochrome Oxidase Subunit I), 16S, 28S, and H3 (Histone 3) to reconstruct evolutionary relationships within the family. Using the concatenated sequences, I will perform parsimony bootstrap analyses, maximum likelihood analyses, and Bayesian analyses, which will result in the construction of well−supported clades and provide a robust framework for future studies pertaining to biodiversity assessment, fisheries management, and coevolution. I have increased taxon sampling and expanded on genetic markers that were lacking in previous studies, which allows me to accurately assess the genera, survey diversity, and map characteristics to uncover major events in Tritoniid evolution.

7.1 HULSEY, CD*; HOLZMAN, R; Univ. of Tennessee, Knoxville, Tel Aviv University, Israel; *chulsey@utk.edu*
Mechanical Transgressive Segregation and the Rapid Origin of Trophic Novelty
Hybrid phenotypes often fall within the parental range. However, when morphological traits are complex,hybridization can generate mechanical phenotypes that segregate transgressively. For instance, even when the morphologies of individual musculo−skeletal components forming a complex functional system do not segregate outside the parental range in hybrid offspring, these systems can exhibit emergent phenotypes whose mechanics do transgress parental values. We examined three functional systems in the trophic apparatus of Lake Malawi cichlids to determine both the frequency of mechanical transgression segregation during hybridization and how the evolutionary divergence of parental species influences mechanical transgression. Generally, when genetic mechanisms underlie transgressive segregation, hybrids between more evolutionarily divergent species show greater transgression. However, two of the mechanical systems in the trophic apparatus exhibited a greater proportion of transgressive phenotypes in crosses between more recently diverged cichlid species. Hybridization does occur in the hundreds of co−occurring species and virtually every lineage we used in the simulations produced hybrids with transgressive mechanics. Therefore, mechanical transgressive segregation has likely helped shape the exceptional trophic diversity of the Lake Malawi cichlid radiation.

P3.190 HUMBEL, E.*; REITZEL, A.M.; University of North Carolina, Charlotte; *ehumbel@uncc.edu*
Role of light wavelength in the circadian entrainment of the starlet sea anemone, Nematostella vectensis
Circadian clocks play an integral role for regulating diel oscillations in animal behavior and are generally entrained by light in the visible spectrum. At the molecular level, bilaterian clocks are in part regulated by light−induced degradation of particular proteins, particularly the blue−light−sensitive cryptochromes, a class of flavoproteins. Recent studies have shown that cnidarians, including the sea anemone *Nematostella vectensis*, have circadian behavior and conserved molecular and functional components of the circadian clock similar to those of bilaterians, including insects and vertebrates. In addition, expression of genes presumably involved in cnidarian clocks is differentially regulated depending on the spectral qualities of the environment. Here we report results describing the role of isolated portions of the light spectrum on the entrainment of *Nematostella*'s behavior. Using programmable LED lighting paired with behavior−monitoring software , we quantified individual movements in response to light:dark cycles, in which various wavelengths were tested. Our results indicate that the anemone circadian clock is differentially entrained by isolated portions of the light spectrum, providing evidence for additional conserved components of the cnidarian clock with those of bilaterians.

68.5 HUMEAU, A.*; CASAS, J.; Institut de Recherche sur la Biologie de l'Insecte, Université de Tours, CNRS, France; *ant.humeau@wanadoo.fr*
Why is the antlion trap a trap? Comparing the locomotion of ants on two media with different slope and roughness
Some predatory antlion larvae (Neuroptera: Myrmeleontidae) build an unstable conical trap in sand and wait at the bottom for arthropods to fall down. This trap can efficiently retain prey but the causes are poorly understood. The trap, compared to the simplest surface, suggests that three factors make the locomotion of prey harder; the type, the slope and the roughness of the medium. The aim of this study was to distinguish their relative impacts on the locomotion of prey. Because ants are the main prey of antlion larvae, the locomotion of the ant *Aphaenogaster subterranea* walking on a combination of the three factors was described. We compared a granular and a solid medium, respectively a Fontainebleau sand and a glass. We also compared a flat surface and a slope of around 37 °. Finally, the smoothness of glass was compared with the roughness of sand. Locomotion was characterized by global trajectory parameters, like the sinuosity and the velocity, as well as by gait parameters like the duty factor and the stride length.

71.2 HUMFELD, SA*; THOMETZ, B; GERHARDT, HC; University of Missouri; *humfelds@missouri.edu*
Advertisement−call novelties in the frequency domain are not favored by stimulation of an untapped inner−ear organ
The pre−existing sensory bias hypothesis predicts that novel signals providing greater sensory stimulation are favored by sexual selection. Frogs have two sensory organs in the inner ear that are sensitive to different frequency ranges: the basilar papilla (BP) (>1000 Hz) and the amphibian papilla (AP) (<1000 Hz). Many frog species produce high−frequency calls that only stimulate the BP, leading to the prediction that females of these species should prefer signals which stimulate the AP. In one of these, we tested whether spectral complexity in the frequency domain is favored by female preferences for call novelties containing low−frequency energy that stimulates the AP. We tested preferences of spring peepers (*Pseudacris crucifer*) using two types of novel computer−synthesized calls in two−speaker forced−choice experiments: advertisement calls with a bimodal spectrum (normal waveform, novel spectrum); single−peaked advertisement calls to which an extra two−peaked call component was appended (novel waveform, novel spectrum). Females did not prefer or avoid the two−peaked advertisement call relative to a normal single−peaked call. However, when spectral complexity was utilized in a novel call component, some low−frequencies elicited significant positive or negative phonotactic preferences. Taken together with similar findings in other species, these results do not provide strong support for the hypothesis that spectral novelty is favored in species lacking low−frequency communication elements, but more comparative studies of AP function are badly needed.

93.5 HUNT, N/H*; MOON, H/S; HAMMOND, A; BURNETT, N/P; PRITCHARD−BERMAN, M; FULL, R/J; University of California, Berkeley; *nathaniel.hunt@berkeley.edu*
Stability of cockroaches running rapidly on rigid rods
Running on branches or rods represents a challenge relative to flat surfaces because stance width and stability can be limited. Cockroaches (*Periplaneta americana*) are highly adept arboreal locomotors, capable of fast running speeds on large branches to small stems. We investigated rapid running on horizontal rods ranging in diameter from 3.2−38.1mm. Cockroaches ran using both an upright orientation on top and an inverted orientation underneath the rods. They exhibited a gait transition from upright to inverted running as rod diameter was decreased with both modes being present at intermediate diameters. We defined gait transition frequency as the proportion of trials that animals transitioned from upright to inverted running. Gait transition frequency did not change abruptly over rod sizes, but gradated with a transition frequency inversely proportional to rod diameter. Surprisingly, animals ran nearly equally fast upside down on the smallest rod (39.0±12.2cm/s) as they did upright on the largest rod (32.9±11.6cm/s). As rod diameter was decreased below 12.7mm, sprawl angle became constrained, eventually violating conditions for passive mechanical stability and leading to a fixed point destabilization of upright running. With the presence of a transition deterrent below small rods, animals used sensory feedback to consistently maintain an upright orientation, indicating that the transition was a choice, not a necessity.

53.6 HUNT, K.E.*; INNIS, C.J.; MERIGO, C.; BURGESS, E.; New England Aquarium, Boston MA; *huntk@neaq.org*
To truck turtles or not to truck turtles: Assessing potential effects of transport stress on endangered Kemp's ridley sea turtles
Sea turtle rehabilitation clinics must occasionally transport sea turtles long distances, e.g. to release animals at certain beaches, but there is little information on the possible effects of transport stress on sea turtles. To assess whether transport stress is a clinically relevant concern, we obtained pre−transport and post−transport plasma samples from 73 juvenile Kemp's ridley sea turtles (*Lepidochelys kempii*) that were transported for 4h, 7h, 13h, or 24h from a sea turtle clinic to various sites for release to sea. To control for effects of handling and time of day, a subset of turtles were also studied on "control days", e.g. with two samples taken to mimic pre−transport and post−transport handling but with no transportation. Plasma samples were analyzed for corticosterone, pH, pCO_2, pO_2, sodium, potassium, ionized calcium, lactate, glucose, white blood cell count (WBC) and heterophil/lymphocyte (H/L) ratio. Mean corticosterone, glucose, WBC and H/L ratio all rose significantly after transportation, and also showed milder elevations on control days (e.g., probable effect of handling). Corticosterone elevations were only significant during the longest (24h) transport event, during which mean corticosterone rose 5x above baseline. Glucose elevations were strongly significant for all transport durations, though the elevated glucose usually remained within clinically normal bounds. WBC and H/L ratio both showed statistically significant, though clinically mild, effects of handling and of transport. Most other measures showed minimal changes. Generally, this species appears only mildly affected by transport stress, but transports approaching 24h duration may have more pronounced effects.

127.1 HURD, PL; University of Alberta; *phurd@ualberta.ca*
Does the development of cerebral lateralization play a role in the evolution of personality?
Cerebral lateralization, the disproportionate partitioning of tasks to one cerebral hemisphere or the other, appears to be ubiquitous among vertebrate species. Empirical work on non−human animals demonstrates some selective advantages to such lateralization. There appears to be, however considerable variation within species in the degree to which different individuals are lateralized. The maintenance of such variation is curious. Within humans, lateralization has long been associated with behavioural variation in sexually dimorphic behaviours, and specifically with variation in the development of traits thought to be linked to pre−natal testosterone exposure. I will discuss recent work in my lab examining the links between cerebral lateralization, behavioural traits such as boldness and aggression, variation in neurological structures, and life−history variation in a cichlid fish.

P1.144 HURLESS, V.H.*; ZELLER, R.W.; San Diego State University; *vhurless@mail.sdsu.edu*
Establishing RNAi in Ciona intestinalis to determine gene function during peripheral nervous system development
RNA interference, or RNAi, is a post−transcriptional process that regulates gene expression by silencing mRNA targets through degradation. RNA−induced silencing is mediated by base pairing of small RNA molecules, such as microRNAs, to their endogenous mRNA targets. Many studies incorporate the use of artificial microRNAs or siRNAs to silence genes to determine their function. Although, RNAi has been established in numerous model organisms, RNAi approaches have not yet been adapted and implemented in the marine invertebrate chordate *Ciona intestinalis*. Our lab has developed an innovative method to develop mRNA target−specific RNAi utilizing artificial microRNAs to knockdown genes of interest in *C. intestinalis*. Using this method, we have been successful in knocking down two genes that result in expected phenotypes, one of which displays a similar phenotype to a published null mutant. Refining this tool will allow for the widespread use of RNAi in *C. intestinalis* further demonstrating they are an ideal model for chordate development and genomics. In addition to establishing effective RNAi in *C. intestinalis*, my project goal is to utilize this tool to explore the epistatic relationship of regulatory genes involved in peripheral nervous system (PNS) development. Our lab has defined a gene regulatory network governing larval PNS sensory neurons and a Pou4 gene target list from RNA−sequencing data. Employing RNAi to knockdown these regulatory genes will elucidate their function and refine the PNS gene network.

67.5 HUSAK, J.F.*; SATHE, E.A.; Univ. of St. Thomas; *jerry.husak@stthomas.edu*

Maximal locomotor performance and sprint sensitivity in green anole lizards (Anolis carolinensis)

Locomotion is arguably one of the most important traits to the survival and reproductive success of animals and has been the subject of intense study for decades. However, locomotion is typically studied as maximal locomotor capacities measured in a standardized laboratory setting and is assumed to be significant to fitness. It is rare for studies to consider whether the performance traits being measured are relevant to the organism in nature and representative of what is likely to be the subject of selection. Since many animals live in complex environments and must move through them in a multitude of ecological contexts, it is critical to consider locomotor performance more broadly. Sprint sensitivity, a measure of how well individuals can perform on a variety of substrates, may in some cases be more important to fitness than any one measure of performance, but we know surprisingly little about sprint sensitivity or what morphological traits predict it. We measured locomotor performance of green anole lizards (*Anolis carolinensis*) on several different substrate sizes that fall within their normal range of use, comparing maximal speeds among them, as well as when navigating a surface with complex obstacles. We examined how maximal sprint speed differs among substrate sizes and whether individuals exhibited tradeoffs in locomotor ability on those substrates. We measured limb size and muscle morphology to determine the best morphological predictors of maximal speed on each substrate, as well as sprint sensitivity.

40.3 HUYGHE, K.*; VAN DAMME, R.; University of Antwerp, Belgium; *katleen.huyghe@uantwerpen.be*

Do dominance and attractiveness of the male guppy go hand−in−hand?

Sexual selection is driven by two mechanisms: male−male competition (intrasexual selection) and female mate choice (intersexual selection). These mechanisms are typically studied in isolation, and although they can be opposing, more often it is assumed that they are reinforcing. A two−fold approach was taken to compare the effects of artificial sexual selection on male traits in the guppy, *Poecilia reticulata*. We conducted male−male competition, and female mate choice experiments on a large number of individuals to determine the importance of male traits in assessing male dominance on one hand, and male attractiveness on the other hand. Phenotypic traits included size, number and colour of spots, melanic pigmentation, and a proxy for aggressiveness. Dominance and attractiveness experiments were organized using a tournament principle and extensive behavioural observations. The relative roles of the different traits in both mechanisms of sexual selection were quantified and discussed. Also, the outcome of the tournaments was linked to the variation in these traits.

76.2 HWANG, A.E.*; DAVIDSON, B.J.; Swarthmore College; *ahwang2@swarthmore.edu*

Functional conservation of heart−related enhancers in Ciona intestinalis and Corella inflata

Cis−regulatory elements (CREs) are responsible for regulating the timing and localization of gene expression. Orthologous CREs from widely disparate species can display conserved regulatory activity despite significant sequence variation. To investigate the evolutionary implications of robust regulatory elements, we have begun to explore functional conservation of heart lineage enhancers between two distantly related tunicate species, *Ciona intestinalis* and *Corella inflata*. Using characterized *Ciona* enhancers, we visualized reporter activity in *Corella* embryos with beta−galactosidase and immunofluorescent staining. Nearly all of the tested enhancers drove conserved patterns of reporter gene expression in *Corella*. Additionally, treatment of *Corella* embryos with the MEK inhibitor U0126 blocked the migration of the heart progenitor cells, indicating that the FGF/Map Kinase dependent induction of progenitor migration, as characterized in *Ciona*, is conserved in *Corella*. Our findings suggest that the regulatory network underlying heart progenitor specification may be functionally conserved between these species. We plan to further explore relationships between CRE function and architecture in the development of the tunicate heart and the role that enhancer evolution might play in key morphological changes, such as heart progenitor cell migration and post−larval heart formation.

P1.99 IKMI, A.*; HACKER, J.; GIBSON, M.C.; Stowers Institute for Medical Research, Kansas City; *aik@stowers.org*

Inducible gene expression in the sea anemone Nematostella vectensis

The cnidarian *Nemtostella vectensis* is an emerging model organism critical for comparative and evolutionary developmental biology. Within the last few years, genetic tools such as mRNA injection and morpholino−mediated gene knockdown have been employed to investigate the functions of genes during early embryonic development. However, no tools exist for inducible gene expression, which would be highly useful to study the function of genes at post−embryonic stages. Here we report the identification and cloning of heat shock promoters (hsp) from *Nematostella* and show that an increase in ambient temperature can activate these promoters to trigger expression of the reporter green fluorescent protein gene. Out of five candidates for hsp promoters, two activate GFP expression after heat shock with induction intensities ranging from weak to strong. Using meganuclease I−SceI mediated transgenesis, we also show that these hsp promoters can be induced at different developmental stages. Thus, this method allows for temporally regulated gene expression in *Nematostella* and will provide new opportunities for studying gene function at later developmental stages.

123.1 INFANTE, C.R.*; PARK, S.; MIHALA, A.; MENKE, D.B.; University of Georgia; *cinfante@uga.edu*

Using ChIP−Seq to identify limb enhancers in the lizard genus Anolis

The vertebrate limb is a classic model for studies of signaling and patterning in developmental biology. Although many important pathways have been identified, the regulatory interactions that drive the development of this complex system are still largely unknown. With advances in technology a global understanding of these interactions is now possible, even in non−model organisms. To discover limb enhancers that may not be highly conserved in the genome, we performed ChIP−Seq on embryonic tissues from the lizard *Anolis carolinensis* using antibodies against the acetylated histone mark H3K27ac and the hindlimb transcription factor Pitx1. Comparisons between these ChIP−Seq datasets enabled us to identify enhancers active only in the forelimbs, only in the hindlimbs, or that are shared between them. Additionally, we compared these datasets to similar data from developing mouse tissues to examine the rate of conservation or turnover at these sites. In the future we hope to use the enhancer lists derived from these data to study the evolution of the the cis−regulatory control of limb development and morphology within the genus *Anolis*.

56.7 IRIARTE−DIAZ, J.*; ROSS, C.F.; Univ. of Chicago; *josdiiri@gmail.com*

Can we predict mandibular kinematics from patterns of EMG activity in primates?

The muscular system that controls mandible movement in mammals is highly redundant and morphologically complex. For example, for a particular mandibular motion, there are multiple ways that a set of muscles can be activated to produce a desired movement. However, little work has quantitatively evaluated how differences in patterns of muscle activation relate to differences in mandibular movement. Using a large dataset of simultaneously recorded 3D mandible kinematics and muscle activation patterns, we investigated the relationship between these factors in three species of non−human primates (macaques, capuchin monkeys, and baboons). We found that each species studied used different strategies to modulate lateral mandible displacement. Capuchin monkeys used differences in timing and magnitude of activity between working− and balancing−side muscles. Baboons used differences in magnitude but not in timing of muscle activity. Macaques presented strong differences between individuals in their modulation of lateral mandible movement, with some individual using differences in timing of activity while other individuals used differences in magnitude of activity between working and balancing side. After controlling for these confounding effects we found weak but significant relationships between the timing of peak muscle activity and magnitude between working and balancing sides and the amount of lateral displacement during feeding. We suggest that mandible kinematics can be predicted from patterns of EMG activity. However, to further improve our understanding of motor control during feeding in primates, we still need to investigate how species−specific and individual differences in morphological and physiological constraints, such as differences in articular morphology or muscle architecture, affect the modulation of mandibular movement.

45.3 IRSCHICK, DJ*; HARTOG, K; ESCONTRELA, D; HAMMERSCHLAG, N; University of Massachusetts at Amherst, Rosenstiel School of Marine and Atmospheric Science, University of Miami; *irschick@bio.umass.edu*

New methods for assessing scaling and body condition in several shark species

Sharks represent one of the most important apex predators in marine ecosystems, yet relatively little is known regarding how body shape scales with size in various species, especially large species (e.g., Tiger Sharks). One of the primary limitations is the lack of museum specimens for a wide range of shark specimens of various sizes, which therefore limits the ability of scientists to analyze variation in body shape. Further, there are no established methods for assessing condition in sharks, despite the obvious importance of this measure for a wide range of ecological questions, and for conservation more generally. For example, recent studies have shown that large apex sharks migrate long distances into deep ocean waters, yet there is little work addressing how variation in condition among different individuals translates into variation in the ability to move long distances. We developed methods for measuring various kinds of body and fin shape from a range of individuals of different sizes for four different shark species captured live, and then released (Tiger shark, Bull shark, Blacktip shark, and Reef shark). We show how scaling with size in various fin and body shape measures differs dramatically among these different species, and we also present a new method for measuring condition in these sharks, which we believe could be widely used in the broader arena of marine ecology and conversation.

128.5 IRVINE, SQ*; STEPHENS, CE; Unv. of Rhode Island; *steven.irvine@uri.edu*

Development in the invasive colonial ascidian Didemnum vexillum

D. vexillum is an encrusting invasive colonial tunicate. It shares a peculiar form of asexual development, called pyloric budding, with other didemnid ascidians. In pyloric budding two buds form on the esophagus. One bud forms a new thorax (siphons and branchial basket), while the other forms a new abdomen (digestive tract, heart and gonads). Curiously, the thoracic bud combines with the parent thorax to form a new zooid, while the thoracic bud combines with the parent abdomen. We have employed histochemistry and confocal microscopy to examine this asexual development in detail. The aim is to determine whether the particular form of budding in this species can help explain its prodigious invasiveness.

126.1 JACKSON, BE*; HEDRICK, TL; Skidmore College, Univ. North Carolina, Chapel Hill; *bjackson@skidmore.edu*

Extending the U: Power estimates of Cliff Swallow low−speed flight and hovering in the field

Most of our understanding of animal locomotion biomechanics comes from examining a limited set of behaviors in laboratory settings. For example, the costs and mechanisms of bird flight have been described from wind−tunnel studies and indicate a *U*−shaped curve for flight power versus speed. However, most experimental or theoretical curves treat low speed flight (< *ca.* 3 ms^{-1}) as a black box, either because our understanding of wing function at low speeds is limited, or because most birds refuse to fly at low speeds in laboratory settings. We recorded Cliff Swallows (*Petrochelidon pyrrhonota*) in the field approaching, departing, and hovering near nests with three synchronized high−speed cameras, and used a new structure−from−motion rapid camera calibration technique designed for the field to measure three−dimensional kinematics of the birds' bodies and wings. Our kinematics−based analysis indicates that the power required for such flight is substantially higher than published power curves at more moderate flight speeds, but well within the likely capacity of the flight muscles. The birds met the high power requirements with geometrically maximal stroke amplitudes, high wingbeat frequencies, high angles of attack, and increased lift coefficients compared to cruising flight speeds. However, power was statistically invariant across these low speeds (0−3 ms^{-1}). This suggests that the left edge of the *U*−shaped power curve, at least in cliff swallows, may be a dramatically high plateau rather than a smooth continuation of the *U*. Such findings, along with our other quantitative field investigations of swallow flight behavior provide substantial new insight into the biomechanics of avian flight. Supported by Office of Naval Research MURI (ONR N000141010952).

117.3 JACOBS, L/E*; ROBERTSON, J/M; VEGA, A; California State university, Northridge, AMBICOR Database Costa Rica; *ljacobs815@gmail.com*

Female Mate Choice in Divergent Populations of Red−Eyed Treefrogs

Behavioral isolation can reinforce the divergence of natural populations. Populations of the red−eyed treefrog (*Agalychnis callidryas()* in Costa Rica show high levels of genetic diversification and substantial variation in body size and color pattern. We conducted mate choice experiments at two sites in Costa Rica (Atlantic and Pacific) to determine whether these differences have consequences for mate recognition. At each site, we introduced a gravid female into an enclosure that contained one local and one non−local male. We determined that a choice' was made when the female approached and displayed to a male. We also quantified latency to choice (seconds) and whether males called prior to female choice. We conducted 20 trials at each site. Females from the Pacific showed local mate preference (X_2= 7.70P = 0.005) while Atlantic females did not (X_2= 1.82P = 0.176). Latency to choice did not differ between local and non−local males for either population. Males called during some trials (25 and 30%, for the Pacific and Atlantic, respectively), but not all. Further, at the Pacific site, female choice for the non−local male was never preceded by a male call. Our study did not explicitly test for the mechanisms that underlie female choice. However, we explore multi−modal signalling in this system and discuss how population divergence in body size, color pattern and behavior could contribute to female choice. Our mate choice trials provide evidence that population divergence could be mediated by social interactions and that these divergent populations could be in the early stages of incipient speciation.

P1.48 JAECKLE, W.*; PERNET, B.; Illinois Wesleyan Univ., Bloomington, California State Univ., Long Beach; *wjaeckle@iwu.edu*

Can the feeding larvae of marine invertebrates capture bacteria−sized particles by drinking?

The feeding larvae of some marine invertebrates ingest bacteria−sized (91 µm) particles, but little is known of the physical mechanism(s) of particle capture. To examine the possibility that larvae collect these particles by ingesting seawater, we compared drinking and particle clearance rates of veligers of *Crepidula onyx* and bipinnariae of *Patiria miniata*. Drinking was measured as the fluorescence of individuals or pairs of larvae after ≤20 min exposure to FITC−labelled dextran, and clearance rates were estimated from the number of 0.45 µm polystyrene beads ingested after 10 min incubation in a bead suspension. Fluorescence of larvae generally reached stasis within the first 10 min of exposure; epifluorescence microscopy confirmed the label was localized to the digestive system. Veligers ingested seawater at an average maximal rate of H24 nL/h, and cleared 0.45 µm beads at a mean rate of 231 nL/h; bipinnariae swallowed seawater at an average maximal rate of H26 nL/h, and cleared 0.45 µm beads at a mean rate of 35 nL/h. These data suggest that bipinnariae might capture bacteria−sized particles simply by drinking seawater and retaining ingested particles in their guts, but veligers must also concentrate these particles by some other mechanism (presumably using velar cilia). Gut volumes averaged H1 nL (*C. onyx*) and 10 nL (*P. miniata*), suggesting that if drinking is continuous, the gut of *C. onyx* would be flushed H24 times/h, and that of *P. miniata* H3 times/h. This has important implications for our understanding of how particulate foods are digested and assimilated by larvae. A rapid flow of seawater through the digestive system may also provide opportunities for larvae to assimilate dissolved organic materials present in this flow across the gastric epithelium.

81.1 JAFFE, A.L.*; HADDOCK, S.H.D; Harvard University, Monterey Bay Aquarium Research Institute; *alexanderjaffe@college.harvard.edu*

Time series analysis and visualization of midwater zooplankton ecology: Automating long−term studies of the VARS dataset

This study uses multi−decadal time series from the Monterey Bay Aquarium Research Institute's unique VARS database to illustrate spatio−temporal patterns of abundance in mesopelagic zooplankton. *In situ* observations from approximately 900 ROV dives over 25 years reveal both long−term annual and short−term seasonal fluctuations in abundance and diversity of these organisms, which have been largely understudied. Correlations between normalized data for midwater siphonophores, krill, and ctenophores indicated potential ecological relationships between taxa as well as sensitivity to oceanographic parameters like temperature, salinity, spiciness, and oxygen. We discuss evidence of niche partitioning between *Praya dubia* and *Resomia ornicephala*, as well as evidence of a bimodal distribution for the ctenophore *Bolinopsis infundibulum*. We also present trends in seasonality and periodicity within the context of environmental shift, and a method of reproduction for similar studies is set forth.

69.7 JAGNANDAN, K*; HIGHAM, TE; University of California, Riverside; *kevin.jagnandan@email.ucr.edu*

Lightening the load: Effects of tail autotomy and regeneration on locomotor mechanics in the leopard gecko.

Autotomy is an effective anti−predation strategy that involves the voluntary shedding of a non−vital body part in order to distract a predator and/or escape from its grasp. Although autotomy studies examining trade−offs often focus on how autotomy impacts running speed, climbing ability, and jumping, little is known about how losing and regenerating a tail affects the mechanics of locomotion. Leopard geckos (*Eublepharis macularius*) have large tails (22% of body mass) that are commonly autotomized. We hypothesize that rapidly losing this large caudal mass will shift the center of mass (CoM) anteriorly and increase hip height, pitching the body forward and causing passive changes in forelimb and hindlimb joint kinematics. Additionally, propulsive hindlimb ground reaction forces (GRF's) are expected to decrease with the loss of mass and then steadily increase as a new tail is regenerated, thus remaining constant relative to body mass. Tail morphology, CoM, 3D kinematics of the fore− and hindlimbs, and hindlimb GRF's (individual footfalls on a custom force plate) of 7 adult leopard geckos were examined as they walked on a level surface prior to autotomy and then at intervals for 22 weeks as the tails were regenerating. Although hip height does not appear to change following autotomy, there were unexpected differences in hindlimb and forelimb joint angles throughout a stride. Additionally, peak vertical GRF of the hindlimb (scaled relative to body mass) decreased following autotomy and did not begin to recover until regeneration of the tail began approximately 4 weeks later. Our results suggest an active locomotor response to tail loss and an increased relative contribution to propulsion by the forelimbs following autotomy. Supported by NSF IOS−1147043.

P3.189 JAMES, C.J.*; GALASSO, A.C.; MEYER−BERNSTEIN, E.L.; College of Charleston, College of Charleston ; *ccjames@g.cofc.edu*

The effect of a simulated tide on gene expression in the starlet sea anemone, Nematostella vectensis.

Animals display rhythms in physiology and behavior that are governed by a self−sustaining biological clock. External stimuli, such as light, serve to synchronize endogenous biological processes with the environment. Circadian rhythms are the most widely studied clock outputs, expressed as a 24 hr oscillation. In marine organisms, non−photic environmental cues such as hydrostatic pressure can also influence clock function. Circatidal rhythms generated in response to hydrostatic pressure are observed every 12.4 hrs, distinguishing them from the 24 circadian period. Circatidal rhythms in behavior have been observed in the marine Cnidarian *Nematostella vectensis* when exposed to a simulated tidal cycle. Unlike circadian rhythms, the molecular mechanisms underlying these rhythms remain unclear. We believe patterns of gene expression are responsible for these multiple frequency rhythms observed in the presence of a tidal cycle. To determine whether known circadian clock genes also underlie circatidal behavior, we will analyze gene expression in animals exposed to a simulated tide. Oscillation of these genes will be quantified at various time points and compared to gene expression under the influence of a light−dark cycle alone. We expect the addition of a simulated tidal cycle to a light−dark cycle to alter rhythms of circadian gene expression, demonstrating the ability of *N. vectensis* to respond to tidal cycling and further describing the molecular underpinnings of the biological clock.

P1.44 JAMES, WR*; WHITE, S; EARLEY, RL; Univ. of Alabama; *wrjames@crimson.ua.edu*

Developmental response to predator−related cues in Kryptolebias marmoratus

Exposure to environmental factors during early life can have potent effect on the development of the phenotype, but it can be difficult to disentangle the influences of genetic and environmental components that contribute to phenotypic variation within and among populations. The mangrove rivulus (*Kryptolebias marmoratus*) can self−fertilize to generate isogenic lineages, which provides the opportunity to explicitly resolve how the environment shapes phenotypic traits. Rivulus' ecology is not well understood, but the mangrove water snake is thought to be a major predator. Our study investigates the developmental response to predator−related cues in lineages derived from regions with and without snakes. We exposed individuals of four lineages from hatching until one month of age to cues from mangrove water snakes that had been fasted, fed rivulus, or fed heterospecifics. After exposure the individuals were tested for fear and boldness responses and photographed for geometric morphometric analysis. We hypothesized that the phenotypic response would vary among treatments and that lineages derived from areas with snakes would show a more pronounced behavioral and morphological response to predator−related cues than the lineages derived from areas without snakes.

78.6 JANZEN, F.J.*; JERGENSON, A.M.; MILLER, D.A.W.; NEUMAN−LEE, L.A.; WARNER, D.A.; Iowa State Univ., Penn State Univ., Utah State Univ., Univ. Alabama−Birmingham; *fjanzen@iastate.edu*

Swimming against the tide: resilience of a riverine turtle to extreme environmental events

Extreme environmental events are likely to exert deleterious effects on populations. From 1996−2012, we studied the nesting dynamics of a riverine population of painted turtles (*Chrysemys picta*) that experienced seven years with significantly definable spring floods. We used capture−mark−recapture methods to estimate the relationship between >5−m and >6−m flood events and parameters for this population of painted turtles in the Mississippi River. Flooding was not associated with annual differences in survival, recruitment, or annual population growth rates of the adult female segment of the population. These findings suggest that female *C. picta* exhibit resiliency to key extreme environmental events, which are expected to increase in frequency under ongoing climate change.

P2.27 JAYAKUMAR, R P*; MADHAV, M S; STAMPER, S A; FORTUNE, E S; COWAN, N J; Johns Hopkins University, New Jersey Institute of Technology; *rperurj1@jhu.edu*

Frequency tracking and spatial localization of unconstrained weakly electric fish reveal complex social interactions in natural populations

Weakly electric fish emit an electric organ discharge (EOD) that is used both for social communication, and the localization and characterization of nearby objects. Since the EOD of these fish can be modeled as an oscillating electric dipole, their field amplitudes in the water are extremely sensitive to distance and orientation. The relative movements of individual electric fish have dramatic impacts on social signalling, but also make it more difficult to localize fish using their electrical signatures on a set of electrodes. In this study we sought to create a technique for examining the relationship between social signals associated with both changes in an individual fish's EOD and those associated with relative movements. We developed a method to localize and track the spatial position and orientation (pose), and EOD frequency of multiple wave−type electric fish using spatially distributed voltage measurements. Each measurement at an electrode records a combination of EODs from multiple individuals. The amplitude of each EOD varies in relation each individual's pose relative to the electrode. Using this data, we designed a Bayesian filter to estimate the state of each individual: its position, orientation, velocity, and EOD signal parameters. The approach was validated against both simulations, and laboratory trials where multiple individuals of both *Eigenmannia* and *Apteronotus* were recorded using both video and a rectangular grid of 8 electrodes. In addition, we made recordings of groups of *Eigenmannia* along the Napo River in Ecuador using a 1.5 meter square grid with 16 electrodes, and our next step is to apply this technique in the analyses of this field data.

93.3 JAYARAM, K*; GOLDMAN, D; FULL, R J; Univ. of California, Berkeley, Georgia Institute of Tech.; *kaushikj@berkeley.edu*

Effect of friction on cockroaches running in confined spaces

Cockroaches, *Periplaneta americana*, run through confined spaces (4−12 mm) less than a third of their standing height using their compression exoskeleton. We hypothesized that limit on the smallest traversable gap could be determined by the animal's ability to generate effective force production driving forward motion. To test the importance of force limitations, we changed the friction on the ceiling (top) and running surface (bottom) of a variable ceiling height rectangular tunnel at gap heights of 4, 6, 9, 12mm. For the top surface, we used uncoated Plexi−glas, P40 grit sandpaper and graphite powder as control, high, and low friction surfaces, respectively. Increasing friction on the top surface decreased running speeds of animals across all gap heights by 5−40% with the greatest decrease at the smallest gap. Decreased speed resulted from a decrease in stride length and a more tortuous path. Decreasing friction did not show any significant change in performance. For the bottom surface, we used Plexi−glas lined with P40, P20, and P100 grit sandpaper as control, high, and low friction surfaces, respectively. Increasing friction did not change performance at 6, 9 or 12mm, but produced decreased speeds at 4mm gaps. The decrease in speed resulted from a decrease in stride length accompanied by increased slipping. Decreasing friction did not change performance at 9 or 12mm, but resulted in discontinuous motion with frequent foot slippage at 4 and 6mm. A simple theoretical model suggests that modifying the spring loaded inverted pendulum−like motion typical of unrestricted locomotion imposes significant forces on the body in confined environments that hinders forward locomotion. The effect of friction in confined spaces is assisting the design of compressible legged robots that can assist in search−and−rescue.

P3.83 JEFIMOW, M.*; DYLEWSKA, E.; BORATYNSKI, J.S.; WOJCIECHOWSKI, M.S.; Nicolaus Copernicus Univ., Torun, Poland; *jefimow@umk.pl*

The energetics of communal torpor in Siberian hamsters

Huddling may bring about significant benefits in terms of animal's energy expenditure. We tested whether living in groups and huddling affect the costs of daily torpor and the costs of rewarming in winter−acclimated Siberian hamsters (*Phodopus sungorus*). Study animals were housed singly, in pairs, and in groups of 3 or 4 siblings and were acclimated to winter−like conditions (short photoperiod L8:D16 and cold 10°C) for 3 months to induce daily torpor. Hamsters were implanted intraperitoneally with miniature data loggers to record body temperature (T_b) throughout the experiment. At the time of maximum torpor frequency we measured their metabolic rate (MR) for ~24 hours at 10°C using indirect calorimetry. Half of animals measured singly and more than half measured in groups entered torpor during MR recordings. Additionally, in 8 trials we recorded spontaneous arousals. Data were analyzed using GLM procedure. We found that mean torpor bout duration and T_b in torpor were similar in single and grouped hamsters. Compared to resting MR, MR during steady−state torpor was reduced by ~64% in grouped hamsters and by ~82% in singles. MR during steady−state torpor (at the duration: 239.8 min, and body mass, m_b = 28.6 g) was similar in grouped and in single hamsters (0.18 ± 0.02 vs. 0.20 ± 0.03 W). However, the total cost of arousal per individual, at mean m_b = 28.9 g, was 21.61 ± 5.09 W in grouped animals and 30.17 ± 5.09 W in solitary hamsters. When grouped−housed hamsters were measured individually, the cost of arousal increased to the level recorded in the single−housed animals. These results indicate that communal torpor in the Siberian hamsters does not affect MR during steady−state torpor but this behavior may reduce the cost of arousal.

P1.75 JENSEN, D*; MONROY, JA; FUQUA, R; NISHIKAWA, K; Northern Arizona Univ.; *Kiisa.Nishikawa@nau.edu*

How skinning affects passive tension in muscle

Skinning is an important method used in muscle physiology and research. Titin (connectin) is a large spring−like protein present in muscles that is responsible for passive force when a muscle is stretched. Skinning removes the muscle's membrane and allows other molecules to easily diffuse into the muscle. Previous studies suggest that the skinning procedure could degrade titin and affect the passive force of a muscle. Optimizing the skinning protocol could effectively improve how we learn about titin and its different components in active muscle. In this study, the passive force of mouse soleus muscles was measured at different lengths before and after a muscle was skinned. First, passive force was measured in physiological Kreb's solution. Then, muscles were submerged in a relaxing solution (to prevent rigor mortis) for one hour, followed by a skinning solution for 24 hrs. After the 24 hr skinning period, muscles were placed into another relaxing solution. Again, passive force data were collected. Both sets of passive tension data were analyzed and compared to determine if there was a significant effect of skinning on passive tension. The results from this experiment showed that there was a significant decrease in passive force after the muscles were skinned. This suggests that the skinning solution does affect muscle elasticity and may have degraded some of the titin protein. This work will improve how we perform and understand how skinning methods affect muscle proteins such as titin. Supported by NSF IOS−1025806.

S10.2−3 JENSEN, K. H.*; HOLBROOK, N. M.; Harvard University; *jensen@fas.harvard.edu*

Liquid Dynamics in Plants: Complex Motion in Fluids

Plants use four different strategies for driving fluid flow: evaporation, osmosis, cytoplasmic streaming, and surface tension. Each strategy plays a key role in facilitating growth and reproduction. Evaporation and osmosis drive flows of water and dissolved sugars over long distances in the xylem and phloem vascular systems. Cytoplasmic streaming is used to circulate the content of individual cells while surface tension is believed to play an important role in removing gas embolisms from the xylem vasculature. We examine the fluid mechanics of these processes. Particular attention is given to flows that depend on osmotic and interfacial effects. Finally, we attempt to rationalize aspects of the transport strategies through consideration of optimization problems.

35.5 JENSEN, MM*; DENNY, MW; Hopkins Marine Station, Stanford University; *mmjensen@stanford.edu*

Characterizing wave impact forces in the field

Wave−swept rocky shores are among the most physically stressful environments on the planet. Hydrodynamic forces produced by breaking waves can damage and dislodge organisms, complicate external fertilization, and ultimately influence the species composition of intertidal communities. However, despite the critical role of hydrodynamics in shaping intertidal communities, what may be the largest forces in the intertidal zone remain poorly understood. Impingement is the sharp, transient force occurring at wave impact, and it is believed to be the largest hydrodynamic force acting on intertidal organisms. This transient force spike is thought to be caused by a brief increase in drag due to higher water velocities at the front of a wave. While impingement has been characterized under experimental conditions, only one study has measured impingement events in the field. Those data showed impingement occurring in less than 1% of waves; however, the measurements lacked the temporal resolution to fully capture and resolve impingement events. To better estimate the frequency of occurrence and forces associated with impingement events, a sensor capable of recording transient force spikes was built and deployed in the rocky intertidal zone at Hopkins Marine Station. High−frequency measurements of wave forces were recorded for multiple sampling periods of several days, and spanned a range of tidal heights, significant wave heights, and seasons. Preliminary data indicate that impingement events appear to occur roughly 40% of the time, regardless of environmental conditions. This suggests that intertidal organisms are exposed to impingement events on a near constant basis, increasing the potential for organism dislodgment and damage.

P2.50 JERABEK, A/S; PIEDMONTE, N/P*; BOSCH, I; SUNY Geneseo; *bosch@geneseo.edu*

Isolation and Characterization of Cyanobacterial Symbionts Associated with Oceanic Clonal Sea Star Larvae

Clonal sea star larvae that are abundant in oligotrophic open ocean waters of the North Atlantic carry an extensive subcuticular bacterial flora. Results of 16s−rDNA sequence analysis reported elsewhere indicate that the dominant microbes are cyanobacteria. We conducted analyses of pigment fluorescence and the RNA polymerase C complex gene (*rpoC1*) sequence to more specifically identify the isolated strains. Clonal larvae were collected from the Gulf Stream and washed four times in filter sterilized water. Samples of intact and crushed larvae were incubated for several days in Guillard's F/2 algal growth medium. After two weeks cyanobacterial cells were evident in cultures. Analysis of absorption and emission by spectrofluorometry indicated that the most abundant accessory pigment in some isolates was phycoerythrin (peak ABS at 540 nm and fluorescence at 561 nm) while others contained primarily phycocyanin (ABS at 620 nm and fluorescence at 650 nm). DNA from one isolate culture was extracted and amplified by PCR using (*rpoC1*) complex gene. The amplification products were purified through an electrophoresis gel extraction and cloned with E. coli. Sequencing results indicated that one isolate was closely related to *Synechococcus* sp. WH8102, a motile strain of *Synechococcus* isolated from the Sargasso Sea. Experiments aiming to colonize newly released aposymbiotic clonal larvae with *Synechococcus* isolates are currently underway.

79.5 JEW, CJ*; GRACEY, AY; YANAGITSURU, Y; GRAHAM, JB; TRESGUERRES, M; Scripps Institution of Oceanography, Univ. of California, San Diego, University of Southern California; *cjjew@uci.edu*

Acclimation to aerial exposure in the long−jawed mudsucker (Gillichthys mirabilis)

The long−jawed mudsucker (*Gillichthys mirabilis*) is an intertidal wetland goby that frequently experiences aquatic hypoxia and, in response, has been known to gulp air in water or emerge onto land. *G. mirabilis* is however limited in its terrestrial capacity, having a quiescent behavior out of water and eliciting a similar transcriptional response as aquatic hypoxia. This study aims to test if and how *G. mirabilis* can acclimate to air−exposure after repeated emersion events. *G. mirabilis* was exposed to air for eight hours daily over 20 days while control fish were left submerged. On day 21 both groups experienced a hypoxia challenge of 24 hours of emersion. Muscle and liver were sampled from control fish on days 20 and 21 and from experimental fish on day 21 for transcriptomic, metabolomic, and enzymatic assays. During acute air exposure (control day 20 vs. control day 21), metabolomic data showed oxygen limitation of carbohydrate metabolism in the muscle, elevated lipid breakdown in liver, and reduction of protein synthesis in both tissues. Acclimated mudsuckers exposed to air (experimental day 21 vs. control day 21) showed a general blunted effect compared to acute exposure suggesting increased air breathing ability. Transcriptomics data showed similar trends as metabolomic data, however, enzymatic activity showed no change in aerobic (citric synthase) or anaerobic (lactate dehydrogenase) ability. This suggests that *G. mirabilis* may already be enzymatically poised, in terms of the glycolytic pathway, to deal with the eight hours of air exposure used for the acclimation treatment but were not able to quickly increase the enzyme activity over the hypoxia challenge.

64.3 JIMENEZ, AG*; WILLIAMS, JB; The Ohio State Univ.; *jimenez.102@osu.edu*

Effects of thermal stress on cellular physiology of winter−acclimated House Sparrows.

Given that our climate is rapidly changing, Physiological Ecologists have the critical task to identify characteristics of species that make them either resilient or susceptible to changes in their natural air temperature regime. Birds are important bio−indicators of detrimental effects of global climate change. Air temperature not only affects the metabolic rate of birds, but also exerts other indirect and direct such as their food supply, and the timing of breeding. The implications of climate change for birds have only recently begun to be addressed and there is already compelling evidence some of species have been impacted by recent climate change. We have explored whether short−term thermal stress at the whole animal level might alter cellular rates of metabolism. We collected winter acclimatized House Sparrows, *Passer domesticus*, during January and February of 2013 in Ohio. We separated 14 birds into a "control" group of 7 birds that was promptly sacrificed after collection, and a "heat shocked" group that was acclimated to 43 ºC for 24 hrs and then sacrificed. Skin from both groups was collected and primary dermal fibroblasts were grown. We predicted that cells from the control group would have lower rates of metabolism than fibroblasts from heat shocked animals. We found that oxygen consumption rates (OCR), measured using a Seahorse XF 96 analyzer, were significantly higher in the heat shocked group of House Sparrows compared with their winter acclimated counterparts. Additionally, we also measured cellular rates of glycolysis and glycolytic capacity and found that heat shocked birds had higher rates for both parameters as well. These results lead us to believe that whole−animal responses to increases in temperature can be translated down to the cellular level in birds.

P1.161 JIMENEZ, Y/E*; MACDONALD, I/A; DICKSON, K; GIBB, A/C; Northern Arizona University, California State University Fullerton; *yej2@nau.edu*

Developmental changes in the escape response of California halibut

Flatfishes (Pleuronectiformes) are symmetrical as larvae and become asymmetrical when they settle out of the water column and become benthic adults. These life history changes in morphology and orientation relative to the environment may necessitate changes in locomotor behaviors. We examined videos of California halibut escape responses for pre−metamorphic, metamorphic, and juvenile individuals and identified four escape response behaviors. These were designated as C−starts, S−starts, O−starts, or J−starts, according to the shape of the body during the first phase of the escape behavior. Pre−metamorphic larvae frequently performed S−starts and produced more C−starts as they grew older. J− and O−starts were only observed in older individuals and occurred infrequently. Relative escape velocities (TL/s) generated by S, C, and J−starts were similar, but O−starts were approximately two times slower. Pre−metamorphic larvae tended to escape towards left−hand side of the body, while metamorphic and juvenile halibut always escaped towards the eyed side. Despite having a 1:1 ratio of right−handed to left−handed individuals as adults, larval halibut may be "hardwired" evolutionarily to escape toward the left−hand side, which may be an evolutionary "artifact" because the family (Paralichthyidae) is predominantly left−handed. Additional work will be necessary to determine how the different movement patterns exhibited by California halibut across development allow the animals to interact with the specific features of their environment (the sounding fluid, substrate, etc.) to produce an effective movement to evade predators.

P1.163 JOFRE−RODRIGUEZ, GI*; ROSENTHAL, GG; Texas A&M University; *gjofre@bio.tamu.edu*

Sexual selection and trait introgression across replicated natural hybrid zones in swordtail fish (Teleostei:Xiphophorus)

Clinal hybrid zones, where one species transitions to another over a spatial gradient, are amenable to powerful tests of evolutionary hypotheses by comparing cline widths among traits and genetic markers. Gene flow in hybrid zones can generate **introgression of specific genes**; sexual selection by mate choice can drive both the loss of novel traits or the loss of an existing one. We will study how these two processes affect specific traits in **natural hybrid zones** between the livebearing fish *Xiphophorus malinche* and *X. birchmanni* along three independent altitudinal gradients in the foothills of the Sierra Madre Oriental of Hidalgo state, Mexico. I will characterize phenotypic clines by quantifying both male sexually−dimorphic morphology and female mating preferences for morphological traits upstream to downstream in at least seven localities per cline. To estimate genome−wide genotypic clines, I will use **Multiplexed Shotgun Genotyping (MSG)** to identify soft ancestry calls in sampled individuals, corresponding to *X. malinche* or *X. birchmanni*. By comparing cline width in morphological traits relative to cline width in genome−wide ancestry, I can **estimate the magnitude and direction of selection** on these traits across the hybrid zone. I can then compare this estimate of selection with that predicted by clinal data on mating preferences. I can also compare cline width for morphological traits with that for candidate gene regions associated with these traits.

68.2 JOHNSEN, S*; SAWICKA, E; REYNOLDS, R; STRAMSKI, D; Duke Univ., Scripps Inst. Oceanography; *sjohnsen@duke.edu*

Through the looking glass: The structure of the oceanic light field and its implications for mirror−based camouflage

Many pelagic species, in particular teleosts, have silvered lateral surfaces. While these can make an animal obvious under certain lighting conditions, mirrored sides are thought to primarily serve as a form of camouflage. The underlying argument for this is that the underwater light field is cylindrically symmetrical; thus a vertical mirror reflects a region of the water column that matches the region directly behind the mirror. Previous research on the biological mirrors themselves has shown that they are exquisitely adapted for camouflage if the light field is indeed symmetric, but the the symmetry of the light field itself has not been assessed. We first modeled the underwater light field using measured optical properties and radiative transfer software. This showed that the light field was surprisingly asymmetrical for most of the day for most latitudes. In addition, it was found that the maximum asymmetry at depth occurred not when the sun was near the horizon, but when it was 45 degrees above it. We validated these modeled results using a custom−built light meter on a cruise of the *RV Kilo Moana* off the coast of Hawaii in 2012. In addition to confirming the model, the measured light field showed that the asymmetry was even higher at longer wavelengths, suggesting that predators may gain an advantage by viewing prey in this spectral range. The modeled and measured asymmetry of the light field implies that mirror camouflage is not as successful as originally thought and suggests that there may be further refinements (such as the ability to dynamically tune the reflectance of the skin) that have not been previously considered.

P1.174 JOHNSON, N.D.*; SCHULZE, A; Texas A&M University at Galveston; *njohnso1@neo.tamu.edu*
Cryptic speciation in Phascolosoma agassizii (Sipuncula) detected with mitochondrial sequence data
The advent of molecular sequencing has opened new avenues for taxonomy of marine species. These new methods allow us to construct a more thorough history of speciation events and population distributions than those based on solely morphological observations. Not surprisingly, molecular identification techniques have helped to identify many new cryptic species, or distinct genetic lineages which share morphological features yet differ significantly in their genetic makeup. The recognition and description of cryptic species is critical for accurate estimates of biodiversity, proper taxonomic classifications, and the conservation of many marine species and habitats. The sipunculan *Phascolosoma agassizii* is one such example of strong genetic divergence among populations overlooked because of similar morphologies. Previously believed to have a cosmopolitan distribution within the North Pacific, recent data suggest the presence of two geographically separated cryptic species. Phylogenetic reconstructions based on mitochondrial sequence data show two strongly divergent clades, one from the North American west coast and one from the Sea of Japan. Our research seeks to characterize the inter− and intrapopulation divergence, by expanding the geographic sampling regime in both regions. We were able to collect samples from Monterey Bay, Friday Harbor, British Columbia, the Kuril Islands, Peter the Great Bay, and Sokcho Bay. Our phylogenetic analyses show that the two lineages are not even sister taxa and diverged relatively early in the radiation of the genus. Thus, the separation is not only based on an arbitrary threshold of genetic distance, but is also supported by the evolutionary history of the genus. More detailed morphological analyses may reveal subtle differences in the future.

P1.191 JOHNSON, B.*; COLGAN, W.; PULVER, S.R.; WYTTENBACH, R.; HOY, R.; Cornell Univ., ADInstruments, Howard Hughes Medical Institute, Emory Univ.; *brj1@cornell.edu*
CrawFly: An Interactive Workshop Featuring Model Invertebrate Preparations in the Neuroscience Teaching Laboratory
CrawFly is an international workshop for educators, sponsored by Cornell University and ADInstruments, offering instruction and review of genetics, ethology, neurophysiology, and data acquisition and analysis. Participants learn to adapt cutting−edge research techniques to undergraduate teaching. The 5−day workshop is divided into 2 complimentary approaches. First, exercises featured from the Crawdad program teach principles of cellular and synaptic physiology using extra− and intracellular recording techniques. Second, opto− and thermogenetic techniques are taught to remotely control behavior and neural circuits in transgenetic fruit flies. Strategies for minimizing costs and maximizing accessibility of the teaching preparations are discussed. Past participants include senior educators, lab coordinators, beginning faculty and post−docs. Evaluations of previous workshops demonstrate success in promoting new teaching at participants' home institutions. Competitive tuition scholarships are available, especially for young investigators, women and underrepresented minorities. CrawFly and the scholarship program are part of an ongoing effort to build an international community dedicated to neuroscience laboratory teaching. Invertebrate model preparations offer diverse student exercises that provide insight into nervous system physiology and offer hands−on experience with live preparations as an effective way to learn and practice scientific methods and experimental design. CrawFly demonstrates how neuroscience laboratory teaching can be performed inexpensively, and without the constraints required with vertebrate preparations.

117.6 JOHNSON, MA; Trinity University; *mjohnso9@trinity.edu*
The Evolution of Muscle Physiology and Social Behavior in Caribbean Anolis Lizards
Lizards in genus *Anolis* (anoles) are a model system in studies of evolution, ecology, and behavior, yet relatively little is known regarding the diversity of behavioral mechanisms in this group. While the mechanisms associated with social display and copulatory behaviors have been described in the green anole (*A. carolinensis*), we do not yet understand how the physiological and neuroendocrine traits that underlie these behaviors vary across the genus. Using 6−9 species, I used phylogenetically−informed comparative analyses to determine whether the frequency of muscle use in display or copulation is associated with the size of the muscle fibers, the fiber type composition of the muscles, and the expression of androgen receptors in the muscles. Results of these studies reveal that the size of the muscle fibers controlling push−up displays and copulation behaviors are associated with the frequency of their use; but in the muscles controlling dewlap (i.e., throat fan) extensions, expression of androgen receptors is associated with the frequency of dewlap use. Comparing these results to studies of intraspecific variation in the green anole demonstrates that the evolution of behavioral mechanisms across the genus may follow multiple trajectories.

P2.116 JOHNSON, J.I.*; FENSKE, B.S.; JASWA, A.S.; Michigan State Univ.; *johnij@aol.com*
Claustrum Puddles in Marsupial Brains
The canonical claustrum, in the forebrains of placental mammals, is a thin sheet of cells between cortex and underlying striatum. But we have reported cases where claustrum cells spread out from the sheet to form "puddles", located in different places in different taxa. Anthropoid primates show a fronto−inferior puddle, pigs have a huge posterior lobed puddle, and many carnivores have a dorsal pyramidoid puddle, large enough to allow detailed experiments, such as those showing, in cats, that this region is an auxiliary of visual cortex. We explored brains of the other major branch of the mammalian radiation, the marsupials, to learn if these show taxon−specific puddles. We used representatives of the 3 major orders of marsupials, 1) from the carnivorous Dasyurimorphia: Opossum, Native Cat, Antechinus, and Dunnart; 2) from the herbivorous Diprotodontia: Wombat, Tammar Wallaby, and Gray Kangaroo; 3) from the smaller ominivorous order Peramelimorphia: Brown Bandicoot. In each we examined a complete anteroposterior series of Nissl−stained coronal sections. From these we made quantitative 3−dimensional reconstructions to display the variations in the puddles. We found in our Wombat a large balloon−shaped puddle at the front end of the claustrum, and a much smaller elongated postero−dorsal puddle. Our Kangaroo and Wallaby showed smaller versions of both these puddles. Most interesting, a dorsal pyramidoid puddle in the Native Cat is very like that of placental domestic cats. The small brains of the tiny, shrew−like, Antechinus and Dunnart, and the larger brain of the Opossum, have barely discernable claustrums on the dorsal aspect of the fundus of the rhinal fissure. Our Bandicoot showed a small, striated, claustrum near the sulcal fundus. The marsupial radiation, like the placental, shows taxon−related variations in claustrum morphology.

P3.99 JOHNSON, JG*; KNIFFIN, CD; BURNETT, LE; BURNETT, KG; College of Charleston; *jilljohnson821@gmail.com*
High density, strand−specific RNA−seq analysis of the Pacific WhiteLeg Shrimp, Litopenaeus vannamei
Acclimation to hypoxia in the Pacific whiteleg shrimp involves regulation at the level of the transcriptome. Previous microarray results suggest that the hypoxia−specific transcriptomic signature is reduced or reversed with the addition of elevated carbon dioxide to the system. In the present study we use high throughput RNA sequencing (RNA−Seq) to explore the regulation of transcriptionally−based response, acclimation, and resiliency to low oxygen/high CO_2 conditions in *L. vannamei*, with particular focus on the two known subunits of the copper−containing respiratory pigment, hemocyanin (Hc). mRNA of juvenile *L. vannamei* exposed to normoxia (n = 18), hypoxia (n = 18), or hypercapnic hypoxia (n = 15) was pooled and sequenced in a strand−specific manner on the Illumina HiSeq 2500 platform. A total of 454,864,339 single end 100 bp high quality (>Q30) raw reads were generated, and 27,102 contigs with a mean length of 960 bp (262 bp minimum; 18,486 bp maximum) were assembled using the de novo assembler, Trinity (N50: 640bp). Raw reads were mapped back on to the Trinity assembly using the short−read aligner, Bowtie (81.2% RMBT). Although verification of the number of transcripts encoded in the genome is not possible in the absence of an annotated genome, the average absolute depth of read coverage across all transcripts was 1642X (Cufflinks: 17X minimum; 542,751X maximum.) Due to the extensive depth of coverage, new isoforms of the large Hc subunit have been identified. Current work is underway to assess Hc subunit usage in relation to low oxygen and high CO_2 conditions. (NSF IOS−1147008)

46.5 JOHNSON, T. A.*; HOFSOMMER, C. H.; BROKAW, J. M.; Abilene Christian University; *jmb97t@acu.edu*
Edaphic specialization in the neoendemic plant Mentzelia monoensis
Mentzelia monoensis is a new species that we have recently described inhabiting pumice barrens and disturbed soils. It appears to be narrowly distributed in the Mono Craters volcanic chain in California. *Mentzelia monoensis* is hexaploid and not easily distinguished from closely related tetraploid and octoploid species. However, we have developed a PCR haplotyping technique to reliably distinguish *M. monoensis*, and we have used this information to determine the geographic distribution and soil specificity of *M. monoensis*. Our results suggest that *M. monoensis* is not only narrowly distributed geographically but also inhabits unusual soils compared to closely related morphologically similar, widespread species.

P1.87 JOHNSON, KM*; HOFMANN, GE; Univ. of California, Santa Barbara; *kevin.johnson@lifesci.ucsb.edu*
Employing a DNA methylation−sensitive assay to elucidate the effects of ocean acidification on larvae of the Pacific Oyster (Crassostrea gigas).
Environmental stress can promote epigenetic modifications (e.g. changes in DNA methylation) that regulate gene expression. This interaction between DNA methylation and gene expression produces many of the phenotypic changes that are collectively referred to as an organism's phenotypic plasticity. We utilized the Methylation−Sensitive Amplification Polymorphism (MSAP) assay to investigate the effects of ocean acidification (OA) on five target genes after exposure to future ocean conditions during the early developmental stages of the Pacific Oyster (*Crassostrea gigas*). The five target genes (Annexin, Calcitonin receptor, Calmodulin, Fascilin, and Troponin C) were selected based on a previous proteomic study that identified these proteins as significantly differentially expressed under OA conditions. Oyster larvae were raised at 25°C with two pCO_2 levels (300 and 1200 µatm) for 6 days. Samples were taken daily to monitor growth and development between the two treatments. For qPCR and MSAP analysis, samples were taken from the gametes prior to fertilization and on developmental days 1, 2, 3, and 6. The physical data highlight that while larval sizes were significantly affected in the elevated pCO_2 treatment there was no detectable effect on their developmental rate. The data from the qPCR and MSAP procedures will also be presented as assays are currently underway.

13.2 JONES, R.A.*; COHN, W.B.; MACKENZIE, D.S.; Texas A and M University, College Station; *rajones@bio.tamu.edu*
Regulation of Thyrotropin mRNA Expression in Red Drum, Sciaenops ocellatus
The role of thyrotropin (TSH) in the regulation of peripheral thyroid function in non−mammalian species is still poorly understood. Thyroxine (T4), the principal hormone released from the thyroid gland in response to TSH stimulation, circulates with a robust daily rhythm in the sciaenid fish, red drum. Previous research has suggested that the red drum T4 cycle is circadian in nature, driven by TSH secretion in the early photophase and inhibited by T4 feedback in the early scotophase. Using quantitative real time RT−PCR (qPCR) we found that pituitary TSH subunit expression cycled inversely to, and 6−12 hours out of phase with, the T4 cycle, consistent with the hypothesis that TSH secretion drives the T4 cycle. We also found that the TH activating enzyme outer−ring deiodinase (*Dio2*) was not expressed with an obvious daily cycle in the pituitary. However the TH deactivating enzyme inner ring deiodinase (*Dio3*) was expressed in the pituitary mirroring the TSH cycle. These results are consistent with T4 negative feedback on TSH and suggest that TH feedback to decrease *Dio3* expression is an important component of the negative feedback system. To examine this possibility, we immersed fish in physiological doses of T3 and T4. T3 and T4 significantly inhibited the expression of the TSH ± and ² subunits. Additionally, both *Dio2* and *Dio3* expression were significantly diminished by T3 and T4 immersion. These results indicate that both circulating thyroid hormones are capable of negative feedback regulation of TSH expression in red drum on a time scale consistent with the T4 daily cycle, and further suggest that Dio3 inactivation of THs in the pituitary, potentially regulated by circulating T4, is an important component of this negative feedback.

57.6 JONES, PL*; RYAN, MJ; CHITTKA, L; University of Texas at Austin, University of Texas, Queen Mary University of London; *patricia.jones@utexas.edu*

Interactions between innate color preferences, individual experience and social information in bumblebee foraging decisions

Social information influences foraging behavior in many taxa, and the costs and benefits of social learning have led to the prediction that animals use social information selectively. We examined how the reward quality acquired during individual experience affects the use of social information in the European bumblebee, *Bombus terrestris*. Bees were trained individually to associate artificial flowers of an assigned color with high quality sucrose rewards (50% by volume) or low quality sucrose rewards (20% by volume). Individual bees were then presented with flowers of a novel color that were associated with high quality rewards and with the presence of conspecific demonstrator bees (social information). Bees without training significantly preferred the flower color that was demonstrated by conspecifics. Bees that were trained on a color with high quality sucrose rewards ignored social information and continued to forage on the trained color. Of the bees that were trained on a color with low quality sucrose rewards, there was an effect of the trained color. Bumblebees innately prefer blue flowers to yellow flowers. Bees that were trained to associate blue flowers with low sucrose rewards did not learn to approach the socially demonstrated yellow flowers. Bees that were trained to associate yellow flowers with low quality rewards, however, were significantly more likely to learn to approach the socially demonstrated blue flowers. This is the first examination of social learning strategies in bumblebees and the first study to examine the interactions between innate preferences, individual experience and social learning in any taxa.

P1.115 JONES, A*; GIBB, A; NAU; *aj324@nau.edu*

Intramandibular joint (IMJ) bending in Poeciliid fishes: what are the biomechanical properties of the IMJ?

The intramandibular joint (IMJ) is found in the lower jaw of several divergent teleost groups. The IMJ joint serves to increase gape angle and allows the fish to adopt a feeding posture that may increase its likelihood of detecting and avoiding predators. The IMJ of some Poeciliid fishes is unusual in that the Meckel's cartilage is retained into adulthood and appears to buckle during the depression of the dentary about the IMJ. We examined the biomechanics of the intramandibular joint of the shortfin molly (*Poecilia mexicana*). We also examined the jaws of the mangrove rivulus (*Kryptolebias marmoratus*), a distant relative of the shortfin molly, and the Western mosquito fish (*Gambusia affinis*), a close relative of the shortfin molly, because they maintain Meckle's cartilage as adults, but lack intramandibular bending. Dissections and clearing and staining of preserved specimens, in combination with segmentation (OsiriX), of 3D CT scans of the cranium were used to describe and quantify the morphology of the lower jaw in all three taxa. We also sectioned and stained the molly and mosquito fish to determine the biochemical and mechanical properties of the Meckel's cartilage. The physical space between the angular−articular and dentary is quite large in the shortfin molly, whereas the bones of the lower jaw of the mangrove killifish are tightly interdigitated. The physical separation of the two bony elements of the shortfin molly jaw appears to allow the Meckel's cartilage to buckle, which creates a very large rotation of the dentary (>90°), which forms a large maximum gape. In addition to facilitating our understanding of how and why new joints evolve, it is possible that, because it undergoes numerous, repeated, large magnitude strain cycles within a single day, the shortfin molly could be valuable as a model for the study of degenerative cartilage disease in humans.

89.4 JONES, BC*; BEBUS, S; SCHOECH, SJ; Univ. of Memphis; *bcjones8@memphis.edu*

Learned anti−predator behavior is impaired by exogenous corticosterone in free−living Florida scrub−jays (Aphelocoma coerulescens).

Appropriate responses to predators are learned for many avian species. However, few studies have explored the underlying mechanisms that mediate the acquisition and retention of anti−predator behaviors. Perception of a known predator is a stressful stimulus that leads to the release of glucocorticoids in a number of different taxa. The avian glucocorticoid, corticosterone (CORT), facilitates physiological and behavioral changes that can enhance survival, but can also affect memory. Given these links, CORT is a likely candidate to mediate the process of learning the dangers of predators, and thus facilitate subsequent anti−predator behaviors. Florida scrub−jays (FSJs; *Aphelocoma coerulescens*) are an avian species capable of learning anti−predator behavior. We developed a model, using an artificial novel "predator", to test the link between CORT and the FSJ's ability to learn and retain information about a novel predator. We exposed subjects to either a threatening novel predator or a non−threatening human. Within each of these exposure groups, half of the individuals were given exogenous CORT prior to the exposure, while the other half received a sham dose. Two days after being exposed to either the threatening or non−threatening stimulus, flight initiation distances (FID) in response to the novel predator were measured. Individuals that received a sham dose and were previously threatened by the novel predator displayed greater FID than control birds. Birds that received exogenous CORT and had been previously threatened by the novel predator, exhibited FID similar to controls. These data indicate that FSJs can learn to identify a novel predator as a threat with a single exposure, and that CORT can significantly affect this cognitive process.

121.3 JONES, C.R.*; OWEN, J.P.; Washington State Univ., Pullman; *cami.jones@wsu.edu*

Diet and the demands of defense: testing resource tradeoffs with deer mice and Rocky Mountain wood ticks

Immunological and behavioral defenses of vertebrates can limit blood loss to ectoparasites and affect pathogen transmission. Previously we determined deer mice (*Peromyscus maniculatus*) acquire resistance to blood feeding by larval Rocky Mountain wood ticks (RMWTs, *Dermacentor andersoni*), but observed variation in resistance among mice. It is thought that resource tradeoffs may produce variation in defense and shape host−parasite interactions. We tested if dietary factors affect the development of tick resistance relative to the maintenance of body weight. To test diet quality we had 4 diet groups with a mix of arthropods and seeds. The range of diets included ratios of seeds versus arthropods at the limits of mouse homeostasis. To test diet quantity we made 2 diet groups, adequate and restricted, using rodent chow. In both studies mice were fed the diets before and during 2 tick infestations. Engorged ticks were recovered from both infestations to determine the relative resistance to ticks for each diet group. Mice acquired resistance to RMWTs after one exposure which was not affected by host diet richness. Mice fed a diet skewed toward arthropods lost more weight when parasitized than mice fed a diet richer in seeds. These data suggest dietary differences affect body mass during parasitism, but defense remains intact. When food quantity changed mice acquired resistance to ticks but resistance was lower in mice fed the restricted diet. The restricted group lost weight when parasitized, unlike the adequate diet group. This suggests diet quantity affects the level of resistance. Though host condition may be influenced by the interaction of food resources and infection, defenses may remain intact even when dietary resources change over space and time.

28.3 JONES, M.A.; Florida State University; *majones@bio.fsu.edu*
Experimentally testing potential benefits of cooperative display in passerine bird
Much of the research of understanding cooperative behaviors has focused on why helpers assist. There has been little attention to why the recipient of the help participates; the benefit is often assumed. Yet it is equally important to understand the costs and benefits of cooperation for the recipient. Within a single population of *Corapipo altera* (White−ruffed Manakin) some males participate in coordinated display with other males, while other males display singly. The variation in cooperative display participation within a single population offers an opportunity to investigate the costs and benefits of cooperation for dominant individuals. Here I present three experiments that test potential benefits of cooperation to dominant individuals. 1) Cooperative dominant individuals may benefit by more effective detection of conspecific intruders. Non−cooperating males near a dominant male's display area may sneak copulations decreasing the dominant male's reproductive success. We tested this hypothesis using playback to simulate a conspecific male intrusion. 2) Dominant individuals may increase their chances of survival with the presence of other males. Longer survival may result from increased vigilance for predators or division of mortality risk during a predation attempt. I tested this possibility by presenting a predator model near each display site. 3) Cooperative display may provide direct benefits to the dominant male by increasing his reproductive success. One mechanism through which this could occur is faster initiation of courtship by the males. Shortening the onset of courtship increases the reproductive success of the dominant male. We tested this hypothesis by presenting a live, caged female at display sites. Overall, we found that some dominant males benefit from cooperative display, but that they also have increased costs.

110.5 JONESON, J. R.*; ELSEY, R. M.; OWERKOWICZ, T.; California State University, San Bernardino, Rockefeller Wildlife Refuge, Louisiana Dept. of Wildlife and Fisheries, Grand Chenier; *corbettj@coyote.csusb.edu*
Tenotomy of the caudofemoralis longus muscle elicits changes in muscular but not skeletal morphology in the American alligator
The caudofemoralis longus muscle (CFL) − a major retractor and medial thigh rotator − is well−developed in reptiles with a sprawling gait and a long tail. The CFL originates on the transverse processes and chevrons of the caudal vertebrae and inserts on the fourth trochanter of the femur. Evolutionary changes to hindlimb orientation and tail morphology among theropod dinosaurs have been ascribed to a reduced role of the CFL in terrestrial locomotion, but no experimental alteration of CFL function has been attempted. In order to investigate the interplay between CFL and skeleton, we used bilateral tenotomy to deactivate the CFL in juvenile (n=12) American alligators (*Alligator mississippiensis*). After eight months, experimental CFL wet mass and fiber length were found to be significantly reduced, by 23% and 13% respectively, compared to controls. Femur length, external diameter and position of the fourth trochanter, and average caudal chevron length, were similar between both groups. CFL tenotomy thus elicited changes at the muscular level, but not at the skeletal level. Given that no changes in terrestrial locomotor performance were observed following tenotomy, our results suggest that voluntary locomotor patterns in crocodilians are dictated primarily by skeletal morphology rather than muscle morphology. Further monitoring of bone growth/remodelling following tenotomy will allow us to investigate the CFL−driven phenotypic plasticity of the archosaur locomotor system and elucidate the role of musculoskeletal strain in shaping the evolutionary transformation of the hindlimb/tail module in archosaurs.

116.7 JONGSMA, GFM; BLACKBURN, DC*; California Academy of Sciences, San Francisco State University; *gregor.jongsma@gmail.com*
Diversity and biogeography of the frog genus Hylarana in sub−Saharan Africa
The evolution and diversity of many African frogs remain incompletely explored. We focus on the frog genus *Hylarana* (family Ranidae) that is diverse in both sub−Saharan Africa and southeast Asia. In Africa, these species occur in a range of habitats, span multiple biogeographic barriers, and are expected to contain cryptic diversity. Based on recent sampling of many populations across Africa, we are using phylogenetic analyses based on one mitochrondrial locus (ribosomal 16S) as a first−pass for estimating species−level diversity. This reveals a number of cryptic lineages that may correspond to undescribed species, especially in Central Africa. In addition, for each described or candidate species, we sampled additional nuclear coding loci to infer species−level relationships among African *Hylarana* species. We will discuss progress to date in delimiting cryptic species diversity and inferring large−scale biogeographic patterns.

132.1 JOOSTE, E*; CHEN, D; NIELSEN, C.K.; Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale; *ejooste@siu.edu*
Bobcats as bioindicators for brominated flame retardants in terrestrial ecosystems in the Midwestern United States
The monitoring of contaminants in the environment is essential to the health of humans and wildlife. Bioindicators are widely employed to understand spatial and temporal trends of environmental contaminants and their risks to ecosystems. Ideally, a biological indicator species should have a high trophic status, a widespread distribution, a well−known biology, and can be captured in sufficient numbers. Mammalian carnivores may be especially useful for evaluating levels of persistent organic pollutants in ecosystems because they occupy high trophic levels and may accumulate high levels of ingested substances via bioaccumulation or biomagnification through food webs. While aquatic mammals have been widely employed as bioindicators, terrestrial mammalian species are much less used. Hence, knowledge on environmental contaminants in terrestrial ecosystems remains relatively limited. In this study, we evaluated the suitability of using bobcats (*Lynx rufus*) as biological indicators to monitor environmental contaminants in the Midwestern United States. Bobcats are widespread throughout North America and in the absence of larger carnivores, serve as the top predator in many ecosystems. Contaminants of concern included emerging brominated flame retardants (BFRs), as well as legacy persistent organic pollutants such as polychlorinated biphenyls (PCBs) and organochlorinated pesticides and herbicides.

117.1 JORDAN, LA; University of Texas, Austin; *lyndonjordan@utexas.edu*

The dangers of an over−extended phenotype: social and ecological costs of increasing male attractiveness

Experimentally testing the costs and benefits of sexual traits is difficult because manipulating one trait often has uncontrolled effects on other traits. Here I use an extended sexual phenotype to measure the cost and benefits of increased male attractiveness in the highly social cichlid fish *Neolamprologus multifasciatus* using natural experiments at Lake Tanganyika. In this species males uncover shells from the sediment that females use as nest sites, and prior work has shown that shell number directly influences male sexual attractiveness, suggesting that male territories operate as extended phenotypes. Although sexual selection favors males with more shells, I found that territory size in the wild is consistently smaller than in captivity. This is despite the fact that males can easily extend their territory and that shells are an effectively unlimited resource under natural conditions. To examine the paradoxical limitation males place on their own attractiveness, I made experimental additions of increasing numbers of shells to 140 wild groups and measured the social and ecological response. I found that increasing shell numbers caused new females to join, but these were followed by additional males also joining, thereby diluting the potential paternity share of the original male. The most striking cost of the male's over−extended' phenotype was that larger piscivorous cichlids usurped many augmented territories entirely, using them as breeding sites and driving off or killing all residents. Even though increasing shell number affords increased access to females, there are strong social and ecological costs of increased attractiveness that are only revealed through experimental manipulation. This study provides a remarkably clear example of classic selection and counter−selection on a sexual trait in the wild.

P3.2 JORDAN, LA*; KOKKO, H; KASUMOVIC, M; University of Texas at Austin; *lyndonjordan@gmail.com*

Reproductive Foraging Theory: spider males choose mates by selecting among competitive environments

Mate choice frequently operates differently for males and females due to male competition for mates. Competitive interactions can alter the fitness payoffs of choice and the realisation of preferences under natural conditions, yet the majority of male choice studies still use binary trials that ignore social factors. Here we test the importance of contest dynamics in male choice with a large scale experiment, using a framework where females are considered analogous to foraging patches that are subject to competition. We track the mate choices and social interactions of 640 spiders (*Nephila plumipes*) before and after manipulation of competition within enclosures, modelling the expected fitness payoffs of actual and all hypothetical mate choices. We find that many males choose new females once social conditions change, and achieve higher fitness than predicted under random movement. Males increase their fitness not by moving to larger females but by choosing favourable competitive environments. Further, we show for the first time that prior residence effects have a strong influence in male reproductive contests and can shape male mate choice. This highlights the importance of situating male choice studies in relevant social contexts, as intrasexual interactions can have profound effects on the payoffs of male mate choice strategies.

P1.114 JORGENSEN, D.; ENGLAND, M.*; HENSLEY, S.; BRINGS, V.; Roanoke College; *mgengland@mail.roanoke.edu*

Does the ventilatory pump affect the gill circulation in blue crabs and lobsters?

Blue crabs and lobsters carry out gas exchange with two sets of gills each housed in a branchial chamber (BC) located on either side of the thorax. The BCs are each ventilated by the action of a scaphognathite (Sc), which generates a suction pressure in its BC that pulls water past its gill set. During periods of increased oxygen demand, Sc activity increases, resulting in greater suction pressure in the BC driving increased ventilation. The gills in both animals are invested with small diameter hemolymph channels that bring hemolymph into close contact with the ventilatory water. A heart contracts rhythmically, pushing hemolymph through the circulatory system including the gill circuits. We are interested in the relationship between gill circuit perfusion and the hydrostatic pressure environment in the BC. We measured hydrostatic pressure in the BCs concurrently with hemolymph pressure in spaces just up− and downstream from the gill circulation to determine hemolymph pressure drop (&deltaP) across the gill circuit (a measure of hemolymph flow resistance). In some experiments, we concurrently measured hemolymph velocity in an afferent gill hemolymph vessel. We challenged the animals by walking them on a submerged treadmill. Our data show that &deltaP decreases by as much as 50% during a period of increased Sc activity. Preliminarily, we found that hemolymph velocity in an afferent gill vessel increases concurrently by as much as 2X. These data suggest that increased Sc activity may cause passive dilatation of gill vessels and assist the heart in moving hemolymph through the gill circulation during periods of higher metabolic demand.

111.4 JOSEPH, M*; FAULKES, Z; The University of Texas−Pan American; *zfaulkes@utpa.edu*

Nematode worms infect, but do not manipulate, sand crabs (Lepidopa benedicti)

Sand crabs (Albuneidae) are a cosmopolitan group of crustaceans, but because they spend most of their time submerged in sand, their ecology is little known. Parasites often shape the ecology of a species, so we investigated what parasites infected sand crabs (*Lepidopa benedicti*), and whether these parasites manipulate their hosts. Most (87%) *L. benedicti* were infected with nematodes (mean = 25.8, SD = 23.9). The number of nematodes was significantly correlated with host size ($r = 0.58$, $p < 0.0001$, $n = 46$). We predicted that if these nematodes were manipulating sand crabs that the number of nematodes would correlate to how long sand crabs would stay above the surface of the sand, because being visible above sand should increase the chances of being eaten by a predator. We measured how long it took sand crabs dropped into water at the top of a tank to submerge into sand, then determined the number of nematodes in each. The number of nematodes did not correlate with time above sand ($r = -0.18$, $p = 0.29$, $n = 37$), so nematodes do not appear to manipulate *L. benedicti*. This suggests these parasites have a simple life cycle that does not require transmission to another host, or that sand crab infections are "accidental" and the preferred host is some other species, such as mole crabs (*Emerita benedicti*), which are often found in the same locations as *L. benedicti*.

90.1 JOST, JA*; KESHWANI, S; SOLTIS, E; MOYER, M; VEZINAW, C; Bradley University; *jjost@bradley.edu*

Sublethal temperature tolerance of the invasive zebra mussel, Dreissena polymorpha: Linking growth to cellular indicators of temperature stress

Temperature stress has been examined in the context of climate change and there is a interest in measuring thermal stress for invertebrates. While climate models predict that invertebrates will be one of the most affected groups as temperatures increase, there are missing links in our knowledge of the physiology. For example, lethal temperatures have been examined for many species, but the organismal and cellular effects of high, but sublethal, temperatures are poorly understood. As an invasive species, the zebra mussel, *Dreissena polymorpha*, can serve as a model invertebrate species. Zebra mussels are capable of biofouling hard substrates, causing severe damage, and therefore, studies investigating zebra mussel physiology may offer insight into the survival and spread of this species. Previous work has examined the lethal limits for zebra mussels, but few have investigated the cellular mechanisms of temperature tolerance or the link between temperature and non−lethal effects such as reduced growth. This study examined the relationship between high temperature stress, AMP−activated protein kinase activity (an indicator of cellular energy), heat shock protein (HSP) levels and growth for the zebra mussel. Animals were maintained at one of three water temperatures (10, 20 or 30°C) for either 12 weeks (winter) or 8 weeks (summer). Data show that prolonged exposure to 30°C results in high mortality, decreased growth (both tissue and shell mass) and an extensive HSP response while AMPK activity does not appear to be a strong indicator of long term stress. In addition, preliminary results suggest that summer collected mussels are less prone to high temperature stress than winter collected animals indicating a seasonal thermal acclimation mechanism is present.

P2.96 JUMARS, PA; DORGAN, KM*; LINDSAY, SM; Darling Marine Center, University of Maine, Dauphin Island Sea Lab, School of Marine Sciences, University of Maine; *kdorgan@ucsd.edu*

Revisiting the diet of worms

Polychaetes are numerically abundant and morphologically diverse, and dominate many infaunas. The classification of polychaete feeding guilds presented by Fauchald and Jumars (1979) has been widely used by ecologists and managers to characterize benthic communities and assess functional diversity as well as by biologists to explain morphologies, behaviors, and ecological roles of polychaetes. Over the past several decades, however, new taxa have been discovered and the phylogeny of annelids revised to include previously distinct groups not included in the original classification, thereby broadening the diversity of guilds within families. Stable isotopic analyses have provided new insights into trophic relationships, and these data have in many cases corroborated previous studies based on behavior or gut content analyses, but in a few consistently reject prior assignments. Recent advances in understanding of burrowing mechanics have highlighted the differences between sands and muds and altered interpretation of morphologies; e.g., tentacles and palps previously used to infer a surface deposit−feeding lifestyle may actually be used to feed on subsurface burrow walls. Advances in understanding of particle selection suggest that few if any deposit feeders are truly "non−selective." Carnivores and deposit feeders have distinct gut morphologies, and digestion theory indicates a lower size limit for deposit feeding, an important generalization as data on meiofaunal feeding remain sparse. We present a revision of polychaete feeding guilds with highlights from a synthesis of new information, and we identify gaps in current understanding and emphasize the need for ongoing research and more frequent reexamination of feeding guilds.

S10.3−3 JUNG, Wonjong; KIM, Wonjung; KIM, Ho−Young*; Seoul National University, Sogang University; *hyk@snu.ac.kr*

Self−burial mechanics of hygroscopically responsive awns

We present the results of a combined experimental and theoretical investigation of the mechanics of self−burial of some plant seeds whose morphologies respond to humidity change of the surroundings. The seeds of *Pelargonium* species have hygroscopically active awns that play a critical role in the dispersal from the parent plant and burial in soil. While the awn uncoils in a highly humid condition, it recoils to a helical shape when dry. The rotation is driven by the structure of the cell walls that are comprised of cellulose microfibers aligned in a tilted helix. During uncoiling of the awn, the revolving tail generates thrust to burrow into soil, so that the seed is self−buried. We present the direct observation of the self−burial of the seed while measuring the thrust into a soft substrate simultaneously. The elastica theory allows us to rationalize this botanical digging mechanics using the structural deformations of the hygroexpansive tissues.

34.1 JURCAK, AM*; MOORE, PA; Bowling Green State University; *ajurcak@bgsu.edu*

The impact of predation events on habitat choice and use in virile crayfish

Animals make some important ecological decisions regarding resource use based on a risk analysis of potential predation events. In these instances, ecological decision making theory would dictate that animals evaluate the benefit of resource gain against the potential harm due to predation. Such decisions will ideally result in tradeoffs with the results being maximizing resource use while minimizing predation risks. Crayfish are a keystone species for many lakes and rivers and are often preyed upon by various species of freshwater fish. To investigate ecological decision making, we presented a crayfish with a choice of resource rich and resource poor habitats under different predation conditions within a y−maze setting. A simulated predatory event was alternately placed in either the resource rich or poor habitat to observe the impact of the predation event on the habitat choice and use. Habitats consisted of multiple food resources, multiple shelter resources or combined food and shelter resources. Trials were videotaped and crayfish behavior were analyzed for initial habitat choice, time in each habitat, shelter use, and time spent with food. The results show that crayfish will make decisions on habitat choice based on the presence of predators as well as the presence and type of resources. As a keystone species, the consequences of these choices and resource use as a result of predation events will alter carbon movement within aquatic habitats. The complexity of habitat and resource distribution as well as the types of predators are critical in the ecological decisions of crayfish.

61.2 KAGAYA, K.*; PATEK, S. N.; Dept. of Biology, Duke University, Durham, NC; *k.kagaya@me.com*
Motor control of an ultrafast spring−driven movement in smashing mantis shrimp
Ultrafast movements are typically driven by springs that are loaded prior to movement. Given that muscles do not directly actuate the movement, how do spring−driven mechanisms generate variable kinematics? The extremely fast smashing behavior of mantis shrimp (Stomatopoda) was analyzed to understand the correlation between motoneuronal activity and strike kinematics. Mantis shrimp use extensor muscles to load the spring and flexor muscles to release it. Thus, we tested the hypothesis that the timing of flexor and extensor muscle contractions controls the kinematics of the mantis shrimp (*Gonodactylus chiragra*) raptorial strikes. We measured strikes using high speed imaging and simultaneously−recorded electromyograms of the extensor and flexor muscles. To load the spring, the lateral extensor units were activated followed by the lateral flexor units. Before the initiation of movement (16−59 msec), the extensor became non−active. We recorded the flexor activity for folding the appendages but could not record during extensor activation. Therefore, we used strike initiation in the video as the timing of flexor relaxation. Within individuals, the time difference between turning−off of the extensor and strike initiation had a negative linear relationship with maximum velocity. The results suggest that mantis shrimp can vary strike velocity through the timing of central nervous system signals. While variation in ultrafast movements likely occurs due to a constellation of factors, such as a nonlinear response of the mechanical system or environmental conditions, these results support a central nervous system−based control of ultrafast movement.

52.4 KAHRL, A.F.*; COX, R.M.; University of Virginia; *afk7df@virginia.edu*
Body condition affects ejaculate traits in a lizard with condition−dependent fertilization success
Sexual selection is predicted to deplete genetic variation in fitness−related traits, but condition−dependence can maintain phenotypic variation in the face of strong selection. Characteristics of the male ejaculate, such as the quantity or quality of sperm, can be both condition−dependent and subject to strong sexual selection. Because sperm production can be energetically costly, males are predicted to respond to limited resources by reducing the quantity or quality of their sperm. We tested the condition−dependence of ejaculate traits by experimentally altering body condition through food restriction in the lizard *Anolis sagrei*, which has condition−dependent fertilization success. As predicted, food restriction reduced male body condition and decreased total sperm production relative to males fed ad libitum. Additionally, sperm morphology within individuals was more variable in food−restricted males, suggesting that energy limitation detrimentally impacted both the quality and quantity of sperm. Food restriction also increased the size of the sperm midpiece, suggesting a possible tradeoff between sperm quality and quantity under energy limitation. Because these ejaculate traits are potentially related to sperm competitive ability and fertilization success our results suggest that condition−dependence may be important for male fitness and the evolution of sperm morphology.

80.2 KALIONZES, K*; FLAMMANG, B.E; LAUDER, G.V; Harvard University ; *kkalionzes@fas.harvard.edu*
Multifin control during backwards maneuvering through an obstacle course by bluegill sunfish
Fish like bluegill sunfish use multifin control to navigate complex environments. Multifin control permits for high flexibility and maneuverability, allowing them to swim backwards through obstacles without having to turn around. To swim backwards in a straight line, precise timing of kinematics is needed in order to balance the torques produced by each fin's independent action. When bluegill sunfish swim backwards through obstacles, rolling torques and hydrostatic forces act on the body resulting in hydrodynamic instability. We hypothesized that having to circumnavigate obstacles while swimming backwards would result in modified kinematics in order to reduce destabilization of the center of mass. Similar to forward swimming, bluegill sunfish tapped the obstacles with their pectoral fins while navigating the course. However, different from forward swimming, they tapped posts also with dorsal, anal and caudal fins. Pectoral fin locomotion was characterized by alternating powered outstroke and feathered instroke on the left and right sides of the body. The dorsal and anal fins rotated anteriorly on the outstroke to the side of the body on which the pectoral fin was performing the feathered instroke. The caudal fin was undulated from ventral to dorsal lobe, which likely corrects for pitch deviations. Body rolling relative to the center of mass was higher as fish moved backwards around an obstacle; however, the center of mass did not fluctuate. These behavioral findings and observations suggest that kinematic phase relationships of pectoral, dorsal, anal, and caudal fin movement compensates for the increased rolling perturbations caused by non−linear backwards swimming and controls stability of the center of mass.

P2.24 KALLINS, M.G.*; CURTIS, N.E.; PIERCE, S.K.; WATSON III, W.H.; NEWCOMB, J.M.; Rollins College, University of South Florida, University of New Hampshire, New England College; *MKALLINS@Rollins.edu*
ULTRASTRUCTURAL ANALYSIS DEMONSTRATES THAT THE NUDIBRANCH MELIBE LEONINA LACKS SYMBIOTIC ALGAE AND KLEPTOPLASTS
The nudibranch, *Melibe leonina* (Gould 1852), is found in kelp or eel grass beds along the Pacific coast of North America. This slug feeds using a unique oral hood to capture planktonic organisms, mostly copepods and amphipods according to gut content analysis. However, examination of the digestive diverticula of cerata from *M. leonina* by confocal microscopy (480 nm) demonstrated intensely autofluorescing circular structures within the cells lining the lumen, possibly indicating the presence of chlorophyll containing structures such as symbiotic zooxanthellae or sequestered chloroplasts. Thus, careful transmission electron microscopy (TEM) was conducted to determine the contents of cells in the cerata. There was no evidence of chloroplasts or symbiotic algae in or near the digestive gland cells of the cerata of *M. leonina*. The cells contained structures typical of molluscan digestive gland cells such as heterolysosomes, residual bodies, and other phagosome−like bodies, and it is suspected that these structures are responsible for the autoflourescence.

117.5 KAMATH, A; Harvard University; *ambikamath@gmail.com*
Relationships between dewlap morphology, display behavior, and sexual size dimorphism in the South Asian agamid lizard species complex, Sitana ponticeriana .
Many lizards in the family Agamidae engage in colorful and complex visual displays aimed at attracting the attention of conspecifics. The South Asian lizard species complex, *Sitana ponticeriana*, is ideally suited to understanding the relationships between different components of the visual display. Distributed across South Asia in open scrubland and coastal habitat, populations of the *Sitana ponticeriana* species complex can differ dramatically in the size and coloration of the dewlap, a fan−like structure under the throat that is extended while displaying. I quantified dewlap morphology and display behavior in eight populations of this species complex, and found variation that indicates an inverse relationship between the behavioral and morphological complexity of display components. Further, sexual size dimorphism, but not habitat structure, was significantly different between populations that differ in dewlap morphology and display behavior, indicating that sexual selection might be involved in behavioral and morphological diversification within this species complex.

82.4 KANE, E.A.*; HIGHAM, T.E.; University of California, Riverside; *ekane001@ucr.edu*
Modeled predator accuracy predicts capture success in three centrarchids
Prey capture is critical for survival and reproduction, and for suction feeding fishes, success likely depends on the ability to correctly position and time the strike (accuracy). Despite this, we currently lack the ability to quantify accuracy when predator and prey are unconstrained in attack or escape behaviors. We applied a predictive model of suction hydrodynamics to calculate predator accuracy during semi−natural capture behaviors using 3D kinematics of three centrarchid fishes (*Micropterus salmoides*, *Lepomis cyanellus*, *Lepomis macrochirus*) capturing evasive and non−evasive prey. Capture success was >90% for non−evasive prey, but evasive prey responded to predators using a fast start, resulting in success ranging from 64% (*L. cyanellus*) to 96% (*M. salmoides*). The greatest ram speeds and gape sizes were observed in *M. salmoides* capturing evasive prey, resulting in the largest ingested volume of water (IVW). Only *M. salmoides* and *L. macrochirus* modulated IVW shape across prey types. The greatest and worst accuracies were observed for *L. macrochirus* capturing non−evasive and evasive prey, respectively, the only species where differences across prey types were observed. We conclude that capture success is increased when predators accurately control the position and timing of their strike and elicit fewer prey escape responses. In addition, predator accuracy is a useful metric of capture performance. Differences in accuracy reflect differences in ecological specialization that affect predator approach strategy and suction performance, and highlight the ability of each predator to capture certain prey types. This application of the IVW model elucidates differences in semi−natural capture strategies that can be used to generate hypotheses of prey capture evolution.

P3.177 KANE, S. A.*; ZAMANI, M.; Haverford College, Haverford PA; *samador@haverford.edu*
Falcons pursue prey using optical flow cues: new perspectives from animal−borne cameras
This study reports on experiments on falcons wearing miniature videocameras mounted on their backs or heads while pursuing flying prey. Videos of hunts by a gyrfalcon (Falcon rusticolus), gyrfalcon (Falcon rusticolus)/Saker falcon hybrids and peregrine falcons (Falco peregrinus) were analyzed to determine apparent prey positions on their visual fields during pursuits. These video data then were interpreted using computer simulations of pursuit steering laws observed in insects and mammals. A comparison of the empirical and modeling data indicates that falcons use optical flow cues to track and capture flying prey via a form of motion camouflage. The falcons also were found to maintain their prey's image at visual angles consistent with using their shallow fovea. These results should prove relevant for understanding the coevolution of pursuit and evasion, as well as the development of computer models of predation and the integration of sensory and locomotion systems in biomimetic robots.

P1.51 KANE , E.G.*; REITZEL, A.M.; University of North Carolina, Charlotte; *ekane1@uncc.edu*
The Conservation and Function of the Cytoprotective Transcription Factor Nrf2 in a Model Cnidarian
The cell is constantly exposed to damaging reactive oxygen species resulting from aerobic metabolism and anthropogenic pollution. In response, the cell must orchestrate dynamically regulated antioxidant defenses that maintain cellular and tissue integrity. A master regulator of the antioxidant response is the bZIP transcription factor nuclear factor erythroid−derived 2 (Nrf2). In mammals, Nrf2 coordinates response to stress and tissue wounding, thereby deterring aging, and also serves critical roles in cell specification during development. Nrf2 and its function are conserved in model protostome lineages, where orthologs in *C. elegans* and *Drosophila* are crucially important for antioxidant defense and play a significant role in development of mesendodermal tissue. The presence and function of Nrf2 in earlier diverging phyla remains unclear but critical for determining the antiquity of this mechanism for cellular homeostasis. Using the sea anemone *Nematostella vectensis*, we identified a single Nrf2 ortholog (*nvNrf*) with high sequence similarity in the DNA−binding region, but not critical residues for interactions with regulatory proteins. Morpholino−mediated suppression of *nvNrf* during development provided evidence that this transcription factor plays a role in the transition from planula to juvenile by repressing tentacle development. Exposure of *Nematostella* to two model pro−oxidants, tBOOH and tBHQ, showed this cnidarian is sensitive to oxidative stress. Measurement of expression for *nvNrf* and a conserved suite of antioxidant response genes suggests that this cnidarian utilized similar stress response pathways as model bilaterians. Together, these data support a multi−faceted role for Nrf in both development and stress response in *Nematostella*.

P1.131 KANGAS, KA*; LAND, D; BENTLEY, GE; Univ. of California, Berkeley, Loyola Marymount University; *k_kangas@berkeley.edu*

The Songbird's Fourth Eye: Melatonin−Synthesizing Enzymes in the Hypothalamus of European Starlings

Annual fluctuations in photoperiod drive seasonal availability of resources and mediate annual physiological and behavioral changes across vertebrate taxa. Variations in the duration of nocturnal melatonin secretion in temperate zones provide information about the time of day and year. Changes in photoperiod regulate gonadal growth and regression in seasonal breeders, and administration of melatonin has profound effects on mammalian gonadal status. Unlike in mammals, there is a long−standing dogma that pineal melatonin is not involved in avian seasonal reproduction, based on just a handful of experiments. Recent evidence suggests hypothalamic melatonin synthesis *de novo* in galliform birds. Our preliminary data indicate that passerine birds *Sturnus vulgaris* are also likely to produce hypothalamic melatonin, causing us to reconsider the role of melatonin in avian seasonal reproduction. We investigated if melatonin can be synthesized *de novo* in the avian hypothalamus by confirming the expression of all four enzymes of the melatonin biosynthesis pathway: tryptophan−5−hydroxylase (TPH), 5−hydroxytryptophan decarboxylase (DDC), aralkylamine N−acetyltransferase (AANAT), and hydroxyindole−O−methyltransferase (HIOMT). This is the first time the expression of these four enzymes has been identified in the songbird hypothalamus. By comparing the diurnal and nocturnal expression levels of these enzymes in the hypothalamus relative to other tissues known to synthesize melatonin *de novo* (i.e. the pineal and the retina), we demonstrate the potential for daily fluctuations of encephalic melatonin to influence avian photoperiodic responses. This will better our understanding of the crucial role of melatonin in the evolution of photoperiodic responses across vertebrates.

99.6 KANKE, MR*; MACDONALD, PM; University of Texas at Austin; *matthew.r.kanke@gmail.com*

Understanding Translational Regulation Using the Model System Drosophila

Translational regulation of localized RNAs is crucial for development across the animal kingdom. In the model system *Drosophila*, proper regulation of localized mRNAs is essential for patterning of the embryo and acts as an ideal model for the study of translational regulation. One of these localized RNAs, *osk* mRNA, is required for posterior patterning. *osk* is synthesized in the nurse cells and subsequently localized to the posterior of the oocyte in a translationally repressed state. Upon posterior localization, translation is initiated and *osk* is translated into two Osk isoforms, Long Osk and Short Osk. Repression has been extensively characterized and relies on defined elements in the *osk* 3' UTR as well as known regulatory factors. Translational activation is less well understood. The current model proposes that a 5' regulatory element, positioned in a protein coding region, acts to override repression specifically at the posterior pole of the oocyte. We have used an *osk::GFP* reporter to better characterize this 5' element. Introduction of the inversion mutation used to define the 5' element results in both lower protein level and loss of the Long Osk anchoring function, providing clear evidence of a protein defect. To determine if there was also an effect at the RNA level, we took advantage of the fact that Long Osk is not essential for Osk function. The proposed regulatory element is within the coding region unique to Long Osk. When the Long Osk start codon is mutated, now only Short Osk is made and any mutation in the proposed regulatory region only affects the RNA sequence, not the protein sequence. We find that indeed there is a translational activation element in the proposed region, and that this element is essential for Short Osk expression.

28.4 KAO, AB*; MILLER, N; TORNEY, C; HARTNETT, A; COUZIN, ID; Princeton University; *akao@princeton.edu*

Collective learning and optimal consensus decisions in social animal groups

Learning has been studied extensively in the context of isolated individuals. However, many organisms are social and consequently make decisions both individually and as part of a collective. Reaching consensus necessarily means that a single option is chosen by the group, even when there are dissenting opinions. This decision−making process decouples the otherwise direct relationship between animals' preferences and their experiences (the outcomes of decisions). Instead, because an individual's learned preferences influence what others experience, and therefore learn about, collective decisions couple the learning processes between social organisms. This introduces a new, and previously unexplored, dynamical relationship between preference, action, experience and learning. Here we model collective learning within animal groups. We reveal that learning as part of a collective results in behavior that is fundamentally different to that learned in isolation, allowing grouping organisms to spontaneously (and indirectly) detect correlations between group members' observations of environmental cues, adjust strategy as a function of changing group size (even if that group size is not known to the individual), and to achieve a decision−making accuracy that is very close to that which is provably optimal, regardless of environmental contingencies. These properties are shown to require minimal cognitive demands on individuals. Thus collective learning, and the capabilities it affords, may be widespread among group−living organisms. Our work emphasizes the importance and need for theoretical and experimental work that considers the mechanism and consequences of learning in a social context.

P1.52 KAPPER, M.A.; Central Connecticut State University; *kapper@ccsu.edu*

Are molecular chaperone proteins used during salinity adaptation in the ribbed mussel?

One of the most important abiotic stressors faced by osmoconforming estuarine invertebrates is the tidal fluctuation of environmental salinity. As environmental salinity changes, these organisms adapt by modifying intracellular free amino acid concentrations so that the intracellular osmotic concentration matches that of the environment. This process takes time. The interim osmotic changes of the cytoplasm before complete adaptation is achieved can potentially disrupt the functioning of cellular proteins with severe consequences to homeostasis. There must be a mechanism to maintain protein conformation and function during the process of salinity adaptation. Constitutive heat shock proteins like hsp(73) act as molecular chaperones, modulating folding during translation ensuring proper conformation of the nascent proteins. Induced chaperone proteins like hsp(72) are synthesized during times of stress, and are thought to bind to target proteins and prevent their irreversible denaturing. There is evidence showing that hsp(72) production is induced by transient exposure to increased temperatures in a wide variety of organisms including molluscs. There is also evidence that hsp(72) is synthesized in response to other environmental stressors like heavy metal contamination or bacterial infection. The 70 kD heat shock proteins are highly conserved across the phylogenetic spectrum. We are testing the hypothesis that induced hsp(72) is produced in gills of the ribbed mussel *Geukensia demissa* as part of an adaptive response to increased salinity. Western blots indicate that this species is able to produce both the constitutive and induced forms of hsp70. Data will be presented to show whether changes in salinity induce production of hsp(72). Supported by a CSU−AAUP grant to MAK.

10.6 KARADGE, U; GOSTO, M; NICOTRA, ML*; University of Pittsburgh; *nicotraml@upmc.edu*

Binding specificities of Hydractinia allorecognition proteins

Colonial marine invertebrates animals such as sponges, corals, and sea squirts are capable of distinguishing between their own tissues and those of conspecifics via cell−cell contact. This phenomenon is known as allorecognition and occurs whenever colonies encounter each other as they grow across their substrate. Compatible colonies typically fuse or peacefully co−exist, while incompatible colonies reject and often aggressively compete for space. In all taxa studied to date, allorecognition phenotypes are determined by highly polymorphic genetic loci. These loci ensure colonies are only compatible with themselves or close relatives. How allorecognition molecules achieve this specificity remains unknown. Here we report data suggesting a biophysical mechanism for allorecognition specificity in the hydroid, *Hydractinia symbiolongicarpus*. Allorecognition in *Hydractinia* is controlled by at least two histocompatibility genes, *alr1* and *alr2*. Both genes encode highly polymorphic transmembrane proteins similar to immunoglobulin superfamily (IgSF) molecules. Colonies with matching alleles at alr1 and alr2 fuse, while colonies with no matching alleles reject. Using in vitro assays with recombinant proteins, we demonstrate that alr1 is capable of binding to itself and that alr1 alleles bind to themselves but not to other alr1 alleles. These results suggest that, in vivo, compatibility between colonies is also determined by allele−specific homophilic binding of alr proteins. Given the fact that fusion is exceedingly rare in nature and that single populations can maintain hundreds of unique alr alleles, the *Hydractinia* allorecognition system appears to be based on homophilic protein−protein interactions with unprecedented allelic diversity and specificity.

98.2 KARASOV, W.H.*; BRUN, A.; PRICE, E.R.; GONTERO−FOURCADE, M.N.; FERNANDEZ−MARINONE, G.; CRUZ−NETO, A.P.; CAVIEDES−VIDAL, E.; University of Wisconsin−Madison, Universidad Nacional de San Luis, Universidade Estadual Paulista − Rio Claro; *wkarasov@wisc.edu*

Intestinal paracellular permeability to nutrients is higher in frugivorous bats than rodents

Based on previous work with intact animals, the capacity for paracellular nutrient absorption seems greater in ying mammals than in non ying mammals, but there has been little testing for the predicted difference in intestinal permeability. We conducted *in situ* intestinal luminal perfusions on three bats (*Artibeus lituratus*, *Sturnira lilium*, *Carollia perspicillata*) and a rodent (*Akodon montensis*). Additionally, we assessed paracellular nutrient absorption (fractional absorption = f) in intact animals of one bat (*S. lilium*) and the rodent. In both approaches, we measured the absorption of a nonmetabolizable D−glucose analog that is absorbed by both paracellular and transporter−mediated mechanisms (3OMD−glucose) as well as a carbohydrate that has no mediated transport (L−arabinose). In intact animals, the fractional absorption of arabinose was complete in the bat (f = 1.2 ± 0.24) and 3x higher than in the rodent (f = 0.35±0.04) whereas 3OMD−glucose absorption was complete in both species (*A. montensis*: 0.97 ± 0.12, *S. lilium*: 1.46 ± 0.4). In accord with these results, bats exhibited 2−4 fold higher arabinose clearance than the rodent in intestinal perfusions. All bat species had a higher percent glucose absorption that was estimated to be paracellular (essentially 100%) compared to the rodent (39%). Our findings agree with previous studies showing that the paracellular pathway for nutrient absorption is more prominent in bats relative to nonflying mammals, and this is driven by differences in intestinal permeability to nutrient−sized molecules.

P2.147 KARRATTI−ABORDO, J*; NERURKAR, P ; University of Hawaii at Manoa; *jadieka@hawaii.edu*

Anti−inflammatory Mechanisms of Tropical Foods

Obesity has become an epidemic in America, increasing the risk of metabolic disorders such as Type 2 Diabetes (T2D). T2D is responsible for about 90%−95% of diagnosed diabetes. In Hawaii, approximately 56.4% of adults are overweight or obese, 14% of children are overweight and 8.4% of individuals have diabetes. Moreover, Native Hawaiians and Pacific Islanders have the highest obesity and diabetes mortality rates compared to Caucasians. Dietary changes form the foundation of obesity treatments. However, culturally acceptable foods may have long−term consequences in continuing adherence to dietary changes. Chronic inflammation is an important etiological factor during obesity and T2D. Our project investigates anti−inflammatory properties of local foods such as *Momordica charantia* (bitter melon), *Lagenaria siceraria* (bottle gourd) and *Luffa acutangula*(ridge gourd), using cell culture models. Such studies are important since identifying local foods with anti−obesity and anti−inflammatory properties may offer easy accessible, cost effective, treatment strategies for obesity or T2D.

S9.3−4 KASPARI, Michael*; CLAY, Natalie; University of Oklahoma; *mkaspari@ou.edu*

Scaling up the effects of Na from individual performance to ecosystem function

Of the twenty five or so elements required for life, sodium has a number of features of interest to ecologists. First, it is relatively unimportant for the metabolism of plants, but vital for those of consumers of plants. Thus, detritivores and herbivores must spend time and energy finding sufficient quantities of sodium; a challenge less important to the carnivores that consume them. Second, Na has a biogeography that arises from the combined effects of geology and oceanic aerosols. Third, as an ionic element, sodium cannot easily be stored, and instead is lost proportional to the metabolic rate of the organism. As a consequence of 2 and 3, sodium limitation of individuals and ecosystems is likely to vary in interesting ways across the terrestrial world both geographically and with temperature and body size. Combined, these premises suggest a dynamic role for sodium in regulating individual performance, trophic structure, and ecosystem function. We propose that a focus on Ionic Ecology will complement the already powerful insights generated from the stoichiometry of C, N, and P.

119.4 KAWANO, S.M.*; BRIDGES, W.C.; SCHOENFUSS, H.L.; BLOB, R.W.; Clemson Univ., St. Cloud State Univ.; *skawano@clemson.edu*

Intraspecific variation in patterns of morphological selection in the waterfall−climbing goby fish, Sicyopterus stimpsoni

Selection is the primary driver of adaptive evolution, and local adaptation can occur when selection is stronger than gene flow. The Hawaiian freshwater goby fish, *Sicyopterus stimpsoni*, exemplifies how the interplay between selection and gene flow can result in population differentiation. The pelagic larval stage during their amphidromous life cycle allows for gene flow across islands, with returning juveniles facing differing selective pressures: 1) escaping from predators in the lower stream reaches, and 2) climbing waterfalls to reach breeding habitats. However, the primary selective agents between Hawai'i and Kaua'i (climbing vs. predation, respectively) may be driving subpopulation differences since adult morphologies match predictions for improving streamlining and thrust production, respectively. We conducted selection analyses to assess whether juveniles recruiting to Hawai'i and Kaua'i exhibit different patterns of morphological selection in response to a brief, yet intense selective agent: waterfall climbing. Our study found that the Hawaiian subpopulation had greater climbing success, and that nonlinear selection patterns were more similar between two Kauaiian subpopulations than between island subpopulations. Quadratic selection was also ~2x stronger on Kaua'i. Traits under selection generally matched predictions for the primary selective agent on each island: taller body heights that could improve predator evasion on Kaua'i, and shallower bodies that improve streamlining during climbing on Hawai'i. These data provide insight into how patterns of morphological selection can contribute to local adaptation despite gene flow.

P1.82 KEEN, Adam N*; GARDNER, Peter; SHIELS, Holly A; Univ. of Manchester; *adam.keen@manchester.ac.uk*

Temperature Dependent Cardiac Remodeling in the Rainbow Trout (Oncorhynchus mykiss)

The heart will remodel under stressful circumstances to maintain an optimal cardiac output and appropriate pressure volume relationships. The ectothermic nature of fish means the heart will remodel seasonally. Cold temperature induces a pressure−overload hypertrophy and fibrosis of cardiac muscle, while warm temperature causes atrophy of cardiac tissue and a reduction in collagen fibre density. The effect of remodeling on cardiac compliance, structure and tissue biochemistry was studied in fish acclimated to 3 temperatures (5, 10 and 18° C), to simulate seasonal temperature fluctuation, on which 3 experimental techniques were then used: generation of pressure volume curves, tissue histology and tissue FTIR spectroscopy. Temperature acclimation had no effect on the cardiac compliance of the ventricle or the outflow tract (OFT), however, there did appear to be an alteration in atrial compliance. Temperature did not affect heart chamber morphology, but collagen density increased in the cold acclimated group, especially in the compact layer of the ventricle. Finally, FTIR spectra showed temperature dependent changes in amide I and amide II absorption bands indicating an increase in protein in the ventricle, a decrease in the OFT and the atrium remaining constant after cold acclimation. The conclusions agree with recent work suggesting temperature acclimation does not affect ventricular filling volume or pressure in addition to showing a remodeling response in the atrium and OFT as well as the ventricle, both of which have until recently been overlooked. Finally, we show the potential of FTIR to determine alterations in protein and metabolic state of fish cardiac tissue as well as suggesting changes in the underlying chemistry of the tissue may arise before morphological or physiological changes during cardiac remodeling.

P1.42 KEIL, K.E.*; OSBORN, K.J.; Oklahoma State University, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution; *katie.keil@okstate.edu*

Associations between hyperiid amphipods and gelatinous zooplankton

Hyperiid amphipods are pelagic crustaceans that associate with gelatinous zooplankton for food, protection, transportation, and provide a substrate for laying eggs. To further define the specificity of hyperiid and gelata associations, we combined lab work and analysis of Monterey Bay Aquarium Research Institute's (MBARI) remotely operated vehicle (ROV) video archives. We sorted through gelatinous specimens in the Smithsonian's Invertebrate Zoology collection to locate and identify hyperiids associated with salps, ctenophores, pyrosomes, and siphonophores. At MBARI, we reviewed a target dataset of ROV footage to view these associations in situ. We discovered 22 new hyperiid/gelata symbioses, identified the depth range of 6 hyperiid groups, and described specific behaviors (i.e. method of attachment) that help us understand the nature of these relationships. Ultimately, this information will be used to better understand how hyperiid morphology relates to these associations.

P3.92 KEIL, D.*; BELY, A.; University of Maryland, College Park; *dkeil@umd.edu*

The Correlates of Regeneration Loss in the Naididae

The ability to regenerate lost body parts is present across the Metazoa, although it varies widely both between and within phyla. The inferred ancestor of animals is thought to be capable of regeneration, as we observe regeneration in basal lineages and many bilaterians, but there have been subsequent widespread loss or reduction of regenerative ability in many lineages, including distantly related groups such as ecdysozoans, mammals, and leeches. We are interested in determining whether certain morphological and physiological characters correlate with regeneration loss in a group of closely related annelids, the Naididae, in which a spectrum of regenerative ability exists. Identifying the correlates of regeneration loss provides a background for understanding why and how regeneration losses occur.

S1.3−1 KELLER, TE; ZENG, J; MENDIZABAL, I; YI, SV*; Georgia Institute of Technology; *soojinyi@gatech.edu*

Epigenetics and Species Divergence

An important aspect of epigenetic inheritance is its pliability in response to changing signals from cellular environments. As such epigenetic modifications exhibit developmental− and cell type specific patterns that may underlie differentiation as well as phenotypic plasticity. Recently, however, a new aspect of epigenetic modification has emerged. Namely, epigenetic patterns also appear to be species−specific, and often exhibit remarkable degrees of conservation across long evolutionary timescales. In this talk we will discuss multiple examples of epigenetic modifications that originated in the distant past and have persisted in a conserved fashion to the present day. As a potential mechanism underlying such conservation, we will also discuss the impact of single nucleotide substitutions and other genetic factors in determining population−specific or species−specific patterns of DNA methylation and histone modifications. In turn, evolutionary dynamics of epigenetic modifications may drive important species−specific features. A particular example is that of the human brain. The Human brain represents an exceptionally rapid and dramatic functional innovation. Comparative studies of DNA methylation and histone modification between human and chimpanzee brains have identified hundreds of loci that exhibit differential levels of DNA methylation. These loci mark those genes associated with cognitive abilities, as well as human−specific neuropsychiatric diseases. Finally, fine−scale recombination rates, which are fundamental aspects of genome variation, appear to co−vary with species−specific patterns of epigenetic modifications. These studies highlight the significant role of epigenetic modifications in species divergence at both short and long evolutionary timescales. Thus epigenetic modifications may provide complementary aspect of evolution in addition to genomic and other functional studies.

P1.74 KELLY, S.A.*; BELL, T.A.; SELITSKY, S.R.; BUUS, R.J.; HUA, K.; WEINSTOCK, G.M.; GARLAND, JR., T.; PARDO−MANUEL DE VILLENA, F.; POMP, D.; Ohio Wesleyan Univ., Univ. of North Carolina, Chapel Hill, Washington Univ., St. Louis, Univ. of California, Riverside; *sakelly@owu.edu*

A novel intronic SNP in the Myosin heavy polypeptide 4 gene is responsible for the Mini−Muscle phenotype characterized by major reduction in hindlimb muscle mass in mice

Replicated artificial selection for high levels of voluntary wheel running in an outbred strain of mice favored an autosomal recessive allele whose primary phenotypic effect is a 50% reduction in hindlimb muscle mass. Within the High Runner (HR) lines of mice, the numerous pleiotropic effects (e.g., larger hearts, reduced total body mass and fat mass, longer hindlimb bones) of this hypothesized adaptive allele include functional characteristics that facilitate high levels of voluntary wheel running (e.g., doubling of mass−specific muscle aerobic capacity, increased fatigue resistance of isolated muscles, longer hindlimb bones). Previously, we created a backcross population suitable for mapping the responsible locus. We phenotypically characterized the population and mapped the *Minimsc* locus to a 2.6−Mb interval on MMU11 a region containing ~100 known or predicted genes. Here, we present a novel strategy to identify the genetic variant causing the mini−muscle phenotype. Using high−density genotyping and whole−genome sequencing of key backcross individuals and HR mice with and without the mini−muscle mutation, from both recent and historical generations of the HR lines, we show that a SNP representing a C to T transition located in a 709 bp intron between exons 11 and 12 of the *Myosin, heavy polypeptide 4, skeletal muscle* gene (*Myh4*; position 67,244,850 on MMU11; assembly, Dec. 2011, GRCm38/mm10; ENSMUSG00000057003) is responsible for the mini−muscle phenotype, $Myh4^{Minimsc}$.

29.1 KELLY, D.A.*; SHAH, C.; FORGER, N.G.; University of Massachusetts, Neuroscience Institute, Georgia State University; *dianek@psych.umass.edu*

Sex difference in neural activation within the mouse bed nucleus of the stria terminalis in response to estradiol

The principal nucleus of the bed nucleus of the stria terminalis (BNSTp) is a sexually dimorphic region of the mammalian forebrain that is larger in volume and cell number in males than in females, and contains neurons expressing sex steroid receptors. Circulating estrogens do not differ, on average, in gonadally intact male and female mice, but the expression of estrogen receptor alpha (ER±) in the adult BNSTp is markedly sexually dimorphic, with the area of ER± immunoreactivity (IR) in male mice less than 5% of that in females. We have demonstrated that this sex difference is caused by the suppression of ER± IR by testicular steroids in adulthood. However, it is not known whether the sex difference is functionally significant. To test this, we examined the immunoreactivity of c−Fos, a marker of neural activation, in response to an estradiol challenge. Gonadally intact mice of both sexes were sacrificed 90 minutes after a single dose of 5 ¼g/mL estradiol or the oil vehicle. We find a significant, greater than 2−fold induction in the number of c−Fos immunoreactive cells as well as increased colocalization of ER± and c−Fos IR in the BNSTp of estradiol−treated females that is not present in vehicle−treated females. In contrast, males treated with estradiol had no more c−Fos positive cells than either vehicle treated males or control females. Thus, the profound reduction of ER± IR in males correlates with lack of a response to an estradiol challenge, suggesting that neural function in the BNSTp of females, but not males is sensitive to acute changes in estradiol levels. Supported by NIMH R01MH068482.

50.6 KELLY, K.L.; GOLDING, C.; LOCKE, B.R.; DILLAMAN, R.M.; KINSEY, S.T.*; Univ. of North Carolina Wilmington, Wilmington, Florida State Univ., Tallahassee; *kinseys@uncw.edu*

Does Ca^{2+} diffusion limit myofibril size?

Tail beat frequency in fishes generally decreases with increasing body length, and it follows that the frequency of Ca^{2+} fluxes during muscle contraction−relaxation cycles decreases during growth as well. Since Ca^{2+} cycling is a reaction−diffusion process, both the catalytic and diffusion demands are therefore relaxed during animal growth. We examined structure−function relationships in the Ca^{2+} cycling system during post−metamorphic growth in white muscle from the black sea bass (*Centropristis striata*) to test the hypothesis that Ca^{2+} diffusion limits myofibril size. Isolated white muscle from juvenile fish was capable of higher contractile frequencies and had higher SR volume density, smaller myofibril diameter, and a greater percentage of fast isoforms of parvalbumin, compared to muscle from adult fish. We developed a reaction−diffusion mathematical model of a myofibril to simulate Ca^{2+} cycling in the juvenile and adult fish muscle, and the model force production curves paralleled that of the experimental data over a broad range of contractile frequencies. Within the physiological range of contractile frequencies, gradients in [Ca^{2+}] concentration were apparent, but [Ca^{2+}] nonetheless was sufficiently high to saturate troponin C. Further, the model contractile profile output was unaffected when diffusion was infinitely fast (reaction control only), suggesting a limited role for diffusion in governing contraction−relaxation cycles. This notion is supported by simulations using hypothetically large myofibrils, which remained fully functional. These results suggest that myofibril size is governed by the need to have adequate sarcoplasmic reticulum membrane surface area and Ca^{2+} pump activity.

101.3 KENALEY, C. P.*; LAUDER, G. V.; Harvard University; *cpkenaley@gmail.com*

Robotic Modeling of Prey−capture Mechanics in Fishes: The Role of Hyoid Musculature

Feeding in the vast majority of teleost fishes involves the generation of oral suction to draw prey into the mouth and subsequent rapid compression of the oral cavity to trap and process prey. Our current understanding of how fishes generate suction and compression is based on decades of research using a combination of techniques including high−speed videography, electromyography, sonomicrometry, and computational kinematic models. This body of research has culminated in widely accepted models of how each of the musculoskeletal and linkage elements in the teleost feeding system facilitate oral expansion and compression. Using data generated from a biorobotic model of the teleost feeding system based on the largemouth bass (*Micropterus salmoides*) and electromyography of live specimens, we show that the protractor hyoideus (PH), a muscle long associated with compression kinematics, plays an important role in expansion. Specifically, we suggest that active stiffening of the PH through eccentric contraction limits retraction of the hyoid during oral expansion and thus permits effective transfer of laterally directed forces to the suspensorium. This, in turn, permits lateral expansion of the oral cavity and enhances suction. Our results demonstrate that the functional role of motor components of the teleost feeding system may be multifaceted, and that a more thorough understanding of the contributions of specific mechanical linkages may be uncovered when robotic experimental systems are utilized.

20.6 KENKEL, CD*; ALMANZA, AT; MATZ, MV; The University of Texas at Austin; *carly.kenkel@gmail.com*

Local adaptation in a Caribbean coral is associated with gene expression plasticity

Understanding the mechanisms used by reef−building corals adapt to local conditions that vary in space can help refine predictions about how they will adapt in time to the effects of global climate change. In the Florida Keys, inshore patch reefs that are subject to high nutrient loads and thermal extremes host diverse coral communities, often with better cover than the more benign offshore reef tract. We preformed a reciprocal transplant of the mustard hill coral, *Porites astreoides* , between inshore and offshore reefs to test for local adaptation and identify the physiological mechanisms that enable this species to inhabit such disparate reef environments. Each reef site was represented by 15 colonies (genotypes), which were fragmented and outplanted at local and foreign sites. Following one year of transplantation coral energetic stores (total protein and lipid) and growth rates were significantly elevated in corals at their home reef site, consistent with local adaptation. Global gene expression profiling revealed significant differential expression in corals from different populations and in response to transplantation. Stress response genes were elevated in corals transplanted to the inshore reef site. Concomitantly, these genes were also constitutively up−regulated in inshore−origin corals, consistent with the front−loading hypothesis. Inshore−origin corals also appear to exhibit higher gene expression plasticity when transplanted to a novel environment than offshore corals, which may reflect acclimatization or adaptation to the environmental variability of their native reef site. Gene coexpression network analysis (WGCNA) revealed significant correlations between coregulated host gene groups and symbiont−related traits, which may reflect host regulation of intracellular symbiont populations.

P2.55 KENKEL, CD*; MATZ, MV; The University of Texas at Austin; *carly.kenkel@gmail.com*

Heritability of fitness−related traits in populations of Porites astreoides from different thermal environments

Determining the amount of genetic variability in traits under selection is essential for evaluating a population's potential for evolutionary change. However, additive genetic variation is sensitive to environmental condition and evolutionary predictions can be improved by understanding such effects. Predicting response to selection is particularly important for reef−building corals, which experience substantial environmental variation across species ranges and are undergoing climate change at an unprecedented rate. We evaluated variation in growth rate and survival in 38 families of recruits of the coral *Porites astreoides* obtained by settling larvae released by parent colonies originating from two different populations. Recruits were reared in common garden conditions for 5 weeks and then subjected to two thermal treatments (28°C and 31°C) for 2.5 weeks. Survival and growth were measured both pre and post thermal treatment for recruits and fragments of the parental colonies. The most significant parental effects were detected during the first 5 weeks: 95% of variance in survival and 42% of variance in growth rate of surviving recruits were explained by parental genotype. In the post−treatment measures these effects diminished such that only 16% of variance in growth rate was explained by parental genotype, of which 3% was attributable to parent origin (inshore or offshore). Still, juvenile growth rate remained positively correlated with parental growth rates. Unexpectedly, heat treatment did not result in any additional variance in recruit growth despite having a significant negative effect on parental growth. This result suggests that thermal stress does not affect fitness in juvenile *P. astreoides*, which may underpin the contemporary demographic success of this coral species.

100.2 KENNY, M*; PENDAR, H; ADJERID, K; SOCHA, JJ; Virginia Tech; *mck66@vt.edu*

What happens when pupae pump? Internal effects of abdominal movements in the beetle Zophobas morio

During metamorphosis, pupal insects exhibit an immobile stage, during which multiple physiological systems undergo extensive remodeling. However, the abdomen retains its ability to move and exhibits periodic contractions via the intersegmental muscles. These movements are postulated to regulate circulation and potentially to control respiratory ventilation. Despite extensive research on pupae, little is known about the volumetric deformation of the tracheal system. Generally, the lower metabolic demands of immobility are thought to limit the need for active ventilation. Here, we test the relationship between abdominal movement, internal pressure, and tracheal deformation to determine the role of active ventilation in the pupal life stage. Synchrotron x−ray imaging was used to visualize the internal body of darkling beetle pupae (*Zophobas morio*) at the Advanced Photon Source at Argonne National Laboratory. Simultaneously, hemolymph pressure and movement of the abdomen were recorded using a fiber optic pressure sensor and infrared sensor, respectively. During bouts of abdominal pumping, we observed pressure pulses on the order of 1−2 kPa, accompanied by correlated movements of the abdomen and the gut. Additionally, select tracheal tubes were compressed during some, but not all, pulsatory events. During rest between pulsations, all visible movements (both internal and external) were absent. In pupae approaching ecdysis, active abdominal pumping was more frequent and in some cases continuous, with a lack of resting stages. Tracheal compression was also observed to be more regular in pupae at this stage, suggesting that active ventilation becomes more prominent as the pupae approach the adult stage. Supported by NSF 0938047.

P2.156 KHAN, N/Y*; ROBERT, K; La Trobe University, Melbourne; *n2khan@students.latrobe.edu.au*

The Effects of Maternal Stress on Offspring in the Zebra finch Taeniopygia guttata

The stress response of the hypothalamic−pituitary−adrenocortical feedback system allows adaptive reactions to environmental challenges, such as resource availability, extreme weather and predation attempts. Acute stressors mobilise energy stores and redirect energy towards survival at the expense of body processes, namely growth, reproduction, and immune responses. These effects are short−term, where the system rapidly returns to baseline. However, extended activation of the HPA feedback system can be detrimental, affecting long−term fitness via immunosuppression, impaired reproductive systems, and eventually, death. This study examines the effect of repeated bouts of maternal stress during egg development on offspring sex ratios, clutch size, fertility, hatching success, and growth rates. Female Zebra finches *Taeniopygia guttata* were given three doses of the stress hormone corticosterone (CORT) daily during egg−laying to imitate an unstable environment. This method ensures physiologically relevant peaks and troughs in CORT concentrations. Here we show Zebra finch mothers dosed orally with CORT produce slightly larger clutches, and fertility is unaffected by treatment. However, CORT−treated clutches show significantly poorer hatching success, and much lower fertile hatchability, in comparison to the control group. Interestingly, CORT−treated clutches tend to be heavier than control clutches throughout their development. Parents appear to be favouring daughters, as female chicks are consistently heavier than males throughout development in both treatment groups. However, once juveniles are nutritionally independent, males catch up' in weight, and remain a similar weight to their female counterparts. Future research is identifying potential trans−generational effects, and changes to parental incubation and provisioning behaviour.

P3.176 KHURSIGARA, A.J.*; BRODEUR, L.K.; GERRY, S.P.; Fairfield University ; *akhursigara@student.fairfield.edu*

Jaw Muscle Activation in Freshwater Stingrays

Batoids (skates and rays) have specialized jaws that can function independently due to their cartilaginous skeleton, a lack of a ligamentous connection between the jaws and skull, and the presence of a highly flexible symphysis at the center of the upper and lower jaws. Bilateral implantation of the jaw muscles has lead to a greater understanding of the activity occurring on the left and right sides of the jaw during feeding events. A previous study has shown that skates activate their jaw muscles unilaterally without any activation of the contralateral side when processing complex prey. Therefore, the goal of our study was to investigate pairwise activation of the jaw muscles of a freshwater stingray *Potamotrygon motoro* when feeding on several prey types in order to determine if unilateral activation is a characteristic of batoid feeding mechanisms. We hypothesized that these rays would use synchronous activation when feeding on simple prey and unilateral activation to process complex prey. Electrodes were implanted bilaterally into three of the jaw adductors when the rays were fed three prey items of varying complexity. Two asynchrony indices were used to quantify the duration of muscle activation and the lag, or degree by which muscles are activated out of phase. Contrary to our hypothesis, data from two rays show that muscle pairs are activated synchronously for all prey types: there is no difference in duration or lag indices ($P > 0.05$). However, unilateral was sometimes observed when feeding on more complex prey. Further studies are needed to compare the variation observed in the feeding mechanisms of these two groups of batoids.

69.6 KILBOURNE, BM; Friedrich−Schiller−Universität Jena; *brandon.kilbourne@uni−jena.de*

Body mass, limb length, and limb mass and their role in locomotor specializations in terrestrial and semi−terrestrial mammals

Traditionally, broader, comparative assessments of limb specializations in terrestrial and semi−terrestrial mammals have focused on osteological measurements, most notably limb proportions. However, the mass of limbs and their constituent segments, which are inclusive of both hard and soft tissues, may also offer insight into the functional specializations of mammalian limbs, as relative muscle and bone size, as well as limb mass distribution, vary according to limb function. I performed a principal components analysis using data on body mass and fore− and hindlimb length and mass from 44 species of terrestrial mammals to determine whether whole limb design differentiates species according to the following specializations: cursorial, natatorial, fossorial, and scansorial. PC−1 represents overall species size in terms of all five variables. Though PC−1 represents 98% of the cumulative variance, PC−2 represents limb length relative to body and limb mass. PC−3 represents a trade−off between fore− and hindlimb mass. At one extreme of PC−3 are taxa possessing relatively more massive and longer forelimbs for digging or capturing/restraining prey, whereas at the other extreme of PC−3 are taxa with forelimbs reduced in length or mass relative to hindlimbs. Interestingly, in a morphospace plot of PC−1 vs. PC−2, cursorial taxa are separate from non−cursorial taxa, which all tend to overlap. The occupation by cursors of a distinct and separate region of morphospace suggests that body size and the length of limbs relative to mass traits contribute to the overall morphology of taxa that are specialized for locomoting at high speeds or long distances. Thus in order to better understand how limb design varies among different mammalian species, mass traits should be investigated alongside purely osteological traits.

131.3 KILVITIS, H.J.*; LIEBL, A.L.; MARTIN, L.B.; Univ. of South Florida; *hkilviti@mail.usf.edu*

Stress−immune interactions in a range−expanding bird: covariation in stress hormone and Toll−like receptor expression

The physiological traits that promote vertebrate range expansions are just beginning to be revealed. In Kenya, the site of a recent range expansion of one of the world's most ubiquitous birds, the house sparrow (*Passer domesticus*), regulation of glucocorticoids and the innate immune system appear integral to colonization success. In populations at the Kenyan range edge, birds release abundant corticosterone, the main avian stress steroid, when exposed to mild, short−term stressors; additionally, their circulating leukocytes also express high levels of Toll−like receptors (TLR) 2 and 4, molecules that enable the immune system to detect Gram−positive and negative bacteria, respectively. Although the immune and endocrine systems may have distinct functions to promote success in new areas, we asked whether positive covariation between these receptors might also manifest along the range expansion. Whereas some level of inflammation is protective, high TLR−2 and TLR−4 expression could lead to excessive pro−inflammatory cytokine production, escalating the risk of collateral damage. Such risks are particularly large in areas where novel parasites, which often cause damage via inflammatory exuberance, are most common. We therefore asked whether TLR expression in macrophage−dense tissues (i.e., livers and spleens) covaried with expression of glucocorticoid and mineralocorticoid receptor expression. Our goal was to discern whether the costs of inflammatory responses were offset in range−edge sparrows by high expression of receptors for immunosuppressive glucocorticoids. In older populations, we expected comparable co−expression but at lower magnitudes for both TLRs and GR/MR. Analyses are ongoing.

S5.2−3 KIM, Sangbae; Massachusetts Institute of Technology; *sangbae@mit.edu*

How to build robots from the lessons from animals: design challenges of the MIT Cheetah

In designing a new generation of legged robots, it is critical to understand the design principles employed by animals. One of the key steps to successful development of such bio−inspired robots is to systematically extract relevant biological principles, rather than direct copying features of an animal solution, which may be impossible to realize or irrelevant in engineering domain. The talk will introduce several examples that successfully implement bio−inspired design principles learned from animals. Our highlighting example is the development of the MIT Cheetah, currently running at 13.5mph with a locomotion efficiency rivaling animals. Three research thrusts of the MIT Cheetah will be discussed: optimum actuator design, biotensegrity structure design, and the momentum balancing control architecture for a fast and stable gallop. Each research component is guided by the biomechanics studies of runners such as dogs and cheetahs capable of fast running on rough and unstructured terrains. Through this project, we seek to derive design principles of quadrupedal locomotion that share characteristics with available mechanical and electrical capabilities in order to develop most efficient, robust robots, which will be part of our life in the future.

P1.139 KIMMITT, A.A.*; DOLBY, A.S. ; O'DELL, D.A. ; CARLO, M.A. ; Indiana University, Bloomington, University of Mary Washington, Clemson University ; *aakimmitt@gmail.com*

Handling prior to blood sampling relates to corticosterone but not to heat shock protein 60 in the Tufted Titmouse

In past studies, corticosterone (CORT) has been used as the primary indicator of chronic stress in birds. CORT, however, responds to acute distress caused by handling, which can provide logistical challenges in circumstances where capture and sampling are difficult to quickly achieve. Heat shock proteins have received increasing attention as potential indicators of chronic stress, but remain understudied, particularly in birds. Further, little is known about their response to handling time. In this study, we investigated heat shock protein 60 (Hsp60) as an alternative indicator of stress. We compared the response of CORT and heat shock protein 60 (Hsp60) to handling time. Blood samples were collected from Tufted Titmouse (*Baeolophus bicolor*) that were captured in mist nets following visits to winter feeding stations. The time in which birds were handled prior to blood sampling varied. We used ELISAs to assay for CORT and Hsp60 concentrations. CORT levels were significantly correlated with handling time ($p < 0.001$), but Hsp60 concentrations were not significantly correlated with handling time. ($p=0.754$). The hypothesis that Hsp60 is less sensitive than CORT to acute distress caused by handling was supported by our results. Researchers may consider evaluating both heat shock proteins and CORT in the future, to yield a more comprehensive evaluation of stress, especially in situations when handling time may be inconsistent.

11.7 KINGSOLVER, JG*; BUCKLEY, LB; Univ. of North Carolina, Chapel Hill, Univ. of Washington, Seattle; *jgking@bio.unc.edu*

Climate variability may limit evolutionary adaptation to climate change in alpine butterflies

Evolutionary potential will be important for the many alpine organisms with limited ability to track long−term climate change via movement. We integrate biophysical, demographic and evolutionary models to explore selection and evolution of wing melanin on the ventral hindwings in an alpine butterfly, *Colias meadi,* in response to recent and future climate changes. Higher levels of wing melanin increase the absorption of radiation and can dramatically increase body temperatures. The fitness surface (fitness as a function of wing melanin) has a single peak as a result of two opposing factors: wing melanin increases activity times and reproductive success in cool conditions, but can reduce egg production and adult survival due to short−term overheating. Preliminary results suggest that the location of the fitness peak varies substantially between years, producing temporal variation in the magnitude and direction of selection. Recent and future climate warming are predicted to cause directional evolutionary reductions in mean wing melanin, but evolutionary adaptation of alpine butterflies to climate change may be strongly limited by seasonal and annual variability in temperature and cloudiness in alpine regions.

38.7 KINGSTON, A*; CRONIN, T; Univ. of Maryland, Baltimore County; *anahm1@umbc.edu*

Visual opsins in non−visual photoreceptors: A common solution for extraocular light detection

Non−visual photoreceptors are common throughout the animal kingdom. Most previously described non−visual photoreceptors function using opsins that are not typically used for vision. However, recent work shows that conventional visual pigments exist and function in some non−visual photoreceptors, and we have discovered the presence of visual opsins in a number of non−visual photoreceptors. Crayfish (*Procambarus clarkii*) have a photoreceptor in the 6^{th} abdominal ganglion that has been previously characterized both physiologically and behaviorally. We used molecular tools to identify a single opsin in the 6^{th} abdominal ganglion that is likely to be associated with this photoreceptor. This opsin has the same predicted amino acid sequence as the long wavelength−sensitive opsin found in R1−7 cells in the retina. Furthermore, we have identified the same opsin in each individual ganglion of the nerve cord as well as in the brain, which suggests that the entire ventral nerve cord is light sensitive. In coleoid cephalopods, we have isolated visual opsins from the skin of several species. In the squid *Doryteuthis pealeii*, evidence suggests that the same opsin is coupled to a typical rhabdomeric−type visual phototransduction cascade in both the retina and skin. It now appears that the use of visual opsins for non−visual tasks is common, and that many animals employ the same visual pigments for both vision and for extraocular light detection.

P1.18 KIRCHER, BK*; JOHNSON, MA; Trinity University; *bkircher@trinity.edu*
Why does the curly tail lizard (Leiocephalus) curl its tail? An assessment of social and predatory interactions
Animal display behaviors are used to convey specific messages to other animals, including potential mates, rivals, and predators. However, because these different types of interactions can be mediated by a single behavioral display, or conversely, multiple signals can be used to convey one specific message, interpretation of any particular behavioral display can be difficult. *Leiocephalus* lizards (i.e., curly tails) provide a unique opportunity to study the use of display behavior across social contexts. Previous research has demonstrated that the use of tail−curling is associated with predation risk, but little is known regarding the use of this behavior in other social contexts. The goal of this study was to determine to what extent the tail−curling display behavior is used to mediate both social and predatory interactions in two species, *Leiocephalus barahonensis* (the orange−bellied curly tail, Dominican Republic) and *L. carinatus* (the northern curly tail, Bahamas). We found that in lizards of both species, tail−curling was used in both social and predatory interactions, while associated head−bobbing behaviors occurred only in interactions with conspecifics. Further, tail−curl intensity did not differ between individuals involved in social encounters and those that were not. *Leiocephalus carinatus* exhibited greater intensity of tail−curl upon fleeing from a human predator than during undisturbed observations, while *L. barahonensis* demonstrated no differences in tail−curl intensity between the two situations. These results suggest that tail−curling behavior, while consistently a component of interactions with potential predators, is not a necessary component of social interactions.

17.2 KIRKTON, S. D.*; CARROLL, J. P.; Union College; *kirktons@union.edu*
Effect of gravidity on jump performance and muscle physiology in the American locust
Trade−offs exist between different physiological characteristics. In terrestrial animals, the trade−off between gravidity (or load) on striding locomotion has been well documented. However, the effect of load on jumping performance is relatively unknown. In lizards, an increased load equal to 30% of body mass produced shorter and less frequent jumps. However in *Schistocerca americana* grasshoppers, 20% heavier gravid females have a similar jump performance as non−gravid females. We tested the hypothesis that grasshoppers vary their jumping muscle contraction duration to increase force produced when gravid (or loaded). We examined the effect of added mass on jump performance by attaching weights (20% or 40% of body mass) to gravid females, non−gravid females, and males. We used high speed video analysis to compare jump performance and electromyography to measure jumping muscle contraction times. Controls indicated that a 30 minute rest after electrode implantation was sufficient for the grasshoppers to regain their jumping ability. Results indicate that muscle contraction duration increases with increased weight. Thus, gravid (loaded) and non−gravid grasshoppers are equally capable of escaping predation. Unlike lizards, grasshoppers may show no effect of loading on jump performance because they use a catapult mechanism to store energy prior to jumping. Support was provided by Union College Student Research Grants.

108.6 KIRSCHMAN, L.J.*; FRITZ, K.F; WHILES, M.R.; WARNE, R.W.; Southern Illinois University; *l.j.kirschman@gmail.com*
The effects of stress on nutrient stoichiometry in larval amphibians and the resulting influence on ecosystem processes
The effects of environmental stressors, particularly low−level, chronic stressors, are not always apparent in populations or communities. A population may be robust and appear healthy, but the majority of individuals may be living in altered physiological states that influence metabolic and nutrient processes. Stressed populations may also affect their environment through altered patterns of nitrogen excretion and nutrient transfers to other trophic levels. These dynamics may substantially alter nutrient availability in aquatic ecosystems, potentially affecting functions such as decomposition and primary production. Amphibian larvae, which are often abundant in freshwater habitats, can operate at multiple trophic levels and significantly influence nutrient cycling. Investigating how environmental stressors may alter the physiological state of these abundant consumers is central to understanding how they can influence ecosystem processes. We used mesocosm experiments to examine the effects of experimentally induced physiological stress, induced through chronic exposure to exogenous cortiscosterone or invertebrate predator cues, on the nutrient stoichiometry of wood frog larvae (Rana sylvatica) tissues and excretion. We also examined the effects of tadpoles on leaf litter decomposition and microbial respiration.

30.4 KITAYSKY, AS*; SCHULTNER, J; WELCKER, J; YOUNG, R; Univ. of Alaska, Fairbanks, Norwegian Univ. of Science and Technology, Trondheim, Norwegian Polar Institute, Tromsø; *askitaysky@alaska.edu*
Mechanistic links between evironmental variability and life−history strategies
Understanding the causal factors and proximate physiological mechanisms leading to variation in animal life−history strategies is of central importance to our understanding of the effects of climate change on wild animal populations. This study examines effects of a common environmental stress−or, i.e. nutritional stress, on patterns of reproduction and aging of a long−lived organism, the black−legged kittiwake, that exhibits opposing life history strategies between Pacific and Atlantic Ocean populations. Within the framework of the metabolic theory of aging and the rate−of−living hypothesis, kittiwakes have been shown to be "faster−lived" in the Atlantic than the Pacific. We will discuss observational and experimental evidence for the functional relationships among stress endocrinology, metabolism, survival and telomere dynamics of a long−lived organism living under differing environmental conditions.

104.5 KLAASSEN VAN OORSCHOT, B*; MISTICK, E; TOBALSKE, B; Univ. of Montana, Harvard Univ.; *brett.kvo@umontana.edu*

The aerodynamic effects of morphing wings during flapping and gliding flight

Dynamic changes in wing shape are characteristic of bird flight, and it is generally hypothesized that these changes in morphology allow birds to modulate aerodynamic force production across a range of flight styles, including flapping take−off and gliding flight. While birds are commonly seen morphing their wings, the underlying aerodynamic effects influencing a bird's choice to modify wing shape remains unclear. Here, we measure aerodynamic forces of extended and swept wings in raptors across three orders (Falconiformes, Accipitriformes, and Strigiformes), ranging in body mass from 56 g to 763 g. We dried wings from the same individual in extended and swept configurations and then simulated gliding flight using a wind tunnel and flapping take−off flight using a propeller model. Our results show that extended wings produce greater absolute forces in both gliding and flapping flight, a result that is concomitant with increased surface area. However, once surface area was normalized, swept wings produced more lift and less drag than their extended counterparts during gliding flight when attack angles were greater than ~20 degrees. Conversely, during flapping flight, the extended wings still outperformed the swept wings across all angles of attack. In gliding flight, extended wings marginally outperformed swept wings at angles less than ~20 degrees. Our results suggest the presence of leading−edge vortices (LEVs) on the swept wings during gliding flight. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE−0809127 and DGE−1313190 and the Herchel Smith−Harvard Undergraduate Science Research Program.

S9.1−4 KLASING, K. C.; Univ. California, Davis; *kcklasing@ucdavis.edu*

Costs of Income Versus Capital Provisioning of Nutrients for Immune Defenses in Birds

An important life history variable is recognized between species that provision offspring using energy gained concurrently (income breeders) and those that provision offspring using energy stores accumulated at an earlier time (capital breeders). Life history variability in the temporal investment in immunity has received very little attention. Previously we examined levels of innate immune defenses of 35 species of temperate and tropical birds and found evidence for an income−capital investment axis. Some species invested constitutively to maintain relatively high circulating concentrations of protective proteins (income defenders), whereas other species maintained low levels until the time of a challenge and then martialed stored resources to quickly bolster defenses (capital defenders). In general, species with higher adult body weight were more likely to be capital defenders. In order to examine the nutritional demands of a capital defense strategy we measured the amount of nutrients needed for a vigorous response to a bacteria challenge in adult healthy chickens. We found that the amount of nutrients needed to mount a large innate immune response was 88% higher than expected due to a mismatch in the balance of essential amino acids in the leukocytes, protective proteins and hepatic tissue accreted for the innate response relative to the storage tissue (e.g. skeletal muscle) that releases these amino acids. This mismatch was driven primarily by the very high levels of cysteine in the protective and antioxidant proteins and peptides accreted during the protective response.

14.5 KLEINTEICH, T; CONWAY, KW; SUMMERS, AP*; Kiel Univ., Germany, Texas A&M Univ., College Station, TX, Univ. Washington, Seattle, WA; *tkleinteich@zoologie.uni−kiel.de*

How do these fish suck? The anatomy and function of the clingfish suction disk

The Northern Clingfish (*Gobiesox maeandricus*) uses a suction disk to adhere itself to rocks in the intertidal zones of the Pacific Northwest. Although it is obvious that the suction disk is built from elements of the paired fins and their adjacent girdles, its function in generating and maintaining negative pressure remains cryptic. We combined high−resolution µCT imaging, 3D printing, high−speed videography, and enzyme clearing and double staining to reveal the functional morphology of the clingfish suction disk. We co−registered two µCT datasets of the same individual to visualize hard and soft tissues simultaneously. Based on the µCT data, we identified all bones and muscles related to the suction disk and prepared a twenty times up scaled physical model with a 3D printer. We found that the pelvic basipterygia are elongated and flattened along the anterior−posterior axis. The basipterygia of the left and the right sides of the body meet along the ventral midline of the fish and can be folded against each other. Folding of the basipterygia will raise the inner surface of the suction disk, which can either increase negative pressure or aid in a pumping mechanism to evacuate the suction disks chamber. An array of muscles that connects the ventral aspect of the pelvis to the proximal and ventral base of the third pelvic fin ray will pull the basipterygia towards the substrate and extrude water from under the suctorial disk while in contact with the substrate. The fourth pelvic fin ray closes the gap between the anterior and posterior lip of the adhesive disk and thus controls venting. Rotation of the dorsal postcleithrum around a joint with pectorial radial four is likely to be important for pulling the posterior lip of the adhesive disk off the substrate during detachment.

55.5 KLOK, CJ*; CAMPBELL, J; DUELL, M; HARRISON, JF; Arizona State University; *cjklok@asu.edu*

Critical oxygen partial pressures during rest and flight in giant scarabaeoid beetles

Prior studies showed that safety margins for oxygen delivery, or the critical partial pressure of oxygen (CritPO_2), is independent of size during low metabolic demand (rest') in adult insects in size ranges up to 4 grams. In this study we expand the upper size limit by an order of magnitude investigating CritPO_2 in a series of scarabaeoid beetle species ranging from 0.5 to 40 grams, to test whether this size independence remains valid for insects of gigantic proportions. Here we measured low metabolic demand CritPO_2, using flow through respirometry and dynamic oxygen reduction, and (for some species) added high metabolic demand measures by determining CritPO_2 during tethered flight. The flight CritPO_2 was determined using a low friction flight mill, logging air oxygen partial pressures, flight speed, and flight duration during normoxic control flights and dynamic oxygen reduction CritPO_2 flights. Our results indicate that the size independence of CritPO_2 holds for all species in this increased size range with CritPO_2 at rest of <1.5 kPa and flight CritPO_2 values of ~10 kPa. This would suggest that the larger species have to employ various compensatory mechanisms to overcome the distance dependent constraints on oxygen delivery that may include tracheal hypermetry and increased ventilation. This research was partially supported by NSF IOS 1122157 to JFH and CJK.

89.8 KNAPP, R.*; CURETON II, J.C.; BROUGHTON, R.E.; Univ. of Oklahoma; *rknapp@ou.edu*

Hormones and parental care in fishes

Although John Wingfield is best known for his groundbreaking work in avian environmental endocrinology, for his dissertation research he examined seasonal changes of steroid hormones in a flatfish, the plaice *Pleuronectes platessa* (Wingfield and Grimm 1976, 1977). The methodological approach he developed in that research has greatly facilitated advances in our understanding of environmental and behavioral endocrinology in all vertebrate clades over the subsequent decades. In this presentation, we will summarize the current state of our understanding of hormonal mediation of parental care in bony fishes in the context of the new phylogeny and recent reclassification of this clade (Broughton et al. 2013, Betancur−R et al. 2013; see also poster by Cureton et al. at this conference). We focus on several species that have been relatively well−studied in this regard. In particular, we examine whether endocrine mediation of paternal behavior differs between species in which courtship and parental care are exhibited sequentially versus simultaneously. We will conclude by identifying fruitful avenues for future research into endocrine contributions to the expression of parental care in fishes.

P1.168 KNOTT, KE*; KESANIEMI, J; BANTA, GT; HANSEN, BW; University of Jyvaskyla, Finland, Roskilde University, Denmark, Roskilde University, Denmark; *emily.knott@jyu.fi*

High relatedness and chaotic genetic patchiness of a polychaete in a heterogeneous estuarine landscape

Population genetic structure in marine organisms frequently defies clear explanation and is described as chaotic genetic patchiness. In these cases, patterns of genetic structure may be determined by barriers to dispersal that are difficult to observe, e.g., those created by variable oceanic currents or by the behavior of dispersive larvae and adults. We examined population genetic structure using seven microsatellite loci in the polychaete *Pygospio elegans*, sampled from 16 sites in a heterogeneous estuarine landscape in Denmark. Most samples showed significant pairwise Fst and Jost's D values and there was no indication of isolation by distance. Using GESTE, we calculated sample−specific Fst values, which characterize how the samples differ from the metapopulation as a whole. Variation in these estimates was not explained by environmental variables, such as salinity, substrate, and distance from the mouth of the estuary. The samples most dissimilar in terms of observed allele frequencies, and those with high estimated numbers of siblings, had larger sample−specific Fst. We hypothesize that polymorphism in the developmental mode of *P. elegans*, which produces both dispersive and brooded larvae, contributes to chaotic genetic patchiness in this estuarine landscape. The large numbers of siblings estimated within samples could reflect high local recruitment of brooded larvae, despite effective dispersal and high gene flow via planktonic larvae.

P3.191 KO, J.H.*; KOHN, A.B.; MOROZ, L.L.; Massachusetts Institute of Technology, Cambridge and Whitney Laboratory for Marine Bioscience, St. Augustine, FL, Whitney Laboratory for Marine Bioscience, St. Augustine, FL; *kojulieh@mit.edu*

Quest for Neurogenic Genes in Ctenophores

The ctenophore *Pleurobrachia bachei* is a basal metazoan with a relatively simple nervous system that consists of subepidermal and mesogleal nets and the aboral organ, an analog of an elementary brain. The initial analysis of the recently sequenced *Pleurobrachia* genome suggests an enormous degree of parallel evolution of neural organization, and no pan−neuronal genes have yet been identified in ctenophores. The aim of this study was to find neuronal markers in *P. bachei*. Specifically, we cloned and, by in situ hybridization, characterized the expression of two candidate genes, Neuroglobin and Musashi3. In bilaterians, both are conservative neural genes − Neuroglobin is most likely involved in oxygen transport in the brain, and Musashi3 is a neural RNA binding protein. We find that Neuroglobin is expressed in the comb plates and individual, unknown cells around the comb plates. Musashi3 is expressed in the aboral organ, polar fields, and combs; however, its expression is not localized in recognized neural type cells in the aboral organ and polar fields. The results for both genes suggest that unlike in other metazoans, Neuroglobin and Musashi3 are not expressed in neurons. They also provide additional support for two related hypotheses − one, that ctenophores are the most basal branching metazoans; and two, the ctenophore nervous systems might have evolved independently from the rest of animals.

P1.160 KO, A*; CHENG, C; CHAIEB, L; KOYAMA, T; MIRTH, C.K.; SMITH, W.A.; SUZUKI, Y; Wellesley College, Instituto Gulbenkian de Ciência, Northeastern University; *ysuzuki@wellesley.edu*

The role of the POU factor Ventral veins lacking in the regulation of metamorphosis initiation

Metamorphosis and puberty are characterized by dramatic morphological and behavioral changes, and their regulation and evolution continues to be a puzzling scientific enigma. In insects, the timing of metamorphosis is regulated by the interaction between juvenile hormone (JH) and ecdysteroids. Here we show that the POU transcription factor Ventral vein lacking (Vvl) plays an important role in regulating the onset of metamorphosis. Silencing Vvl expression using RNAi interference (RNAi) resulted in the induction of precocious metamorphosis in *Tribolium castaneum* and a reduction in the expression of the JH−inducible gene *kruppel homolog 1 (kr−h1)*. Topical application of JH on individuals lacking Vvl delayed the onset of metamorphosis and rescued the normal expression of *kr−h1*, indicating that JH levels are reduced in *vvl* RNAi animals. Furthermore, the expression of the JH biosynthesis enzyme coding gene *jh acid methyltransferase 3* also decreased with *vvl* knockdown. Interestingly, in addition to inducing precocious metamorphosis, molting was also inhibited in *vvl* RNAi animals. Since molting is regulated by ecdysteroids, the activity of ecdysteroid signaling pathway was examined in *vvl* knockdown animals. Consistent with this hypothesis, ecdysone response gene expression was decreased in *vvl* RNAi animals. Vvl was also found to interact with Ecdysone receptor and its heterodimeric partner, Ultraspiracle. Finally, ecdysone titers were lower in *vvl* knockdown animals. Thus, Vvl influences both JH and ecdysone signaling and biosynthesis, potentially acting as an integrator of both hormonal pathways to regulate the metamorphic onset.

94.1 KOCH, R.E.*; HILL, G.E.; Auburn University; *rek0005@auburn.edu*
Effects of domestication on sexual dichromatism in the island canary
In many songbird species, males exhibit flashier and more colorful plumage than females. This sexual dichromatism is commonly accepted to arise through sexual selection, though research on the topic is heavily biased toward largescale phylogenetic analyses. Domestic species present an interesting but rarely studied system in which reproductive success is determined not by natural and sexual selection but by artificial selection for traits considered desirable by humans. In domestic individuals, we may therefore examine how sexually dichromatic traits evolve when released from the selection pressures presented by male−male competition, female mate choice, and predation. We investigated the effects of domestication on sexual dichromatism in the island canary (*Serinus canaria*), the only songbird that has been bred in captivity over several centuries to produce a multitude of domestic breeds. We used a reflectance spectrometer to quantify dichromatism in the wild progener population of canaries and in captive canaries bred for bright yellow plumage coloration. The sexual dichromatism evident in wild canaries is no longer detectable in modern domestic breeds, indicating the powerful effects of artificial selection and captivity on the coloration of both sexes in this species. The implications of loss of sexual dichromatism in captive breeds of canaries on evolution of dichromatism will be discussed.

P3.100 KOCH, BJ*; SCHNITZLER, CE; GILDEA, DE; HENRY, JQ; MARTINDALE, MQ; BAXEVANIS, AD; BROWNE, WE; Natl. Human Genome Res. Inst., NIH, Univ. of Illinois, Urbana−Champaign, Whitney Lab. for Marine Biosci., Univ. of Florida, Univ. of Miami; *bernard.koch@nih.gov*
Differential Gene Expression During Early Embryogenesis in the Ctenophore Mnemiopsis leidyi
Mnemiopsis leidyi is a lobate ctenophore found in near−shore waters of the western Atlantic Ocean. Despite being one of the five extant deep metazoan lineages, little is known about many aspects of ctenophore development, including gene expression in the early embryo. To better understand the developmental genetic changes that occur during early *Mnemiopsis* embryogenesis, we performed RNA−seq experiments comparing gene expression between the zygote and 8−cell stage embryo, when the first asymmetric cell divisions occur. In addition to collecting multiple bioreplicates of these stages, we experimentally isolated E and M blastomeres from 8−cell embryos for a total of four experimental conditions. We pooled RNA−seq reads from all conditions to assemble a *de novo* reference transcriptome using the Trinity assembler. Our assembly contains 20,424 unique transcripts and rates highly in terms of contiguity, with an N50 of 2,245 bp. It also includes near−full length transcripts for 234 of the 248 CEGMA core eukaryotic genes, suggesting the assembly is not only contiguous, but also complete and accurate. Most importantly, we were able to map an average of 91% of our RNA−seq reads back to this assembly per sample, indicating that it successfully captures the diversity of our conditions. The DESeq and edgeR algorithms were used to assess differential expression among the four conditions. DESeq produced more conservative results than edgeR, detecting fewer differentially expressed genes between the zygote and the 8−cell embryo. This study is one of the first significant attempts to comprehensively characterize developmental gene expression in a ctenophore.

P1.91 KOENIG, KM*; MEYER, E; GROSS, JM; University of Texas, Austin, Oregon State University; *kmkoenig@utexas.edu*
Evolution and Development of Photoreceptor Cells in the Single−Chambered Eye of the Squid Doryteuthis pealeii
In comparing the development of complex organ systems across the Metazoa, it is often necessary to understand conservation from a cellular perspective. It is this perspective that has identified cellular homologies between the single−chambered vertebrate eye and the compound Drosophila eye. We aim to better understand the evolution and development of complex image−forming eyes across the Metazoa by studying the single−chambered eye of the squid, *Doryteuthis pealeii*. To dissect the molecular underpinnings of eye development in *D. pealeii*, we sequenced the embryonic transcriptome and performed RNA−seq studies of isolated eye and optic lobe tissues from developing embryos, quantifying changes in gene expression over time. These analyses revealed multiple members of the Notch signaling pathway to be expressed early in the optic placode and later, after eye vesicle closure. Functional perturbation of the Notch pathway suggests that Notch signaling is necessary for photoreceptor cell differentiation in the retina of *D. pealeii*. With the known involvement of Notch signaling in the differentiation of photoreceptor cells in both the vertebrate and Drosophila eye, this work provides greater insight into questions concerning parallel and convergent evolution of specific organ systems.

86.1 KOHL, K.D.*; WEISS, R.B.; COX, J.; DALE, D.; DEARING, M.D.; Univ. of Utah; *kkohl78@gmail.com*
Gut microbes mediate plant−animal interactions with respect to dietary toxins
The foraging ecology of mammalian herbivores is strongly shaped by plant secondary compounds (PSCs) that act to defend plants against herbivory. Nearly forty years ago, ecologists Freeland and Janzen hypothesized that gut microbes allow animals to feed on toxic plants. However, this hypothesis has not been tested in a wild herbivore feeding on a complex of PSCs. We investigated the gut microbiota of the desert woodrat (*Neotoma lepida*), some populations of which specialize on highly toxic creosote bush (*Larrea tridentata*). We demonstrated that the gut microbiota is critical in allowing herbivores to feed on toxic plants. The foregut microbiota exhibited an increased abundance of genes associated with the metabolism of toxic compounds when woodrats were fed creosote PSCs. Treatment with a broad−spectrum antibiotic decreased the ability of woodrats to ingest creosote bush. In addition, natural populations of *N. lepida* that had no prior experience with creosote bush and are thus naïve to its PSCs, exhibited increased toxin tolerance when inoculated with microbes from experienced individuals. These animals eliminated creosote PSCs through unique detoxification routes as determined by metabolomic analysis of the urine. These results demonstrate that microbes can enhance host tolerance to PSCs and thus, potentially expand the dietary niche breadth of wild mammalian herbivores. Furthermore, microbial transfers represent a mechanism by which wild herbivores may rapidly adapt to novel and more potent PSCs brought about by environmental changes.

P2.115 KOHL, K.D.*; AMAYA, J.; DEARING, M.D.; MCCUE, M.D.; Univ. of Utah, St. Mary's Univ.; *kkohl78@gmail.com*
Prolonged fasting and starvation alter gut microbial communities: a comparative study of host animals from five vertebrate classes
The number of microbial cells in the guts of animals is often greater than that of the host animal. In nourished animals these microbial communities may function like an organ and provide services including protection from pathogens, production of essential vitamins, degradation of toxic substances, digestion of refractory compounds, and regulation of gastrointestinal motility. Changes in the macronutrient composition of the diet are well known to influence microbial community structure, but little is known about how the microbiome responds to starvation − a situation where the microbes encounter diminished nutrient and habitat resources and increased interspecific competition. We documented the sequential changes in the colonic microbiomes at four predetermined time points from animals representing five classes of vertebrates fasting for different periods: tilapia (21 d), toads (21 d), leopard gecko (21 d), quail (6 d), and mice (3 d). Microbial 16S rRNA genes were amplified and sequenced; QIIME was used to analyze changes in the relative abundances of major taxa and several measures of biodiversity within the microbial communities. We found differences in the starvation−induced changes in the microbiome among the different species. Preliminary results indicate a rapid change in the microbial community following fasting, with subtle changes occurring through prolonged starvation. For example, after one day of fasting, mice exhibited an increase in the relative abundance of Bacteroidetes, and a decrease in the abundance of Firmicutes and Tenericutes. This study demonstrates that short−term food restriction can alter microbial communities, and perhaps the services they provide to their hosts.

74.3 KOHL, ZF*; ELSEY, RM; CROSSLEY II, DA; University of North Texas, Louisiana Department of Wildlife and Fisheries; *zac.f.kohl@gmail.com*
Differential vascular perfusion in response to bouts of acute hypoxic exposure in embryonic American alligators.
American alligators develop in mound nests and are subject to environmental challenges such as reduced oxygen levels from which they cannot escape. The central focus of our research group is to understand the modifications in cardiovascular function to persist through those environmental insults. Previously we have focused on embryonic blood pressure and heart rate responses to acute and chronic hypoxia, documenting the ontogeny of cardiovascular regulation and function. However our understanding of preferential vascular perfusion during bouts of reduced oxygen is limited. Here, we assess the capacity of embryonic alligators to regulate blood flow distribution using microsphere distribution technique. Blood flow distribution was measured in normoxia and acute 10% hypoxia in embryos at 70 and 90% of age incubated in normoxia or chronic hypoxia. The regulatory capacity was assessed via pharmalogical manipulation with the nitric oxide synthase inhibitor L−NAME or the alpha−receptor blockade agent phentolamine. Treatment with L−NAME resulted in an acute sustained hypertension while alpha blockade resulted in the opposite response. The patterns of blood flow distribution will be discussed.

32.1 KOHN, A.B.*; MOROZ, L.L.; UF, Whitney lab, UF, Whitney lab and Dept of Neuroscience; *abkohn@msn.com*
Origin and Lineage−Specific Evolution of Ligand−gated Ion Channels in Basal Metazoans and Bilaterians
Ligand−gated ion channels (LGICs) or ionotropic receptors are transmembrane ion channels that are opened or closed in response to the binding of a chemical messenger such as a transmitter or signaling peptide or even metabolite and protons. They are vital for virtual all aspects of neural signaling and nervous system evolution. There are three major classes of such ionotropic receptors: cys−loop receptors, ATP−gated channels, ionotropic glutamate receptors, etc. − with over 70 LGICs in humans. Here, we have reconstructed the evolution of major families of these channels with an evidence of parallel recruitment of different transmitter systems in both basal metazoans and different bilaterian lineages. Specifically, we used information from two newly sequenced genomes of the ctenophore *Pleurobrachia bachei* and the sea slug *Aplysia californica* as well as from more than three dozen deep transcriptomes from both basal metazoans and bilaterians (focusing on Lophotrochozoa). For example, the ctenophore genomes and their transcriptomes do not have cys−loop receptors; however there is a considerable diversity within other classes of receptors, significantly greater than previously described for any other basal metazoan. We also showed that the cys−loop receptors are underrepresented in many lophotrochozoans including *Aplysia*. In contrast, ionotropic glutamate receptors (iGluR) underwent an extraordinary expansion in both ctenophores and molluscs with numerous lineage−specific innovations and the origin of new iGluR classes that are missing in vertebrates.We also showed that the increase in a complexity of some iGluRs is based upon different molecular mechanisms suggesting an independent origin of selected postsynaptic complexes associated with glutamergic signaling.

P2.163 KOHNO, S*; GUILLETTE, LJ, Jr; Med Univ of South Carolina/Hollings Marine Lab, Charleston; *kohno@musc.edu*
Association of mRNA abundance for various steroid hormone related factors in circulating blood cells with plasma chemical components during the stress response in the American alligator
The molecular response of blood cells following exposure to acute capture stress and the associated elevation in plasma glucocorticosteroids concentrations has been poorly evaluated in reptiles. Juvenile American alligators were restrained for 16 hours to examine the stress response in plasma and blood cells. Plasma corticosterone concentrations were increased by restraint as were plasma concentrations of aspartate aminotransferase (AST), creatin kinase (CK), uric acid (UA) and glucose with sexual dimorphism in AST and CK concentrations. The lapse time of restraint was associated with mRNA levels of heat−shock protein 90² (HSP90²) in red blood cells (RBC), glucocorticoid receptor (GR) and androgen receptor (AR) in white blood cells (WBC), and cJUN in both blood cell types. Cloacal temperature was negatively correlated with cJUN in WBC, whereas plasma corticosterone concentrations were positively correlated with HSP90² in WBC. A two−way cluster analysis revealed that two different groups of factors analyzed here: i.) GR in RBC and HSP90² mRNA in both blood cells are associated with the corticosterone level in plasma, and ii) AR and c−JUN mRNA in both blood cells were associated with the cloacal temperature and body compositions. Although these data were difficult to interpret as the direct causation(s) and phenomenon in this study, we propose that this approach, which is both physiological approach on plasma and molecular biological approach on blood cells, could provide important insights into the molecular responses associated with the stress in reptiles as well as many other non−traditional model species including endangered species.

4.3 KONOW, N.*; ROBERTS, T.J.; BOERMA, D.; VON BUSSE, R.; SWARTZ, S.M.; Brown Univ. Providence; *nkonow@brown.edu*

Mechanics of proximal limb muscle tendon units in a small flying mammal

The role of tendon elasticity in muscle function is unclear for flying animals, and for small mammals. Bats are small and have wing muscles with relatively large, proximally located muscle bellies actuating the wing via long slender tendons. Given their length, these tendons might reduce wing inertia by keeping muscle mass close to the body. Their length and slenderness also suggest that wing tendons may stretch significantly to store and recover elastic energy during flight. We looked for evidence of tendon stretch during ascending flight in the phyllostomid fruit bat *Carollia perspicillata*. We measured triceps and biceps muscle length and activity, as well as elbow and shoulder joint position using biplanar high−speed fluoromicrometry, electromyography and XROMM. Triceps muscle fiber length was almost entirely decoupled from elbow movement. During downstroke, the elbow flexed while the triceps muscle actively shortened and the tendon was stretched. During upstroke, triceps tendon recoil provided energy that could help extend the elbow. XROMM modeling of shoulder and elbow kinematics clarified the function of the biarticular biceps. There was a tighter coupling between muscle fiber length and joint position than for triceps. Biceps tendon stretch occurred briefly, around the time of peak elbow extension, when the muscle operated eccentrically and the wing membrane was aerodynamically loaded. Eccentric muscle contraction produces high force, which may be needed to stretch the biceps tendon. In conclusion, the tendons of both triceps and biceps were stretched during ascending flight in *C. perspicillata*. Differences between the muscles in the decoupling of muscle fiber length and joint position may owe to differences in muscle activity timing relative to aerodynamic loading.

102.3 KOOPMAN, HN*; WESTGATE, AJ; SIDERS, ZA; UNC Wilmington; *koopmanh@uncw.edu*

Potential biological implications of rapid ocean warming in the Bay of Fundy, Canada

Ocean temperatures have been increasing globally at rates of 0.05−0.5°C per decade, but little is known about potential consequences to ecosystems. One aspect of marine invertebrate physiology that is very thermally sensitive is reproduction, particularly in the American lobster, *Homarus americanus*. Lobsters require cold (<5−8 ºC) winters for proper ovarian development. The Bay of Fundy (BoF), Canada, is known to be an important reproductive area for lobsters both locally and for the entire Gulf of Maine, but little is known about recent ocean temperature trends in these waters. We observed rapid increases in summertime ocean temperatures in the BoF over a four year period. We deployed temperature recorders on nine free−swimming basking sharks (*Cetorhinus maximus*) in the BoF between August and September of 2008−2012 and obtained 33 days of water temperature data. Temperatures increased at all depths (0−230 m) over the study period; below the thermocline this increase was >2ºC. The magnitude of the increase in sea surface temperatures over the same time period was similar (from 13.7ºC to 15.9ºC) to those found at depth (8.8ºC − 11.1ºC). We also documented a decrease in the fecundity of female American lobsters (n=764) by 8−10% each year over this period (overall decline 25%; P<0.001). We do not know the precise cause of these temperature increases, but no association with local meteorological trends or the North Atlantic Oscillation were observed. Increasing temperatures have been predicted to lead to higher lobster landings in the short term, since animals are more mobile when warmer. However in the long term, these increased temperatures may negatively impact recruitment into the fishery via decreased reproductive success.

117.7 KRAEMER, A. C.*; SERB, J. M.; ADAMS, D. C.; Iowa State University; *kraemer1@iastate.edu*

Coevolution of Coloration and Conspicuousness in a Batesian Mimic

In Batesian mimicry a palatable mimic deceives predators by imitating the appearance of an unpalatable model. Two hypotheses have been proposed to describe how selection from predators influences the evolution of warning signals in models and mimics. First, predators are thought to drive mimic coloration to converge on models while selecting models to appear distinct from mimics. Second, predators are thought to select for conspicuousness in models and inconspicuousness in mimics, and furthermore, models will evolve towards higher conspicuousness when mimics are present to appear distinct from mimics. To test these hypotheses we used a Batesian mimicry system between two salamanders: the model species *Notophthalmus viridescens*, and a mimic, *Plethodon cinereus*. We compared salamander color and conspicuousness by projecting their reflectance spectra into the visual spaces of three predators. We found that mimics and models were indistinguishable from the perspective of all three predators. Second, model coloration was found to be most conspicuous, and mimic coloration least conspicuous, against backgrounds that predators most likely view salamanders. Third, model and mimic conspicuousness co−varied among sites where they co−occurred. Finally, we found models were most conspicuous at sites where mimics occurred. These findings indicate that mimic coloration has converged on the coloration of models while appearing relatively inconspicuous to predators, particularly against likely backgrounds. Our findings also show that models have evolved to be most conspicuous against likely backgrounds, especially in the presence of mimics. These results suggest that not only does selection for mimicry drive mimic phenotypes towards models, but may also drive up model conspicuous keep predators from confusing them with mimics.

10.5 KRASNOV, B.R.*; KHOKHLOVA, I.S.; Ben−Gurion University of the Negev; *krasnov@bgu.ac.il*

Parasite performance as indicator of host resistance in ecological studies

From ecological and evolutionary perspectives, host resistance is nothing other than loss of fitness in a parasite induced by a host. Consequently, ecoimmunological studies should focus not only on immunological responses of a host to parasites, but also on responses of parasites to host anti−parasitic defenses. We present the results of several experimental case studies carried out on flea parasites of small mammals. We will consider the effect of host resistance on feeding and reproductive performance of fleas. First, we will focus on flea performance on individuals of the same host species that presumably differ in their resistance abilities (males versus females, young versus mature versus senile individuals, immune−naïve individuals versus individuals that acquired resistance against fleas). Second, we will consider performance of individuals of the same flea species on several species of small mammals that presumably have different innate resistance against this flea species. Feeding performance of fleas is measured via bloodmeal size, rate of digestion and energy expenditure for digestion, while reproductive performance is evaluated via both quantity (egg and new imago production) and quality of offspring (development rate, survival under starvation and body size).

18.2 KRAUEL, J.J.*; MCCRACKEN, G.F.; Univ. of Tennessee, Knoxville, Univ.of Tennessee, Knoxville; *jkrauel@utk.edu*

Migratory Predators Adjust Foraging Behavior in Response to Migratory Prey

Little is known about interactions between migratory predators and migratory prey, although these systems may be at high risk to disruption due to habitat loss and climate change. Migratory Brazilian free−tailed bats (*Tadarida brasiliensis*) track resources in time and space and consume migratory noctuid moths to fuel the bats' own energy needs. During migration, moths fly at high altitudes in layers representing favorable temperature and wind direction, resulting in prey concentrations that might be detected by bats. However, these events have not been linked to shifts in foraging behavior of bats. We predicted bats will alter foraging patterns by flying at higher altitudes during moth migration than at other times, and bats will adjust echolocation calls with altitude and levels of moth activity. We flew a Helikite near Frio cave, Texas, on 13 nights in fall 2012 representing 3 levels of moth migratory activity. We used SM2Bat ultrasonic detectors to record bat passes at ground level and two altitudes (approx. 100 and 200m). Bat passes were assigned to species and parameters were measured on high−quality calls using Sonobat 3. 1,104 bat passes were confirmed as *T. brasiliensis*. Bat activity was proportionally higher at higher elevations than ground level during moth migration events (chi sq = 6.36, DF = 2, p = 0.042). In a PCA of call parameters, PC1 explained 30% of variation and consisted primarily of variables describing duration, amplitude, and bandwidth. PC1 differed significantly with altitude (Anova, F = 50.33, p = 0) and with the interaction of altitude and moth activity (F = 5.26, p = 0.005). Results support predictions that migratory bats change both foraging behavior in response to seasonal availability of migrating insect prey.

89.2 KRAUSE, JS*; MCGUIGAN , MA; WINGFIELD, JC; MEDDLE, SL; Univ. of California, Davis, Univ. of Edinburgh; *jskrause@ucdavis.edu*

Changes in glucocorticoid and mineralocorticoid receptor mRNA expression during the short arctic breeding season in a free living wild song bird the Gambel's White−crowned Sparrow

Every spring, migratory songbirds leave their wintering grounds to travel to breeding grounds where they can encounter demanding situations such as intense storms, food shortages, predation and social disputes. During such times, songbirds are reliant upon the hypothalamic pituitary adrenal (HPA) axis and the production of the stress hormone, corticosterone (CORT), to induce changes in behavior and physiology to promote survival. In many high latitude breeding songbirds, the stress response is higher during arrival on their breeding territories compared to the parental phase. The reduction in the stress response is critical for preventing nest abandonment and ensuring parental investment but little is known about the neural regulation of this adaptation. This study investigated changes in the expression of mRNA for the two CORT receptors termed the mineralocorticoid receptor (MR) and the glucocorticoid receptor (GR) in the brain of male Gambel's White−crowned sparrows using in situ hybridization. There was a significant decline in MR mRNA expression in the hippocampus when birds at the preparental phase were compared to those in the parental phase; no significant change was found in GR in the paraventricular nucleus. Changes in MR and/or GR expression may be critical for regulating negative feedback and thus controlling both baseline and stress induced levels of CORT. These data suggest that changes in MR sensitivity may be important for regulating the stress response in birds that have very short breeding seasons at high latitude.

P1.119 KRENTZEL, D; Univeristy of Chicago; *dkrentzel@uchicago.edu*

A comparative analysis of sciurid feeding systems with a focus on the functional morphology and biomechanics of the enigmatic Bornean tufted ground squirrel Rheithrosciurus macrotis

The sources of selection that produce dramatic phenotypes and novel specializations can be difficult to determine. Distinguishing the forces of competitive exclusion, evolutionary arms races between predator and prey, and other mechanisms requires an integrative approach. *Rheithrosciurus macrotis*, a large sciurine ground squirrel endemic to Borneo, is an enigmatic species with a highly derived zygomasseteric system among the relatively conservative squirrel family, Sciuridae. A recent landmark−based morphometric analysis of mandibles across sciurids found *R. macrotis* to be a major outlier in the phylomorphospace. *R. macrotis* was the furthest diverged in terms of allometry, and also had the highest estimated mechanical advantages for most of the muscles in feeding system. It has been reported that *R. macrotis* feeds on the seeds of *Mezzettia parvi ora*, characterized by extreme hardness and toughness, supposedly at the intersection between the most durable material properties and ability to germinate for this seed. The authors reported that it would be incredibly strenuous for *R. macrotis* to feed on *M. parviflora* seeds. However, their maximum bite force estimation was based solely on expected bite force given the squirrel's body size. Here, we reassess the functional morphological parameters of *R. macrotis* crania and include this cranial data in a comparative analysis of sciurids, with a particular focus on the attachment sites for the masseteric musculature.

9.1 KROCHMAL, A.R.*; ROTH, T.C.; Washington College, Franklin and Marshall College; *akrochmal2@washcoll.edu*

Understanding the effects of seasonal drought and climate change on animal cognition: overland navigation in an aquatic turtle

Animals living in changing environments tend to show high levels of plasticity in behavior and cognitive ability. Studies examining the evolution of cognitive abilities seldom compare populations where change is rapid and selection pressures are strong. Terrestrial movements are central to the biology of aquatic turtles, but the frequency and duration of such movements are increasing, due in part to global climate change. While overland movements are critical for survival, we do not understand the impact of climate−induced increases in movement frequency on turtles' cognitive abilities. Using a model population of Eastern Painted Turtle (*Chrysemys picta*) that has experienced predictable, rapid, human−induced losses of habitat for over 100 years, we examined the movement patterns during long−distance terrestrial movements to alternative water sources. Resident adults (N=40) follow one of four specific (+/−5 m), directed, and intricate routes to new, far−off (300−1100m) permanent water sources annually; routes are consistent within and among animals and years. Adults translocated to the site (N=30), fail to locate water and move randomly about the habitat. Even when portions of their routes overlap those of residents, translocated animal fail to follow known routes and cannot locate alternative aquatic habitats. Naïve juveniles (both resident and translocated; N=18) however, locate aquatic habitats and do so using the same habitual routes employed by resident adults; juveniles possess this ability until they reach *ca*. 4 years of age. Overall, our data suggest that experience plays an important role in turtles' overland navigation and the behavior of naïve juveniles suggests a critical period in learning during development.

106.3 KROH, GE*; DEATON, PR; JOHNSON, DR; St. Edward's University, Austin TX ; *gretchkroh@gmail.com*

Female Fitness as a Function of Stored Sperm in the Livebearing Western Mosquitofish,

Females in promiscuous mating systems can use sperm storage as a mechanism of post−copulatory sexual selection to preferentially choose sperm and to give birth to multiple broods before mating again. In coersive mating systems, sperm storage can evolve in females to decrease the fitness costs of mating. Interbrood interval (IBI; the time period between two different broods), number of offspring per brood, female body fat composition, gonadosomatic index (GSI; measure of energy allotted to reproduction) and number of broods produced are all factors that can affect female fitness by suggesting the length of time a female can store sperm and the quality of sperm. , an invasive live bearing fish, was studied due to its ability to store sperm, the natural abundance of the species and the ease at which it can be studied in the laboratory. We examined the above variables resulting from stored sperm of female . We investigated 10 females from each treatment (0,1,2, or 3 males) over the breeding season (March to November). We predict for females relying solely on stored sperm that 1) brood number and number of neonates are inversely related; 2) IBI will remain constant and 3) GSI and body fat composition will be low. For females mated with males, we predict 1) brood number will increase due to presence of males; 2) number of offspring should remain constant; and 3) GSI and body fat composition will be high. IBI remained constant across treatments while mean number of neonates and number of broods was significantly different between the 0 and 2 male treatments (p=0.008 and p= 0.006 respectively). GSI was most variable for females in the 0 and 3 male treatment. These results provide a comprehensive understanding of sperm storage in promiscuous mating systems.

P3.29 KROTZ, R T*; SHERO, M R; COSTA, D P; BURNS, J M; RICHMOND, J P; University of North Florida, Jacksonville, University of Alaska Anchorage, University of California Santa Cruz; *rileytkrotz@gmail.com*

Linking Metabolic Hormones to Nutritional Status in Weddell Seals (Leptonychotes weddellii)

The metabolic hormone insulin−like growth factor (IGF)−I facilitates anabolism, increasing growth rate and the synthesis of lean and adipose tissue. Growth hormone (GH) acts directly on adipose, inhibiting nutrient deposition during periods of adequate intake and mobilizing energy during reduced intake. In many species, IGF−I and GH accurately reflect nutritional or metabolic status. In the Antarctic, Weddell seals exhibit seasonal life history patterns in intake which affects nutritional status. Seals actively forage at sea for 8−months (March−October), followed by 3−months of reduced intake due to land based life−history events including breeding, pupping and molting (November−February). As a result, nutritional status is expected to be reduced in January compared with October. To evaluate the relationship between nutritional status and metabolic hormones in Weddell seals, morphometrics, body fat percentage, and serum were gathered from 97 adults over 3 years. As expected, mass ($p<0.01$) and percentage body fat ($p<0.01$) were greater in October (347.1±73.1kg; 36.0±4.0%) compared with January (293.8±75.0kg; 30.9±3.6%). Unexpectedly, IGF−I ($p=0.20$) concentrations were not different between January (71.08±33.72ng/mL) and October (59.2±35.2ng/mL). However, GH ($p=0.03$) was greater in January (26.46±13.12ng/mL) compared with October (15.90±15.42ng/mL). Even though animals were larger and fatter in October, the reduced IGF−I in conjunction with increased GH suggests a low nutritional status at both time points. Alternatively, low IGF−I concentrations may suggest protein conservation mechanisms required for energetically expensive life−history events during the austral summer.

P3.116 KULINS, S.*; FREEMAN, A.; FOWLER, A.; BLAKESLEE, A.; Adelphi University, Garden City, NY, USA., Purdue University, West Lafayette, IN, USA. , Long Island University−Post, Brookville, NY, USA.; *skulins@gmail.com*

Invasion of rhizocephalan parasite Loxothylacus panopaei (Gissler, 1884) in the northwest Atlantic.

Loxothylacus panopaei is a parasitic rhizocephalan barnacle that infects at least nine species of xanthid crabs. Rhizocephalan parasites interfere with key crab functions such as molting, reproduction and the immune system. We recorded the first occurrence of *Loxothylacus sp.* north of the Chesapeake Bay (USA) in the Long Island Sound in August 2012. Field surveys conducted in 2013 of intertidal sites in New York and New Jersey confirmed the rhizocephalan parasite's presence at several sites in Long Island Sound. Intertidal surveys consisted of 10−15 one meter^2 quadrats, randomly placed along transects in the mud/rocks above the water's edge during low tide. Quadrats were searched thoroughly until all crabs were collected and then the number of each species of crab, its sex, size and infection status (based on the presence of rhizocephalan externae) was recorded. Environmental conditions such as temperature, salinity and dissolved oxygen were also recorded at each site since *Loxothylacus sp.* is often found within particular salinity and temperature ranges. We discuss the parasite's current distribution and prevalence in New York and New Jersey, vectors for the parasite's expansion and possible impacts on other native crabs.

P1.97 KUNTTAS−TATLI, E.*; OZPOLAT, B.D.; Carnegie Mellon University, University of Maryland; *ekunttas@andrew.cmu.edu*

Comparative Analysis of Insect Ovaries: Lessons from comparing Drosophila ovaries to other insects

The Drosophila ovary is a well−understood model system used to study various cellular processes, including stem cell maintenance, cell migration, cell shape changes, and metabolism. Holometabolous insects, like Drosophila, exhibit polytrophic meroistic oogenesis in which, nurse cells follow and supply the oocyte with various components to allow for the rapid development and patterning. In contrast, other Holometabolous insects, like Tribolium, exhibit telotrophic meroistic ovaries, in which a common pool of nurse cells is shared by all the oocytes. On the other hand, more ancestral insects such as the members of the Hemimetabolous family, like Damselfly, are less well understood and exhibit panoistic oogenesis without nurse cells. More can be learned from exploring different modes of oogenesis, which might reveal different modes of stem−cell maintenance, cell−shape changes among others. In this study, we investigated examples from both meroistic and panoistic insects such as Blue bottle fly, Wasp, Butterfly, Beetles, Crickets and Damselfly and compared to the Drosophila. We examined cytoskeletal structures and germ cells by using markers such as specktrin, vasa, piwi and phalloidin. We compared overall tissue organization of germaria, by looking at stem cells, cyst formation, and the presence of ring canals. We also examined later stages of oogenesis focusing on egg chamber elongation and the presence or absence of border cells, among other well−known Drosophila landmarks. Our studies revealed a number of similarities and differences between Drosophila and other insects and provide insights into how various aspects of oogenesis might have evolved.

87.1 KUO, D.−H.; National Taiwan University, Taipei, Taiwan; *dhkuo@ntu.edu.tw*

The Molecular Basis of the Leech O−P Equivalence Group and the Evovability of Metazoan Patterning Mechanisms

The O−P equivalence group is a classical experimental paradigm in leech embryology. In leeches and their clitellate annelid allies, embryogenesis largely follows a stereotyped pattern of cell lineage. In these animals, segmental ectoderm and mesoderm arise from five bilateral pairs of teloblasts. Each teloblast undergoes repeated rounds of asymmetric cell divisions to produce a column of segmental founder cells (blast cells), each of which then follows a lineage−specific developmental pattern to give rise to a definitive set of differentiated pattern elements. Among the five pairs of teloblasts, the M teloblast primarily contributes to the mesoderm, and N, O/Ps, and Q to the ventral, lateral and dorsal ectoderm, respectively. Experimental evidences suggested that fate specification of the M, N and Q lineages occurs at the birth of each of these teloblasts and appears to be cell−autonomous. In contrast, the developmental potential of the O/P teloblasts is initially equivalent, and the specification of O and P fates only occurs later in the blast cells and depends on localized cell−cell interactions. Recent molecular analyses of the O−P equivalence group suggested that the patterning mechanism of this system is homologous to BMP−mediated dorsoventral patterning of neuroectoderm observed in many other metazoan species. However, the deployment and the effects of the BMP signal in the O−P equivalence group appear to have deviated significantly from the general model of BMP−mediated neuroectoderm dorsoventral patterning. Here, I will illustrate how these mechanistic differences can provide insights into the evolution of patterning mechanisms in metazoan embryonic development.

P3.153 KUO, C−Y*; PAVLUHINA−SHOWALTER, I; FEDERLE, W; CROSBY, A; IRSCHICK, DJ; Univ. of Massachusetts Amherst, Univ. of Cambridge; *chiyun@bio.umass.edu*

Digital tendon morphology and adhesive performance in five gekkotan lizards

The adhesive ability of that gekkotan lizards possess to move along vertical surfaces has fascinated biologists for decades. Over the years, much has been uncovered about the microstructure of subdigital pads that grant many gecko species with their superior adhesive ability. However, adhesive ability varies among species, and such variation may be explained partly by differential expression of digital hyperextension when geckos deploy their adhesive pads to the substrate. The ability to perform digital hyperextension is facilitated by a pair of lateral digital tendons that run along the length of each digit. In this study, we took a functional morphological approach and compare the length and diameter of lateral digital tendons among five different gecko species. We also performed material testings to compare the strength of the tendons among species. We aim to examine the relationship between tendon morphology and material property with the behavior of digital hyperextension. Moreover, we hope to test the long standing hypothesis that tendon morphology is an underlying factor that affect adhesive performance in gekkotan lizards.

24.1 KURKA, N.*; CLARKE, J.; Univ. of Texas, Austin; *nicole.kurka@utexas.edu*

Transition from aerial to aquatic flight in birds using quill knobs as a proxy for feather morphology and flight style

Quill knobs, also known as papillae remigalis, are created by the attachment of the secondary feathers to the ulna. In most birds, quill knobs manifest as tubercles formed by ligamentous attachments. However, in aquatic taxa depressions are often present instead of tubercles, and the functional significance of these has not been well studied. Quill knob morphology was assessed in penguins and alcids in this study. Both groups contain wing−propelled divers, but only alcids, excluding the Great Auk, retain the ability to fly. This new research resolves the identity of tubercles and depressions and ascertains their relationship with the position and morphology of secondary and covert feathers. Assessment of quill knob data for penguins, alcids, and out groups in a phylogenetic context reveals changes in quill knobs related to flight mode. Dissections, examination of skeletons and fossils, scanning electron microscopy, and phylogenetic software were utilized to assess quill knob morphology. In most penguins, the feathers are so tightly pressed into the wing that the quills are forced into the ulna, creating depressions. The inferior umbilicus of the quill is in direct contact with the ulna. In most alcids, the feathers are not as tightly pressed into the ulna as in penguins because more feather mobility is required for retaining aerial flight. Thus, tubercles are still present in most alcids, but so are depressions formed by covert feathers. The impacts of this study go beyond aquatic birds. Fossilized feathers are rarely preserved, so quill knobs are often all that is left to infer information about feather and wing morphology. Quill knobs may be used as a key tool not only to study aquatic flight, but also the evolution of avian flight.

9.3 KURNATH, P.*; DEARING, M. D.; University of Utah, Salt Lake City; *patrice.kurnath@utah.edu*

The Effects of Ambient Temperature on Toxin Tolerance in Mammalian Herbivores

Intrinsic factors such as plant toxins and nutrients are well known to influence diet selection in mammalian herbivores, yet extrinsic factors like ambient temperature have received less attention. There is growing evidence that plant secondary compounds (PSCs) become more toxic at elevated ambient temperatures due to decreased liver function by the herbivore. This phenomenon, known as temperature−dependent toxicity, could have critical implications for mammalian herbivores that must balance the physiological functions of homeothermy and PSC detoxification. Here, we investigated how ambient temperature affects the maximum tolerable dose of PSCs in the desert woodrat, *Neotoma lepida*. Based on our previous work, we predicted that woodrats would have a lower maximum tolerable dose for PSCs and would therefore ingest fewer PSCs at warmer temperatures. Wild caught *N. lepida* (N=20) from the Mojave Desert were acclimated to one of two ambient temperatures (warm=29°C, cool=21°C) for 30 days before a 21 day feeding trial. Woodrats were given diets containing resin from creosote bush leaves (*Larrea tridentata*), which comprises most of their native diet and is high in PSCs. Body mass, food intake and resin intake were recorded daily. The maximum tolerable dose was defined as the greatest amount of resin ingested over a 24 hour period for each animal. Warm−acclimated woodrats had a significantly lower maximum tolerable dose of creosote resin compared to cool acclimated woodrats (ANOVA, $p<0.01$). The maximum tolerable dose for warm−acclimated woodrats was 69% that of cool−acclimated woodrats. These results suggest that the amount of creosote resin woodrats can consume is substantially limited by warmer ambient temperatures. Our results also could have adverse implications for mammalian herbivores in a warming climate.

S3.2−2 KURODA, Reiko*; ABE, Masanori; Tokyo Univ. of Science; *rkuroda@rs.tus.ac.jp*

How a single gene twists a snail

Gastropod *Lymnaea (L.) stagnalis* has unique features, *i.e.* , the chirality, the sinistrality and the dextrality, is hereditary, determined by a single locus that functions maternally at the very early embryonic stage. Both left− and right−handed snails exist in nature with the dextral one being dominant. Thus, *L. stagnalis* is ideal to study "chiromorphology", i.e., to study the organization process from molecules (genes and proteins), to cells, to organs and to individual organisms through chirality. We have shown, by creating mirror−image fertile creatures as a result of blastomere manipulation, that the chirality of shell coiling is determined by the blastomere arrangement at the third cleavage which is dictated by the handedness determining gene. We have also revealed that the blastomere arrangement regulates asymmetric expression of *nodal−Pitx* genes in the later development. Further investigation on the expression pattern of *nodal − Pitx* genes during the development for both the dextral and sinistral *L. stagnalis* embryos have revealed interesting similarity and dissimilarity with the vertebrates. For example, in both the dextral and sinistral embryos, *nodal* expression was first detected during the as early as 33−49 cell stages in a specific blastomere which is destined to develop into ectoderm, on the right side for the dextral and on the left side for the sinistral embryos following the third cleavage chirality. The gene expression region extended during the course of development, but was confined only to the left or the right side of embryos, and was mirror images of each other throughout the development. The expression continued towards the late developmental stage when the asymmetrical morphology was noticeable and the shell started to develop. The feature is clearly different from the vertebrates' which shows asymmetric expression of *nodal* in the lateral plate mesoderm only transiently at the late developmental stage.

45.2 KURTH, J. A. *; KIER, W. M. ; Univ. of North Carolina, Chapel Hill; *jkurth@live.unc.edu*

Bigger is not Better: The Effects of Body Size on 3D Burrowing Kinematics in the Earthworm Lumbricus terrestris

Relatively little is known about the effects of body size on both soft−bodied invertebrates and terrestrial burrowing. We studied the ontogenetic scaling of burrowing kinematics using *Lumbricus terrestris* earthworms. Previous analyses had suggested that small worms might use existing cracks and soil spaces as tunnels' to assist in underground movement, but larger worms are too large and must forcefully displace soil to excavate a burrow. We thus hypothesized that the kinematics of burrowing change as a function of size and large animals would show reduced burrowing speed. To test the hypothesis, we glued several lead markers on specific sites on the anterior portion of *L. terrestris* worms ranging in body mass from 0.075g−7.812g. We then used bi−planar x−ray cinematography to film the marked worms burrowing through topsoil in three dimensions. We tracked the lead markers and analyzed the kinematic data in MATLAB. We controlled for moisture content and bulk density between experiments, and used soil properties that have been previously recorded in natural topsoils. Our results indicate that the scaling of burrowing kinematics is fundamentally different from the scaling of surface crawling kinematics in this species. In contrast to crawling, the absolute speed and duty factor (time stationary/ total stride period) for *L. terrestris* decreased significantly with size during burrowing, while the absolute stride length did not change significantly with size. As in crawling, stride frequency decreased with body size during burrowing, but the scaling exponent during burrowing was significantly lower than the scaling exponent during crawling. Overall, our results support our hypothesis.

S7.3−2 LAFFERTY, K D*; KURIS, A; US Geological Survey, University of California, Santa Barbara; *lafferty@lifesci.ucsb.edu*

Ecological consequences of host manipulation by parasites

Numerous studies have shown that the direct effects of parasitism significantly affect populations, community structure, and ecosystem energetics. In addition, manipulative parasites are more than just entertaining cocktail party anecdotes. They can exert effects across hierarchical ecological levels. Those that have strong manipulative effects on their hosts can alter aspects of the distribution and abundance of their host populations. If parasitism is common, effects on the host population can be strong. If the host is common or interacts with other species in the system, indirect effects on the food web could occur through the alteration of trophic cascades, creation of new habitats, or new niches, or by altering the flow of energy among habitats. It will be a while before we have a systematic understanding of the importance of manipulative parasites at the ecosystem level. Further insight into the effects of manipulative parasites will require challenging experiments and observations, ideally with strong collaboration among parasitologists and ecologists.

29.7 LAGARDE, M.T.*; RIVERA, G.; O'LEARY, F.A.; St. Edward's University; *mlagard@stedwards.edu*

Examining Temporal Relationships Between Amyloid ² Accumulation, Reactive Oxygen Species Accumulation, and Loss of Neurological Function in a C. elegans Model of Alzheimer's Disease

Alzheimer's disease (AD) is characterized by a gradual loss of cognitive function accompanied by numerous neuropathologies. These include the accumulation of neurofibrillary tangles, amyloid plaques, a rise in oxidative stress levels, and neuronal death. Current AD research seeks to understand the causal relationship between amyloid accumulation and oxidative stress and whether either one acts as the primary driver of the pathological process (Zhang, et al., 2012). The nematode *C. elegans* is a useful model for neurodegenerative disease due to its short life span, simple nervous system, and the availability of a variety of disease models. In this project we examined the temporal relationship between the progression of cognitive decline, the level of reactive oxygen species (ROS), and amyloid plaque formation in an AD model expressing neuronal amyloid beta. *C. elegans* AD strain, AD control and wild type control were cultured at 20°C on solid agar medium seeded with *E. coli* OP−50. Populations were synchronized by dissolution in sodium hypochlorite bleach solution to which eggs are resistant (Stiernagle, 2006). ROS species were assayed at five ages across the lifespan using 2',7'−dichlorfluorescein−diacetate (DCFH−DA) fluorescent measurement (Wu, et al., 2006). Associative learning was assessed by training worms to associate food with a specific temperature. Trained worms were then tested for learning on a foodless temperature gradient. Data indicates that the AD model exhibits an associative learning deficit on days 7 and 9 which precedes abnormal oxidative stress levels on day 9. This may suggest that oxidative stress does not directly contribute to cognitive dysfunction.

P1.64 LAGRANGE, SM*; KIMBLE, SJA; MACGOWAN, BJ; WILLIAMS, RN; Southern Illinois University, Purdue University; *smlagrange@gmail.com*

Seasonal Variance of Hematological Values, Plasma Parameters and Body Condition Index of the Timber Rattlesnake Crotalus horridus

Hematology analyses and body condition indices are useful tools for describing the health of individuals, especially when making management decisions for species of conservation concern. Analysis of these health measures can be useful for catching at early stages diseases caused by viral pathogens, parasites, and stress. Stress caused by changes in environmental conditions can suppress the immune system, increase the prevalence of disease, and give a diagnostic signature in certain hematological parameters. Baseline health data are procured from healthy, wild populations and are integral in order to detect divergence from normal values. Unfortunately, these data for non−model species are rare yet needed to accurately assess the health of wild populations. Timber rattlesnakes *Crotalus horridus* provide a great example of an endangered species with no baseline health data. By analyzing 13 timber rattlesnakes from an intact upland hardwood forest in south−central Indiana we are establishing normal temporal variation over an active season. Female packed cell volume and potassium levels were significantly higher in the summer compared to males. Summer values for aspartate aminotransferase and creatine kinase were significantly correlated with summer body condition. Summer glucose values were significantly correlated with summer albumin levels. Fall calcium levels were significantly correlated with fall phosphate levels. Fall globulin and sodium levels were significantly correlated with fall body condition. These baseline data may become increasingly important for future studies on timber rattlesnakes if suitable habitat continues to decline, as new diseases emerge, and associated stress increases.

36.5 LAHMAN, S E*; MOORE, P A; Bowling Green State University; *slahman@bgsu.edu*

Where's the Food?: Copper Impairs Foraging in a Keystone Indicator Species

Elevated pollution levels can disrupt ecosystem functions by altering a keystone indicator species' ability to perform behaviors such as foraging, reproduction, or predator avoidance. This is particularly true for habitats in which keystone species rely on olfaction to make crucial ecological decisions. Increased amounts of a pollutant may impact chemoreceptive abilities by altering the sensory landscape or physiologically impairing the reception of chemical stimuli. Heavy metal pollution entering an aquatic ecosystem is of increasing concern due to discernible effects on chemoreception in many ecologically and economically important species. The purpose of this study was to determine the impact of increased copper concentration on a key chemically mediated behavior (foraging) in crayfish. Rusty crayfish, Orconectes rusticus, were exposed to ecologically relevant concentrations of copper for 120 hours. Following exposure, animals were allowed to orient toward a food stimulus. During trials, animals were exposed either to a point or nonpoint source copper pollutant, while others were allowed to orient in non−polluted water. Videotaped trials were analyzed using EthoVision XT for differences in overall success in locating the food source and walking parameters. Significant differences were found in the overall orientation abilities of O. rusticus in locating an odor source when previously exposed to elevated levels of copper and run in a point or nonpoint source of copper pollution. These results indicate that increased levels of copper pollution cause a physiological impairment which is removed when animals are exposed to non−polluted water. Consequently, reducing pollution through management and mediation practices may allow keystone species to recover the ability to perform chemically mediated behaviors.

P1.104 LANCASTER, W/C; ARY, W/J*; CRANFORD, T/W; Sacramento State Univ., Sacramento, San Diego State Univ., San Diego; *tcranfor@mail.sdsu.edu*

Precocial Development of the Tympanoperiotic Complex in Cetaceans

Cetaceans use acoustic signals to orient and communicate. Light penetrates poorly in aquatic environments, which places a premium on acoustic communication and increases selective pressure to develop a completely functional organ of hearing at or near the time of birth. William F. Perrin found that the tympanoperiotic complex in juveniles in two delphinid species, *Stenella longirostris* and *S. attenuata*, were near adult size in spite of smaller skulls and bodies. We gathered data to test whether this feature is common across the Cetacea. We collected homologous measurements from skulls and tympanic bullae of 1 adult and 1 juvenile in 14 species of cetaceans (6 families in Odontoceti and 2 families in Mysticeti). Across all samples, total (body) length (TL) of juvenile specimens ranged from 46−81 % of adult TL, juvenile condylobasal (skull) length (CBL) ranged from 53−93% of adult CBL, and juvenile tympanic bulla length (TBL) ranged from 93−109% of adult TBL. For two species we measured 10 adults and 10 juveniles to assess individual variation. In these samples of *Tursiops truncatus* and *Pontoporia blainvillei*, the CBL of juveniles was significantly smaller than adults (Paired Two−sample t−test, P=0.0004 in *T. truncatus*, P<0.0001 in *P. blainvillei*), whereas juvenile TBL was not significantly different from that of adults (Paired Two−sample t−test, P=0.0945 in *T. truncatus*, P=0.4607 in *P. blainvillei*). Our data demonstrate a pattern of accelerated allometric growth of the tympanic bullae compared to the skulls across a broad range of cetacean taxa. We interpret this as evidence for precocial development of auditory function in the Cetacea.

108.5 LANE, S.J.*; FRANKINO, W.A.; ELEKONICH, M.M.; ROBERTS, S.P.; Central Michigan Univ., Mount Pleasant, Univ. of Houston, Texas, National Science Foundation & Univ. of Nevada, Las Vegas; *steven.lane@umontana.edu*

The Effects of Age and Lifetime Flight Behavior on Flight Capacity in Drosophila melanogaster

The effects of flight behavior on physiology and senescence may be profound in insects due to the extremely high metabolic costs of flight. Previous studies have shown that flight capacity decreases with age, and that flies prohibited from flying had longer lives and slower age−related loss of antioxidant capacity and accumulation of oxidative damage in flight muscles. Using *Drosophila melanogaster*, we tested the effects of age and lifetime flight behavior on wingbeat frequency, metabolic rate, and the ability to fly in a hypo−dense gas mixture. Specifically, 5−day old adult flies were separated into three life−long treatments: (A) those not allowed to fly (no flight), (B) those allowed − but not forced − to fly (voluntary flight), and (C) those mechanically stimulated to fly (induced flight). Flight capacity senesced earliest in flies from the no−flight treatment, followed by the induced−flight group and then the voluntary flight group. Wingbeat frequency senesced with age in all treatment groups but was greatest in the voluntary and induced flight groups. Metabolic rate during agitated flight senesced earliest and most rapidly in the induced flight group, and was low and uniform across ages in the no−flight group. Early senescence in the induced flight group was likely due to the acceleration of effects such as the rapid accumulation of damage at the cellular level, while the early loss of flight capacity and low metabolic rates in the no−flight group demonstrate that disuse effects can also significantly alter senescence patterns of whole−insect performance.

6.4 LANG, A. L.*; BRADSHAW, M. T.; SMITH, J. A.; MOTTA, P. J.; HABEGGER, M. L.; HUETER, R. E.; Univ. of Alabama, Univ. of South Florida, Mote Marine Lab; *alang@eng.ua.edu*

A Passive Flow Control Mechanism to Decrease Drag

Flow separation is a major source of pressure drag on mobile aquatic organisms and separation control can lead to increased swimming speeds and maneuverability. Our recent results from a collaboration involving biologists and engineers have demonstrated the separation control capability of shark skin. With a specific focus on the shortfin mako (*Isurus oxyrinchus*) known for its high speed and agility, we investigated the bristling angle of placoid scales across the body. Our observations indicate larger bristling angles are linked to scale morphology, more specifically an increase in crown length and decrease in size of the base, to promote flexibility primarily in the streamwise direction. Results also show key regions of high bristling capability correspond with those most prone to flow separation, including the tail, flank regions aft of the gills, and pectoral fins. Shark skin samples also were tested in a water tunnel facility using Digital Particle Image Velocimetry (DPIV) and evidence of flow separation control was observed under laminar and tripped boundary layer conditions. Experiments conducted in the $Re = 10^5$ range resulted in sufficiently strong backflow induced close to the surface such that the shear threshold to induce bristling on the real skin sample was achieved. Flow control at lower Re was not as evident. We hypothesize the presence of an adverse pressure gradient induces flow reversal in a region very close to the skin. This reversed flow induces passive, localized scale bristling, thereby interrupting the subsequent flow development that leads to global flow separation from the body. Thus, scale bristling on sharks decreases pressure drag.

P3.71 LANGLAND, KM*; POWERS, DR; WETHINGTON, SM; George Fox Univ., Newberg, OR, Hummingbird Monitoring Network, Patagonia, AZ; *klangland11@georgefox.edu*

The Influence of Environmental Temperature on Heat Dissipation in Hummingbirds

Hummingbirds in landscapes warming due to climate change will have greater need to dissipate excess heat. Elevated environmental temperatures could result in surface temperature (T_s) exceeding body temperature (T_b) due to increased radiative heat gain. This would favor net heat gain due to a reversal of the thermal gradient. Heat dissipation across body surfaces requires a gradient where $T_b > T_s$. In this study we determine how changes in T_s, over a range of operative temperatures (T_e) on hummingbird landscapes might influence this thermal gradient and thus the ability of the hummingbird to dissipate excess heat. We measured T_s of shaded perched broad−billed hummingbirds (*Cynanthus latirostris*; ~ 3.2 g) by infrared thermography (FLIR SC6700). T_s was positively correlated with T_e ($R^2 = 0.96$, $P < 0.0001$). As T_s approaches T_b (assumed ~41−42 °C), the thermal gradient becomes smaller and passive heat dissipation is limited. At high T_e (> 45 °C), T_s = ~42°C similar to our presumed T_b minimizing any thermal gradient between the body core and surface. While we have no measurements at $T_e > 47$ °C we frequently observed hummingbirds panting at times when T_e was high (sometimes > 50 °C) suggesting that reversal of the thermal gradient might have occurred. T_s of hummingbirds perched for an extended period of time (> 60s) increased linearly with time regardless of T_e suggesting that body surfaces are perhaps convectively cooled during flight before perching. Our data suggests that infrared thermography might be a good tool for identifying critical T_es at which thermoregulation becomes difficult due to the inability to passively cool. Such information is important in our efforts to understand organismal response to warming environmental temperatures associated with climate change.

P1.206 LARA , A*; BRUGLER , MR; RODRíGUEZ, E; Richard Gilder Graduate School; *Alr1129@hotmail.com*

Evaluation of intra− and interspecific variation within the deep−sea polar sea anemone genus Actinostola (Cnidaria: Anthozoa: Actiniaria) using morphology and novel nuclear DNA markers

Sea anemones (Actiniaria) are a group of relatively simple animals that display great anatomical and life history diversity. Despite their simplicity sea anemones are a very successful group, having adapted to − and thus occupying − all marine environments. Traditionally, the taxonomy of sea anemones has been based on the internal anatomy of the polyp and cnidae, both of which require histological analysis and intense optical microscopy examination and quantification. Recently, molecular data has been utilized to elucidate phylogenetic relationships among sea anemones; however, low variability of mitochondrial DNA markers − along with the lack of suitably variable nuclear DNA markers − within the group hinders the ability to differentiate species. Thus, our goal was to locate and test several variable, single−copy nuclear DNA markers to facilitate species−level identification of sea anemones. We targeted seven nuclear introns using EPIC (exon−priming, intron−crossing) primers. The PCR products of all nuclear introns were cloned to determine copy number. The data obtained revealed upwards of 5 different copies of a given intron within a single individual; nonetheless, some introns were indeed single copy. The results of these new markers as applied to an intra− and interspecific analysis of *Actinostola* will be discussed.

P3.69 LARKIN, M.*; SECOR, S.M.; Univ. of Alabama; *mlarkin@crimson.ua.edu*

Variation in organ and tissue mass loss during fasting for the snake Nerodia rhombifer

Fasting related loss in body mass stems from the cumulative loss of mass of individual tissues and organs. However, not all organs and tissues lose mass at the same rate resulting in variation among organs in the reduction of mass with fasting. Tissues that provide a source of energy and are not essential for performance during fasting (e.g., fat bodies) would predictably be depleted at a faster rate than organs that still need to maintain performance during the fast. In addition, individuals may vary in the rate of organ loss during fasting as a function of differences in metabolic expenditure and the allocation of endogenous energy. We examined individual variation in the loss of body and organ mass with fasting for the diamondback watersnake *(Nerodia rhombifer)*. We obtained baseline measures of body and organ masses from ten snakes immediately after their capture. For the next six months we dissected five snakes each month to assess the reduction in body and organ masses from fasting. For the first three months of fasting, snakes lost body mass at an average rate of 1.3 g/day, thereafter mass loss continued at 0.3 g/day. Relative to the loss of body mass, we found that the fat bodies, liver, pancreas, small intestine, and kidneys lost mass at a greater rate. Muscle, heart, lung, and skin lost mass at a rate equal to or less than that of body mass loss. As expected fat and organs associated with digestion lose relatively more mass with fasting than organs necessary for day to day survival. We found considerable variation in fasting loss of body fat after 6 months, ranging from 25−100% depletion. Watersnakes in this population exhibit variation in standard metabolic rate independent of body mass, suggesting that individual variation in SMR explains, in part, the variation in body fat loss.

66.4 LARSON, DJ*; MIDDLE, L; BARNES, BM; Univ of Alaska Fairbanks; *djlarson@alaska.edu*

Wood frog adaptations to overwintering in Alaska: New limits to freezing tolerance.

We investigated the ecological physiology and behavior of wood frogs (*Lithobates [Rana] sylvaticus*) overwintering in Interior Alaska by tracking animals into natural hibernacula, recording microclimate, and determining survival in spring. We measured cryoprotectant (glucose) concentrations in tissues from subsamples of naturally freezing frogs. We also recorded behavior of wood frogs preparing to freeze in artificial hibernacula, and tissue glucose concentrations in captive wood frogs frozen in the laboratory to −2.5°C. Wood frogs in natural hibernacula remained below freezing for 193±11 consecutive days and experienced average (Oct−May) temperatures of −6.3°C and minimum temperatures ranging from −8.9 to −18.1 °C with 100% survival (n=18). In early October, wood frogs underwent 10−15 freezing then thawing events before wood frogs froze for the remainder of winter. Tissue mean glucose concentrations were 13−fold higher in muscle, 10−fold higher in heart, and 3.3−fold in liver in naturally freezing compared to laboratory wood frogs frozen linearly. We mimicked the freeze−thaw cycles wood frogs experience in natural hibernacula in the laboratory and observed a net accumulation of glucose with each re−initiation of freezing. Tissue mean glucose concentrations in freeze−thaw wood frogs were 5.7−fold higher in muscle, 5.4−fold higher in heart, and 2.7−fold higher in liver than glucose concentrations from tissues in linearly frozen wood frogs. Wood frogs in interior Alaska survive freezing to extreme temperatures and durations compared to limits reported in animals collected in southern Canada or the US Midwest. We hypothesize that it is exposure to successive freeze−thaw cycles and the associated elevated cryoprotectant levels that produce the enhanced cold tolerance in wood frogs in Alaska.

P2.52 LARSON, DJ*; JOHNSON, PTJ; BARNES, BM; Univ of Alaska Fairbanks, Univ. Colorado−Boulder; *djlarson@alaska.edu*

Parasite survival in freeze−tolerant hosts

We examined the overwintering strategies of *Ribeiroia ondatrae*, an ecologically important parasitic trematode, in the freeze tolerant wood frog (*Lithobates [Rana] sylvaticus*), and tested the hypothesis that the pattern of freezing affects parasite survival. We exposed 107 wood frog tadpoles from interior Alaska each to 30 *R. ondatrae* cercariae. Wood frogs were raised to metamorphosis and divided into three groups: control, linearly frozen, or frozen over several freeze−thaw cycles, a pattern associated with higher accumulation of cryoprotectants (glucose) and enhanced cold tolerance in naturally freezing wood frogs. We necropsied 10 frogs from each group prior to freezing and found no significant difference in parasite survival. In unfrozen, control wood frogs (n=22) held for two weeks at 2°C, no reduction in parasite survival occurred. Linearly frozen wood frogs (n=26) were cooled from 2°C to −5°C over 12 hours, nucleated at −1.5°C, and then held for two weeks at −5°C; no parasites survived. Wood frogs experiencing successive cycles of freezing and thawing (n=29) were cooled over 12 hours from 2°C to −5°C, nucleated at −1.5°C, and then warmed over 12 hours to 2°C. We repeated this cycle twice before wood frogs were then held at −5°C for two weeks; 23% of parasites survived in this group. We hypothesize that parasite and host overwinter survival is enhanced in wood frogs that experience successive freeze and thaw cycles, due to the higher concentrations of glucose that accumulate with this pattern of freezing that characterizes natural conditions.

116.3 LARSON, P*; DALY, M; Ohio State University; *larson.309@osu.edu*

Morphology and Taxonomy of Brooding Anemones in the North Pacific Ocean

The sea anemone genus *Epiactis* Verrill is notable for diversity in reproductive behavior and strategy among its species. The name *E. ritteri* Torrey has been applied both to internally brooding individuals on the West coast of the contiguous USA and British Columbia (Canada), and to externally brooding individuals from Alaska (USA). The confusion stems, in part, from a lack of author−designated material associated with work done on this group. Alaskan individuals of *E. ritteri* have been proposed by some to be synonymous with the externally brooding Japanese species, *E. japonica*. Based on morphological study of new collections from Japan, Alaska, and California in conjunction with borrowed museum collections from Alaska, British Columbia, and California, we present data which helps define the taxonomic and geographic boundaries of proposed species found in the North Pacific Ocean.

P1.172 LASALA, JA*; WYNEKEN, JW; Florida Atlantic University; *jlasala1@fau.edu*

Microsatellite analyses compare trends in paternity in two sympatric species of marine turtle (Caretta caretta & Chelonia mydas)

Mating systems have an important role in shaping life history evolution and population dynamics of a species and should be considered when planning conservation efforts. Polyandry, a single female mating with multiple males, may result in the multiple paternity of progeny arrays (clutches). Within a population, multiple paternity influences the effective population size and the maintenance of genetic variation. Several recent studies together suggest that multiple paternity occurs in most reptile species but within the Testudines there is a high degree of variation. Assessing multiple paternity within marine turtles is challenging because males rarely return to land and matings are not often observed. By conducting exclusion analyses we can approximate the number of males and critically assess population estimates. Loggerhead and green nesting mothers and up to 20 offspring were sampled from more than 70 nests over the summer of 2013, on three large nesting assemblages in southern Florida. To determine if species sharing the same rookeries have a common pattern, we assessed the frequency of multiple paternity. Here we compare how many males contribute to the assemblages and whether males are active on multiple beaches. Our study provides the first assessment of effective population size for important southern Florida nesting populations and addresses connectivity of rookeries through male mediated gene flow.

22.1 LATTIN, CR*; KENISTON, DE; ROMERO, LM; Tufts University, Yale University; *christine.lattin@tufts.edu*
Corticosterone receptor concentrations are correlated across different tissues within individual house sparrows (Passer domesticus)

Hormonal mediators often show enormous intraspecific variation. Although there have been increased calls to make this individual variation the focus of inquiry, relatively few investigators have done so, especially with endocrine mediators other than hormone titers. For example, does an animal with high receptor density in one tissue also tend to have high receptor density in other tissues? We used a dataset of 72 house sparrows to examine individual correlations in glucocorticoid receptor binding (GR) and mineralocorticoid receptor binding (MR) across 14 different tissues: bib, back and belly skin, pectoralis and gastrocnemius muscles, subcutaneous and omental fat, liver, kidney, spleen, whole brain, hippocampus, testes and ovary. We used restricted maximum likelihood to estimate mixed models of receptor concentration with fixed effects at the tissue level and random effects at the bird level. Significance tests of random effects strongly rejected the null hypothesis of no bird−level variation in GR and MR. We also examined which receptor concentrations in individual tissues could be explained by receptor concentrations in all other tissues. For MR, we found hippocampus, kidney and throat fat most correlated with other tissues. No specific tissues showed significant GR receptor correlations with others. Back and belly skin receptor concentrations were consistently uncorrelated with other tissues, as were omental fat and pectoralis GR. These results clearly demonstrate that individual house sparrows tend to exhibit higher or lower sensitivity to CORT across all tissues, perhaps due to regulation of receptor concentrations by the common signal of circulating CORT. Receptors in tissues showing the lowest correlation with other tissues may be co−regulated by tissue−specific factors, such as local CORT production and the presence of metabolizing enzymes.

P3.105 LATTIN, CR*; NGAI, H; ROMERO, LM; Tufts University, Tufts University ; *christine.lattin@tufts.edu*
Evaluating the stress response of wild birds as a bioindicator of sub−lethal effects of crude oil exposure

The hypothalamus−pituitary−adrenal (HPA) axis allows wild animals to regulate baseline physiology and respond to environmental stressors. However, there is some evidence that the HPA axis may be especially vulnerable to endocrine−disrupting chemicals. This study aimed to systematically quantify the effects of ingested Gulf of Mexico crude oil on the stress response and blood chemistry parameters of wild−caught house sparrows (*Passer domesticus*). Crude oil was weathered to ~75% volume by heating at a low temperature and stirring continuously. Oil birds received a dose of 1% oil weight:food weight, determined using preliminary dose−response feeding experiments. Controls received sunflower oil instead of petroleum, and both groups were allowed to feed ad libitum. After 4 weeks, birds on the oiled diet showed reduced stress−induced CORT titers in response to a standardized stressor, as well as decreased CORT secretion after an injection of adrenocorticotropic hormone. They also had increased plasma concentrations of phosphorus and Na+, potentially indicative of disruptions in fluid balance. All of these effects could be due to adrenal and/or kidney damage. A reduction in stress−induced CORT titers after ingesting oil has also been seen in ducks, suggesting this particular effect may occur across many avian species. These effects are important not only as potential bioindicators of petroleum exposure, but because birds with impaired HPA function show higher mortality when faced with stressors.

6.6 LAUDER, G. V.; Harvard University; *glauder@oeb.harvard.edu*
Simple robotic models of aquatic locomotion

Robotic models of aquatic locomotion have many advantages over studying live animals, including the ability to manipulate and control individual morphological or kinematic factors that affect performance, substantially easier measurement of locomotor forces and torques, and the ability to abstract complex organismal designs into simpler components. Such simplifications, while not without their drawbacks, facilitate interpretation of how individual traits alter swimming performance and the discovery of underlying physical principles. In collaboration with a number of colleagues, we have been engaged in using a robotic flapping foil apparatus to investigate several key features of aquatic propulsion. This robotic device allows programming of heave (side−to−side) and pitch (angular) motions at the leading edge of both rigid and flexible swimming bodies, and investigation of how changing frequency and Strouhal number affects cost of transport and efficiency. Measurement of three forces and three torques on the flapping object is synchronized with the digital motion program and high−speed video of fluid flow over the foil using particle image velocimetry. Using this robotic system we have investigated (1) resonant effects of swimming foils of different stiffnesses, and the effects of structural resonance on propulsive efficiency, (2) the hydrodynamic effect of simplified tubercle structure on the leading edge of swimming bodies, (3) the effect of non−linearities along the length of swimming foils on locomotor performance, and (4) the effect of specialized engineered drag−reducing surfaces on swimming efficiency. Selected results from these studies will be discussed in detail to illustrate the utility of even simple robotic models for uncovering new features of aquatic propulsion.

P1.76 LAVERGNE, J.N.*; DEAROLF, J.L.; Hendrix College, Conway, AR; *lavergnejn@hendrix.edu*
Effect of prenatal steroids on the myoglobin concentration in the diaphragm of fetal guinea pigs

Currently, glucocorticoids are used to promote the survival of premature children by accelerating their lung development. However, very little is known presently about how these steroids affect breathing muscle development. Work in our laboratory has shown that one of these steroids, betamethasone, increases the concentration of NADH−D, an oxidative enzyme, in an accessory inspiratory muscle of guinea pigs. These results suggest prenatal glucocorticoids accelerate the acquisition of mitochondria by fetal muscle, and to support the generation of ATP by these organelles, the fetal muscle would therefore require more oxygen. Thus, we propose that glucocorticoids will increase the concentration of myoglobin (Mb), the oxygen carrier in muscles, in the diaphragm (DIA) of fetal guinea pigs. To test this hypothesis, pregnant guinea pigs were given three injections of betamethasone (0.5 mg/kg) at 65%, 75% and 85% gestation. Twenty−four hours after the last injection, the females and their fetuses were euthanized and fetal tissue was collected. Extracts of the fetal muscle samples were prepared and separated in SDS−polyacrylamide (12%) gels for ~ 2 hours (30 mA/gel) at 16° C. These gels were silver stained, and ImageJ software was used to determine the proportion of Mb relative to actin in the treated and control DIA muscles. If Mb concentrations are higher in the treated muscles, they may be better able to deliver oxygen to their mitochondria and thereby resist fatigue in comparison to non−treated muscles. Thus, babies exposed to prenatal steroids will have more mature DIA muscles and be better prepared to respond to ventilatory challenges.

S2.2−3 LAVINE, L.C.*; EMLEN, D. J.; DUKE, A.; WARREN, I.A.; GOTOH, H.; Washington State University, University of Montana, University of Bristol; *lavine@wsu.edu*

Mechanisms of Honest Signaling in Condition Dependent Growth in Exaggerated Traits

Many male animals wield ornaments or weapons of exaggerated proportions. These traits are often used for mate choice, or to deter rival males, because they act as reliable signals of the condition of individual males. Only the best−quality animals produce full−sized ornaments or weapons. But why don't males cheat? How can signal traits evolve that are resistant to invasion by cheaters who fake attractive signals? We expect the answer to be found in the intricate and dynamic mechanistic systems that link growth with condition. Using the sexually dimorphic rhinoceros beetle as our model, we present evidence suggesting that exaggerated sexually−selected signal traits arise when specific structures become extra−sensitive to physiological signals like insulin or insulin−like growth factors. We then illustrate how enhanced sensitivity to insulin/IGF signaling in a growing ornament or weapon would cause heightened condition−sensitivity and increased variability in expression among individuals critical properties of reliable signals of male quality. The possibility that reliable signaling arises as a byproduct of the growth mechanism may explain why trait exaggeration has evolved so many different times in the context of sexual selection.

87.3 LAYDEN, MJ*; MARTINDALE, MQ; University of Florida; *layden@whitney.ufl.edu*

Notch signaling may have evolved to control cellular differentiation and growth during development of metazoan animals

The emergence of multicellular animals possessing distinct differentiated cell types requires a mechanism to regulate the cellular decision to differentiate or remain undifferentiated. Notch is a novel metazoan signaling pathway used to regulate cellular differentiation during animal development. However, essentially all functional characterization has been conducted in bilaterian species. Though it is likely Notch has been co−opted into multiple developmental programs, one way to generalize Notch signaling is that the cell(s) in which the Notch receptor is activated remain undifferentiated and are often characterized as proliferative. This observation suggests Notch may be a core conserved metazoan regulator of cellular differentiation. Thus, characterization of Notch signaling in more basally branching animals is critical for reconstructing putative ancestral Notch functions. To address this issue we investigated Notch during neural development of the cnidarian sea anemone Nematostella vectensis. We find that cells experiencing high Notch fail to express differentiated neural markers. However, we have currently found no correlation between active Notch signaling and cell proliferation. We find evidence that the Notch ligand Delta also functions as a receptor, suggesting that Notch signaling in Nematostella is bidirectional. Misexpression of an activated form of Delta induces neural differentiation and inhibits cell proliferation. The conserved role for Notch−Delta signaling as a regulator of cellular differentiation in basally branching animals suggests that one of the driving forces for the emergence of Notch signaling in the metazoans was a general mechanism to regulate the delicate balance of growth and differentiation during development of multicellular animals.

98.5 LE GALL, M.*; BEHMER, S.T.; Texas A&M University; *le−marron@tamu.edu*

The effects of food macronutrient content on an insect herbivore: a fitness landscape approach.

The plants that insect herbivores eat can be highly variable with respect to their protein and digestible carbohydrate content. Here we explore the effects of protein−carbohydrate balance and concentration in the generalist grasshopper *Melanoplus differentialis* by conducting two separate experiments. In the first we presented last instar nymphs with two foods that differed in their nutrient content, and measured the extent to which individuals actively regulated their intake. In the second we presented insects with one of nine foods that differed in their protein−carbohydrate ratio and/or amount, and measured consumption, performance and nutrient utilization. For this second experiment, the results are presented as detailed fitness landscape. This visualization technique provides a comprehensive overview of how nutrient content affects an insect herbivore, and a powerful link between lab and field studies. In the first experiment we found that grasshoppers tightly regulated their protein intake across all treatments. However, when the available foods had low total nutrient content, carbohydrate intake decreased; these insects also gained less mass. In the second, where insects were constrained to one of nine foods, grasshoppers initially consumed larger quantities of carbohydrate−biased food. Over the entire stadium, however, insects on the most dilute diet ate the most food. Development time decreased as macronutrient concentration increased, but mass gain and growth rate was best on diets that were: 1) concentrated and 2) carbohydrate−biased. Interestingly, food utilization, measured as the amount of food digested, was best on diets with low protein and moderate carbohydrate content. We interpret our results in relation to the protein−carbohydrate landscape occupied by insect herbivores in the field.

P1.15 LEARY, C.J.; Univ. of Mississippi; *cjleary@olemiss.edu*

Male green treefrogs use acoustic signals to manipulate the stress physiology of receivers

Agonistic interactions among male anurans characteristically involve the exchange of acoustic signals. Detection of nearby conspecific males, for instance, often results in the production of advertisement calls that are directed at the encroaching individual and may escalate to include the production of distinct aggressive calls. I examined how acoustic signals influence corticosterone (CORT) and androgen levels in male green treefrogs, *Hyla cinerea*. Males in natural choruses that were recently involved in an aggressive acoustic interaction had significantly higher levels of CORT than males that were not involved in an aggressive interaction. Additionally, while winners of aggressive bouts and non−aggressive males had similar circulating androgen levels, losers of aggressive bouts had significantly higher CORT levels and lower androgen levels. I subsequently simulated territorial intrusions by broadcasting isolated aggressive calls or advertisement calls to captive males to examine the effects on hormone levels in signal receivers. Males exposed to aggressive calls exhibited a dramatic increase in CORT level and a reduction in androgen level. Surprisingly, males exposed to isolated advertisement calls showed a similar hormonal response but aggressive calls were more effective at eliciting elevations in CORT. CORT level is inversely related to androgen level and high CORT/low androgens negatively affect the attractiveness of vocal signals or suppress vocalization in this species. Hence, signaling males may increase their chances of acquiring mates by eliciting elevations in CORT level in rival males. Results will be compared to previous work in anurans that showed a stimulatory effect of advertisement calls on androgen production in signal receivers.

P3.51 LEE, E.A.*; SCHMITT, A.; EARLEY, R.L.; The University of Alabama; *lizlee423@gmail.com*

Changes in endocrine status and gonadal morphology in mangrove rivulus exposed to ethinyl estradiol

A diversity of aquatic organisms inhabit mangrove ecosystems, which are rapidly becoming imperiled due to anthropogenic influences. Many mangroves are exposed to wastewater treatment plant effluents, potentially subjecting organisms to endocrine disrupting compounds (EDCs) such as ethinyl estradiol (EE2). The mangrove rivulus (*Kryptolebias marmoratus*) thrives in mangroves and is an excellent model organism in which to assess anthropogenic effects at the organismal level. Populations consist of self−fertilizing hermaphrodites with males being quite rare. Studies have shown that male fish exposed to EDCs in freshwater habitats show a dramatic reduction in androgens. We hypothesized that individuals exposed to EE2 would exhibit changes in estradiol (E2) and 11−ketotestosterone (KT; a fish androgen) as well as changes in gonad morphology. We used 116 individuals (58 hermaphrodite, 58 male) from four isogenic lineages. They were kept in 500 ml glass jars with 25 ppt salt water for 30 d. Each day the water was changed and half of the animals received a dose of 4 ng/L EE2 while the other half received vehicle. At 30 d we collected waterborne hormone samples from a subset of individuals and excised gonads for histological analyses from the remaining. Exposed males showed a decrease in KT while exposed hermaphrodites exhibited no change. Both sexes showed a decrease in E2 when exposed. Males also showed a significant decrease in sperm density as a result of EE2 exposure, but no significant changes occurred in the gonads of exposed hermaphrodites. Our findings provide insights into how EDCs might disrupt reproduction in fishes and raise questions concerning the extent of exposure and the mechanisms driving EDC accumulation in mangrove ecosystems.

P2.86 LEE, H.R.*; MERZ, R.A.; Swarthmore College, Pennsylvania ; *hlee3@swarthmore.edu*

Extraordinary elongation and mechanical properties of the body wall of the burrowing sea cucumber Leptosynapta clarki

The movement and locomotion of an animal are governed in part by the mechanical properties of its body wall. *Leptosynapta clarki*, a burrowing sea cucumber, collected from False Bay, San Juan Island, WA, extends its body nearly 3 times its minimum length as measured using time−lapse video in a laboratory setting. Observations in cryolite revealed that it extends by a combination of whole body peristalsis and tentacular crawling. Individual *L. clarki* whose tentacles were removed were only able to extend twice their minimum length and could not burrow while those with intact tentacles extended 3.4 times their minimum length. This indicates that the oral tentacles are required for extensive elongation and burrowing. Tensile tests were performed parallel to the anterior−posterior axis on sections of intact, cylindrical body wall (obtained by removing the anterior and posterior ends from anesthetized animals and leaving the viscera in place) and on isolated longitudinal strips of body wall. Using extension rates of either 2 mm/min (comparable to the extension rate achieved by *L. clarki*) or 50 mm/min neither stiffness nor strength of cut strips of body wall were affected by the rate of extension. In contrast, samples of cylindrical body wall were 3 times stiffer and 4 times stronger when pulled at the faster rate. Creep tests on samples of cylindrical body wall confirmed its viscoelastic behavior. These results suggest that viscoelastic elements in the body wall of *L. clarki* might have been disrupted when it was cut longitudinally or when the internal organs were removed. Since the natural range of maximum extension and the maximum strain from mechanical testing were very similar, it appears that *L. clarki* is operating near the maximum capacity for strain of its body wall.

108.1 LEE, T.N.*; BUCK, C.L.; BARNES, B.M.; O'BRIEN, D.M.; Harding University, Searcy, AR, University of Alaska, Anchorage, University of Alaska, Fairbanks, University of Alaska, Fairbanks; *tnlee@harding.edu*

A test of alternative models for increased tissue nitrogen isotope ratios during fasting in hibernating arctic ground squirrels

We describe two models explaining the increase in tissue nitrogen isotope ratios ($\delta^{15}N$) that occurs during fasting in animals. The catabolic model posits that protein breakdown selectively removes the lighter isotope of nitrogen (^{14}N) from catabolized tissues, causing an increase in the proportion of heavy nitrogen isotope (^{15}N). The anabolic model posits that protein synthesis during fasting results in elevated $\delta^{15}N$ values, as the unreplaced loss of ^{14}N to urea results in a higher proportion of ^{15}N in plasma amino acids used for protein synthesis. We effected a range of lean mass loss in arctic ground squirrels (*Urocitellus parryii*) fasting during hibernation before collecting organ and muscle tissues for analysis of $\delta^{15}N$ values. The catabolic model predicts increased $\delta^{15}N$ values in both liver and muscle, since these tissues undergo significant catabolism during hibernation. The anabolic model predicts no change in muscle, but an increase in $\delta^{15}N$ values in liver, which has high levels of protein synthesis during euthermic phases of hibernation. We found a significant increase in liver $\delta^{15}N$ values and no change in muscle $\delta^{15}N$ values with lean mass loss, which supports the anabolic model. Heart, small intestine, and brown adipose tissue also increased in $\delta^{15}N$ values, indicating protein synthesis in these organ tissues during hibernation. Urine was 3.80 lighter than plasma, and both urine and plasma increased in $\delta^{15}N$ values with lean mass loss. This study helps clarify the mechanisms causing $\delta^{15}N$ change during nutritional stress, thus increasing its utility for physiological research and reconciling previously contradictory results.

S5.2−1 LEE, David V*; MCGOWAN, Craig P; ISAACS, Michael R; University of Nevada Las Vegas, University of Idaho Moscow; *david.lee@unlv.edu*

Is the spring in our step the spring in our leg?

Virtual leg spring stiffness k_{leg} has long been used to characterize bouncing gaits such as running, hopping, and trotting. Although k_{leg} is a spring constant, it is divorced from the physical leg because virtual spring deflections are determined solely from vertical and fore−aft displacements of the center of mass (CoM) rather than measured deflections of the physical leg. The virtual leg assumption that time−varying force and deflection are symmetrical sinusoids is the exception rather than the rule for the physical leg. Here we use a serial actuator−spring model, acting as a radial pogo−stick from the hip to the ground, to determine a spring constant k_{rad} for the physical leg based upon actual time−varying force and length changes. Radial leg spring constants k_{rad} of bipedal runners and hoppers increase significantly with speed − a phenomenon not observed in k_{leg}. The effect of speed on k_{rad} indicates that an increasingly stiffer leg spring would minimize the work required of the in−series actuator. While the radial leg spring constant k_{rad} is similar to k_{leg} during bipedal hopping, it is three times greater than k_{leg} during human bipedal running. Hence, dynamics of the radial leg of wallabies more closely match the virtual leg model. The three−fold greater k_{rad} compared with k_{leg} found during human running is also observed during quadrupedal trotting. Consistent with the observation that the bipedal hopping leg more nearly approaches an idealized virtual leg spring, we find that the in−series actuator does one−third of the radial leg work during hopping but more than half of the leg work during human bipedal running. Our results support the concept that legs utilize stiffer built−in springs than the virtual leg spring model would predict and suggest that large bipedal hoppers may represent an exception to this rule.

S8.3−3 LEMA, S.C.; CalPoly, San Luis Obispo; *slema@calpoly.edu*
Ecological variation and hormone−mediated plasticity in Death Valley's pupfishes: Insights into the dynamics and distinctiveness of phenotypic diversity
Phenotypic variation is generated via the complex orchestration of interacting factors that an organism experiences during development. Studies of hormone signaling systems can play a central role in understanding how those factors integrate during development, since hormonal systems both respond to conditions in an organism's external environment and are well established as regulators of patterns of gene expression that, ultimately, underlie variation in morphological, physiological and behavioral traits. And yet, there are many gaps in our understanding of the mechanistic relationships between environment, hormones and phenotype, and several crucial questions remain unanswered about how hormone−mediated developmental processes link phenotypic traits to ecological variation via processes such as phenotypic plasticity. How do hormonal systems mediate developmental stage−specific malleability in phenotypes, and how does environmental variation at different stages of development contribute to phenotypic variation among individuals or populations? Does environmental experience have differential impacts on the signaling components (e.g., hormone, conversion enzyme, receptor) that comprise a hormone signaling pathway, and how does any such plasticity in those components contribute to flexibility or constraint in the coupling of correlated traits? And critically, how do adaptive, hormone−mediated phenotypes evolve if the hormone signaling pathways themselves are often plastic with environmental variation? These questions will be discussed in the light of studies on the phenotypic plasticity of Death Valley's pupfishes (*Cyprinodon* spp.) in an effort to provide traction toward understanding plasticity and phenotypic diversity in an ecological and evolutionary context.

56.4 LEMBERG, JB*; ROSS, CF; SHUBIN, NH; DAESCHLER, EB; University of Chicago, Academy of Natural Sciences of Drexel Univ.; *lemberg@uchicago.edu*
Digital reconstruction of the skull of Tiktaalik roseae with insights into early tetrapod feeding mechanics
Recent studies of the feeding mechanics of early tetrapods have focused on the adaptation of an aquatic suction feeding mechanism to one capable of feeding on land. *Tiktaalik* is an important transitional taxa at the boundary of the fin−to−limb transition that exhibits early examples of tetrapod−like characteristics in the cranium. The platyrostral condition of early tetrapods is first seen in elpistostegids, but its functional consequences for aquatic feeding are not fully understood. By comparing *Tiktaalik* with extant platyrostral taxa, like *Alligator* and gars, we can bound our inferences of the function of early tetrapod morphology. Patterns of cranial sutures are hypothesized to provide information about suction feeding versus biting. Crocodilians and gars possess broad scarf joints along their tooth rows. It is hypothesized these rostral scarf joints are adaptations for resisting torsion incurred during unilateral biting. Similarly the derived secondary palate of crocodilians is hypothesized to resist torsional loads. Here, we used computed tomography (CT) data of several *Tiktaalik* specimens, to digitally reconstruct cranial morphology and define areas of sutural contact between bones. Anteriorly, the rostrum of *Tiktaalik* is characterized by scarf joints, and posteriorly the squamosal broadly overlaps the quadrate and pterygoid. Medially the postorbital forms a complex suture with the postfrontal, which immediately overlays the prootic process of the braincase. The region of bones bounded by these sutures overlay approximately two−thirds of the tooth row, a robust palate, and the adductor chamber. Comparing this morphology with gars and crocodilians suggests a feeding system capable of resisting torsion incurred during unilateral biting.

125.2 LENDVAI, AZ*; OUYANG, JQ; SCHOENLE, LA; FASANELLO, VJ; HAUSSMANN, MF; MOORE, IT; BONIER, F; Virginia Tech, Bucknell Univ, Queen's Univ; *lendvai@vt.edu*
Functional significance of hormonal plasticity in house sparrows
Hormone concentrations are among the most labile of phenotypic traits. Plasticity in levels of corticosterone (cort), the main avian stress hormone, provides a mechanism for individuals to rapidly respond to environmental change. However, the functional effects of such plasticity are unknown. We studied individual differences in cort levels under varying conditions to test whether there are consistent individual differences in (1) baseline cort levels; (2) responsiveness (plasticity) to an ecologically relevant stressor (food restriction); and (3) whether individual differences in plasticity are related to immune function and the overall oxidative damage experienced by individuals. We took 25 wild−caught house sparrows, Passer domesticus, into captivity and randomly assigned them to a food restricted or control treatment (60% and 110% of their daily food consumption, respectively) for one week. We controlled for order effects by alternating the treatments for four consecutive weeks, such that each individual experienced food restricted and control diets twice. At the end of each week, we recorded the body mass of the birds and took blood samples within 3 minutes for hormone and oxidative stress analysis. We found that during food restriction, birds lost mass and had higher cort levels compared to control treatments. Birds showed significant individual variation in baseline cort levels and stress responsiveness, even after controlling for changes in body mass. However, these individual differences in hormonal plasticity were not related to wound−healing capacity (a measure of immune function) or plasma oxidative damage. Therefore, despite individual differences in stress responsiveness, the adaptive significance of this variation is unclear.

P3.159 LEVENFELD, V*; GOLDMAN, D.I.; Georgia Institute of Technology; *vlevenfeld@gmail.com*
Development of a system to study the effects of foot use on punching force
Martial artists have developed different styles of fighting over thousands of years. High level practitioners know well the importance of integrated body, limb and hand movements. However, there is little quantitative understanding of how the striking forces from hand punches are affected by the forces generated at the feet. To help remedy this, and to allow martial artists to quantify mechanics during training, we have developed a low−cost system consisting of two force platforms and multiple high−speed cameras to simultaneously record strike forces, ground reaction forces in three−dimensions from both feet, and limb/body kinematics. Preliminary results indicate common features in the ground reaction force signature for all closed−fist hand strikes. In particular, legs undergo distinct loading and driving stages as the punch is executed, with some significant differences in the timing and weight distribution during these stages among practitioners of varying experience levels. We observe that less experienced practitioners tend to keep their weight equally distributed over both legs at the time of impact. Experienced martial artists shift weight quickly from leg to leg during a punch.

P3.96 LEVINE, J.*; MCCAULEY, B.; HINMAN, V.; LOWE, C.; Stanford Univ., Carnegie Mellon Univ.; *levinej@stanford.edu*
Relating the pentaradial starfish body plan to the bilaterian anterior posterior axis
The echinoderms are a bilaterian phylum with a highly derived radially symmetric adult body plan. As larvae, echinoderms possess a bilateral body plan with clearly defined anteroposterior (AP) and dorsoventral axes. However, at metamorphosis larvae undergo a radical transformation to a five−fold radially symmetric adult body plan. The unusual anatomies of this derived adult body plan have hindered even basic axial comparisons with other bilaterians. Bilaterian phyla pattern their AP axes with a network of transcription factors, expressed in a highly conserved spatial sequence. This suite of developmental genetic characters could inform an investigation of the axial properties of echinoderms. We are carrying out a comprehensive analysis of AP patterning gene expression during the development of the bat star *Patiria miniata* to explicitly test whether 1) echinoderms have retained the ancestral bilaterian gene expression domains, which would represent a cryptic molecular axis and facilitate axial comparisons with other bilaterians, or 2) echinoderms have changed the order of these domains, indicating that they remodeled the deeply conserved network of transcription factors that pattern the bilaterian AP axis while devising novel ways to pattern their five−fold radially symmetric body plans. We produced a transcriptome from a wide range of *P. miniata* larval and juvenile stages, and analyzed it for orthologs of AP patterning genes. We cloned orthologs of genes with conserved roles in patterning the anterior, mid, and posterior regions of the bilaterian AP axis, performed *in situ* hybridization on larvae and juveniles, and present the localization of these genes in larval and adult body plans.

P3.14 LEVINE−WEINBERG, M.P.*; MERZ, R.A.; Swarthmore College; *mlevine1@swarthmore.edu*
The intertidal front lines: A comparison of the aggressive response in high and low intertidal clones of the anemone Anthopleura elegantissima
Sessile organisms must contend with different challenges depending on their vertical position in the rocky intertidal zone. Those individuals in the lower part of their species' intertidal range typically experience greater predation and competition while their relatives in the higher intertidal are exposed to more frequent, extreme and longer lasting variation in physical factors. *Anthopleura elegantissima* are found from Baja California to Alaska and form intertidal, clonal colonies that make an aggressive response to nearby non−clonemates. We hypothesized that anemones living higher in the intertidal would have less energy to allocate towards aggression than those in the lower intertidal. We sampled clones from both the lower and higher intertidal at Cattle Point, San Juan Island, WA and, in the laboratory, pitted them in battles against individuals from a single clone from a rock ledge adjacent to the Friday Harbor Labs. Post−battle counts of acrorhagi (specialized battle tentacles), as well as time−lapse videos of the battles, were analyzed for metrics of aggression. There were significantly more acrorhagi in animals from the lower intertidal than those in the higher intertidal. No behavioral battle metric showed a significant difference between the higher intertidal and lower intertidal clones; however, in 11 of 13 metrics lower intertidal clones ranked as more aggressive. Based on the results of the individual analyses of metrics, higher intertidal animals seem to have an increased fighting efficiency, behaving as aggressively as lower intertidal animals, but with fewer acrorhagi. The rank analysis suggests that upper intertidal clones are more limited in their aggression.

P2.167 LEVINSON, B.M*; BLATZHEIM, L; BOWER, C.D; POLK, T; IKIZO LU, D; KARAHN, A; GUNE^, N; ÇAKMAK, I; WELLS, H; HRANITZ, J.M; University of California, San Diego, Southwestern Oklahoma State University, Bloomsburg University, Southern Nazarene University, Uluda University, Bursa, TURKEY, University of Tulsa; *blevinso@ucsd.edu*
The neonicotinoid pesticide imidacloprid affects motor responses in honey bees.
Pesticides and insecticides have been increasingly used in commercial produce and farming for decades. Neonicotinoid pesticides, mimics of nicotine, are being used at a high rate globally and have been implicated as a causal agent in the honey bee colony collapse disorder (CCD). Of the variety of neonicotinoid pesticides currently in use, imidacloprid is by far the most widely used in this class. As a systemic pesticide, imidacloprid is applied to a wide array of crops and is reported in both nectar and pollen used by honey bees at concentrations that should ensure doses lower than the LD50. As a neurological blocker of acetylcholine synapses, the sublethal effects of imidacloprid were expected to manifest as lack of motor control over muscle. Therefore, our goal was to investigate the effect of sublethal doses of imidacloprid on motor coordination of the honey bee. We fed bees sublethal doses of imidacloprid ranging from 1/5 to 1/500 LD50 in 50% sucrose. Control bees were fed 50% sucrose only. At 4 h post−ingestion, honey bees were scored for their motor coordination by assessing the proboscis extension reflex as well as coordination of the antennae, legs, and abdomen. Bees fed doses of imidacloprid higher than 1/100 LD50 showed reduced motor coordination similar to that of thermally stressed honey bees. These results show that imidacloprid, even at doses 1/100th of the LD50, impair basic motor coordination fundamental to locomotion and foraging.

S10.2−2 LEVY, R*; SWANSON, E; DANIELS, K; STRICKLAND, S; Harvey Mudd College, Centre College, NC State University, NC State University; *levy@hmc.edu*
Surface tension in human lungs: modeling and experiments
Naturally produced surfactant, which lowers surface tension is required for normal human lung function. Premature babies born before surfactant production begins, are at risk for respiratory distress, and often require surfactant replacement therapy. For 20 years mathematicians, engineers and physicists have sought to model the complicated flow of fluid lining the passageways and alveoli of the lungs. New experiments allow us to visualize a simplified system that includes a thin film of glycerol and a surface layer of surfactant. This talk will describe what we can learn from such experiments, how the results compare to a commonly accepted model, and how we might modify the experiments to better capture dynamics in the lungs.

64.6 LEVY, O*; BUCKLEY, BB; KEITT, TH; ANGILLETTA, MJ; Arizona State University, Tempe, AZ, University of North Carolina at Chapel Hill, Chapel Hill, NC, The University of Texas at Austin, Austin, TX; *levyofi@gmail.com*

Bringing regional projections of climate and landscape to the organismal level

Organisms are the fundamental components of ecological systems. Organisms interact with microenvironments and respond to microclimatic changes. Macroclimate, on the other hand, operates and changes at spatial scales well beyond any organism. Climatic data used to predict biological responses are temporally or spatially aggregated. Hence, these data obscure natural variation that occurs among microhabitats as well as climatic extremes, both of which are important for accurate forecasting. To resolve this problem, we used the Community Earth System Model to predict 30 years of current and future climates around the globe. We then used the Weather Research and Forecasting model to downscale these climatic predictions to spatial and temporal resolutions of 36 km and 1 h, respectively. Finally, we modeled changes in vegetation cover caused by climate change. To simulate fine−scale climatic variation, we used the model output and heat transfer functions to calculate ambient, surface, and soil temperatures for various levels of shade and heights above or below ground. We applied this climatic downscaling to predict operative temperatures for a widespread species of lizards, *Sceloporus undulatus*. We implemented an individual−based model where lizards forage, grow, and reproduce based on their thermal tolerance and predicted climates. Lizards can buffer climate change by thermoregulating behaviorally, but this capacity varies dramatically among locations. Since embryos cannot thermoregulate, the timing and location of nesting should shift differently among locations, given predicted changes in soil temperatures. Our downscaling approach should enable one to make more accurate predictions about the biological impacts of climate change.

P3.67 LEVY, O; SMITH, C; BOATENG, K; KUMAR, D*; ANGILLETTA, MJ; Arizona State University, Tempe, AZ 85287, USA; *levyofi@gmail.com*

Pre−heating to sublethal temperature did not improve thermal limits of lizard embryos

Future climates will impose acute heat stresses that should be most stressful to embryos, which cannot behaviorally thermoregulate as effectively as juveniles and adults. We studied the heat tolerance of lizard embryos (*Sceloporus undulatus*) from populations in New Jersey and South Carolina. A previous experiment showed that these embryos could not survive a single brief exposure to 42°C, suggesting a threshold for thermal tolerance. However, many animals can adjust their thermal tolerance through acclimation. To explore the potential for heat hardening by embryos, we exposed eggs to either a peak of 35°C (control) or 40°C (pre−heated) prior to exposing both groups to either 42° or 44°C. Survival was inferred daily from measurements of heart rate. We expected that embryos pre−heated to 40°C would survive exposure to higher temperatures whereas control embryos would not. However, neither pre−heated nor control embryos survived a single brief exposure to 44°C and all embryos survived a similar exposure to 42°C. Rapid heat hardening does not appear to be a mechanism by which lizards will cope with thermal stress during embryonic development.

22.3 LEWIN, NS*; TREIDEL, LM; PLACE, NJ; HOLEKAMP, KE; HAUSSMANN, MF; Michigan State University; *lewinnor@msu.edu*

Social rank predicts telomere length in female spotted hyenas (Crocuta crocuta)

The social environment plays an important role in shaping developmental trajectories, but we have little understanding of whether or how these effects express themselves later in life. While social stress accelerates telomere erosion in humans, no research to date has explored this in free−living animal populations. Spotted hyenas *(Crocuta crocuta)* are long−lived gregarious carnivores that live in groups, called clans, in which dominance rank confers priority of access to resources and predicts growth, reproductive success, and sociality. The dominance hierarchy is maintained by aggressive behavior such that low−ranking animals receive the most attacks and may experience greater social stress. Here, we investigated telomere length among adult females in a population of closely−studied, free−ranging spotted hyenas using the telomere restriction fragment (TRF) assay. High−ranking females exhibited significantly longer mean TRF lengths than either low−ranking females or immigrant males. Although the mediating mechanisms are unknown in hyenas, current hypotheses suggesting oxidative stress and social buffering offer exciting avenues for future research. This work offers an unprecedented look at telomere dynamics in a wild long−lived mammal, and seeks to explore the contribution of social behavior to aging in a non−primate model.

P2.68 LEWIS, ZR*; HANKEN, J; Harvard University, Cambridge, MA; *zlewis@oeb.harvard.edu*

Evolutionary linkage of heart and lung development in lungless salamanders

Separation of oxygenated from deoxygenated blood in the heart is a critical component of pulmonary respiration in tetrapods that facilitates their terrestrial existence. In mammals, the closure of the foramen ovale and the complete separation of left and right atria yield efficient dual circulatory pathways. In amphibians, an atrial septum forms embryonically to separate pulmonary and systemic blood flows. Whether the lungless salamanders (family Plethodontidae) possess an atrial septum as adults is a contentious topic; authors have stated opposing claims for over 100 years. The atrial septum presumably would have little function in lungless salamanders due to the absence of pulmonary return. Here, we use μ−CT imaging to examine atrial septum development of both lungless salamanders and salamanders with lungs. We show that lungless salamanders fail to develop atrial septa. In mammals, the lungs induce formation of the atrial septum by secreting morphogens to neighboring mesenchyme. We hypothesize that atrial septum loss in lungless salamanders is a direct result of evolutionary loss of this signal, and present evidence that administration of exogenous morphogens results in partial restoration of atrial septa. Hearts and lungs are a genetically and evolutionarily interconnected module, whose morphology and physiological function are dictated by developmental signals. Atrial septum loss in plethodontids is likely a direct consequence of lunglessness.

2.8 LEWIS, A.M.*; WHAM, D.C.; LAJEUNESSE, T.C.; The Pennsylvania State Univ.; *allisonlewis@psu.edu*
Partner specificity precedes environmental zonation in coral−algal symbioses
It has been nearly two decades since the first account of the environmentally regulated patterning of microalgae (genus *Symbiodinium*) associated with the western Atlantic corals *Orbicella* (=*Montastraea*). This early revelation suggested that coral−algal symbioses might be highly dynamic, responding to environmental fluctuation by changing resident symbiont populations. Recently developed high−resolution genetic markers expand our ability to define species boundaries among morphologically nondescript *Symbiodinium* and identify individual genotypes through phylogenetic and population genetic analyses. These data obtained from a broad range of host sources indicates that *Symbiodinium* common to Orbicella are host−specific and distinct from the many species of *Symbiodinium* found in other cnidarians in the immediate environment. Furthermore, while many Orbicella at shallow and intermediate depths harbor multiple (2−3) *Symbiodinium* species, each resident species comprises a monoclonal population. Our results suggest that high specificity exists between species of coral host and symbiont.

93.2 LI, C*; FULL, R.J.; Univ. of California, Berkeley; *chen.li@berkeley.edu*
Insects traversing grass−like vertically compliant beams
Small running animals encounter more challenging terrains than larger ones. These terrains can be filled with three−dimensional, multi−component obstacles. Here, we study cockroaches (*Blaberus discoidalis*) moving through grass−like, vertically compliant beams during escape. We created an apparatus to systematically control and vary geometric parameters and mechanical properties of model grass that include their height, width, thickness, lateral spacing, fore−aft spacing, angle, number of layers, stiffness, and damping. We observed a suite of novel locomotor behaviors not previously described on simpler 2D ground. When model grass height was larger than 2 times the animal's body length and the lateral spacing was smaller than 50% of the animal's body width, the animal rolled its body onto its side to rapidly maneuver through the narrow gaps between the model grass. 50 percent of the time, animals (N = 6 animals, n = 361 trials) locomoted on their side through three layers of grass within 2.1 ± 1.3 seconds. We hypothesized that the animal's slightly curved, oval body shape (resembling a slice of an ellipsoid) facilitated its traversal. To test our hypothesis, we modified the animal's body shape by adding a rectangular plate onto its dorsal surface (N = 6 animals, n = 374 trials). The probability for traversal on its side through grass decreased to 5% and the travel time increased to 5.8 ± 3.2 s. Upon removal of the rectangular plate (N = 4 animals, n = 225 trials), the probability and time for traversal on its side through grass recovered to 47% and 2.7 ± 2.1 s, respectively. Locomotor geometry effectively coupled to terrain dynamics can enable negotiation of multi−component obstacles, and provide inspiration for small robots to navigate extended terrain with minimal sensing and control.

101.5 LI, Z.*; CLARKE, J.A.; University of Texas at Austin; *zhiheng_li@utexas.edu*
The relationship between feeding mode and tongue structure in waterfowl (Aves: Anseriformes) illuminated through enhanced contrast X−ray computed tomography and morphometric assessment of hyoid shape.
Within Anseriformes, waterfowl (ducks, geese and swans) exhibit two specialized feeding modes, distinctive among birds: one form of filter feeding with fine keratinous ramphothecal lamellae and cropping, or grazing, of vegetation. The myology of the tongue and its involvement in feeding has been explored in other vertebrate taxa. However, they remain comparatively little explored in birds. As part of a larger study of variation in the osteology and myology of the avian tongue, we explore differences in structure seen in filtering and grazing taxa in Anatidae. Since many anatomical features of the tongue and cranial region are delicate, contrast−enhanced high resolution X−ray Computed Tomography (CT) data were used to visualize these structures. Two exemplar species within Anatidae, (*Branta canadensis*, Canada Goose, and *Aythya americana*, Redhead) were the focus of this study. These exemplars were chosen based on morphometric analyses evaluating of bony tongue structures, skull shape and feeding mode. Segregation by feeding mode is recovered in the multivariate analyses using the hyoid and skull measurements. Variation in muscles within buccal floor and muscles associated with bony hyoids provide an anatomical basis to interpret the different lingual motions dominated in filtering and grazing. Protraction and retraction of the tongue is remarkable in grazers, in which the hyoid apparatus and extrinsic hyoid muscles are larger in size than in filter feeders. By contrast, lingual depression in filter feeders is indicated by enlargement of two intrinsic hyoid muscles. Lastly, the morphology and development of sensory organs (the olfactory bulb and the inner ear) show significant differences that also appear to be explained by foraging ecology.

80.5 LI, G.*; MULLER, U.K.; VAN LEEUWEN, J.L.; LIU, H.; Chiba University, California State University Fresno, Wageningen University; *dr.mango@icloud.com*
Can larval fish enhance their hydrodynamic performance of backward C−starts by capturing their own wake?
Fish can sense and capture the wakes of other fishes to achieve better hydrodynamic performance. In this study, we explore whether fish are also capable to enhance hydrodynamic performance by capturing their own wake when the body bends with a sufficiently large curvature as occurs during extreme backward C−starts'. We examined the extremely fast backward C−start maneuver of zebrafish larva. So far, the flow field of such maneuvers has not been measured directly. Recently, however, we have developed an integrated computational approach by coupling the equations of body dynamics and hydrodynamics to simulate a free−swimming larval zebrafish. We validated our model through a careful comparison of both flow patterns and body kinematics with experimental observations, which showed a reasonable agreement. We further conducted a series of simulations to explore the mechanism of forward and backward C−starts, including the performance of maneuvers, as well as their correlations with the simulated flow patterns.Our numerical simulations suggest that a wake capture mechanism in larval fish occurs during the backward C−start: when the fish ends the preparatory stroke, it almost accomplishes the backward turning with the body curved into an approximate circle and the wake shedding from the tail and occasionally sweeping over the fish's snout. During the subsequent propulsive stroke, the larva apparently follows the shed jet while absorbing it into its own boundary layer. By exploiting this jet−momentum flowing around the snout, the fish presumably enhances its hydrodynamic performance.

58.3 LIAO, J.C.*; AKANYETI, O; BALLO, A; HAEHNEL, M; LEVI, R; The Whitney Lab for Marine Bioscience/U. Florida; *jliao@whitney.ufl.edu*

Sensory and Motor Responses to Deflection of Single Neuromasts in the Lateral Line System in Larval Zebrafish

Larval zebrafish (*Danio rerio*) are able to use their lateral line system to detect flow−related information. To characterize the system, we performed electrophysiological recordings of posterior lateral line afferent neurons while deflecting individual neuromasts with a piezoelectric stimulator. We applied three distinct stimuli: a single deflection to look at the response to variations in deflection velocity (0.01 − 30 ¼m ms^{-1}), pure sine waves to test which frequencies (1 − 90 Hz) to which cells were most tuned, and a pulse that contained a broad frequency spectrum to quantify the ability of cells to transmit information at various frequencies. For single deflections, we found that maximum spike rate increased with stimulation velocity, while the time delay between stimulus onset and maximum spike rate decayed exponentially as a function of velocity. For sine wave stimuli, we used firing rate and vector strength to characterize responses across frequency and found mainly one type of cell with band−pass qualities, although we did record several cells that exhibited high and low−pass qualities. For pulse stimuli, we found that spiking rate did not increase linearly with stimulation frequency. Rather, as stimulation frequency increased, cells transitioned from phase−locking with spontaneous activity to only phase locking, and finally to a decreased ability to phase lock. Cells with higher spontaneous firing rates showed a corresponding sensitivity to higher stimulus frequencies. Remarkably, we could elicit fictive swimming with 50 − 85% probability with a single deflection of an individual neuromast, revealing a surprising sensitivity. Our findings advance our understanding of the neuronal mechanisms that enable fish to their lateral line system to convert mechanical stimuli into motor behaviors.

S7.2−1 LIBERSAT, F.*; GAL, R; Ben Gurion University; *libersat@bgu.ac.il*

Wasp Voodoo Rituals, Venom−Cocktails and the Zombification of Cockroach host.

Much like humans, animals may choose to initiate behavior based on their "internal state" rather than as a response to external stimuli alone. The neuronal underpinnings responsible for generating this internal state', however, remain elusive. The parasitoid jewel wasp hunts cockroaches to serve as a live food supply for its offspring. The wasp stings the cockroach in the head and delivers a neurotoxic venom cocktail directly inside the prey's cerebral ganglia to apparently hijack its free will'. Although not paralyzed, the stung cockroach becomes a living yet docile zombie' incapable of self−initiating walking or escape running. We demonstrate that the venom selectively depresses the cockroach's motivation or drive' to initiate and maintain walking−related behaviors, rather than inducing an overall decrease in arousal or a sleep−like' state. Such a decrease in the drive for walking can be attributed to a decrease in neuronal activity in a small region of the cockroach cerebral nervous system, the sub−esophageal ganglion (SEG). Specifically, we have used behavioral, neuro−pharmacological and electrophysiological methods to show that artificial focal injection of crude milked venom or procaine into the SEG of non−stung cockroaches decreases spontaneous and evoked walking, as seen with naturally−stung cockroaches. Moreover, spontaneous and evoked neuronal spiking activity in the SEG, recorded with an extracellular bipolar microelectrode, is markedly decreased in stung cockroaches as compared with non−stung controls. By injecting a venom cocktail directly into the SEG, the parasitoid Jewel Wasp selectively manipulates the cockroach's motivation to initiate walking without interfering with other non−related behaviors.

93.6 LIBBY, T.*; HWANG, M.; KOH, M.; XIE, B.; FULL, R.J.; Univ. of California, Berkeley; *tlibby@berkeley.edu*

Ground reaction forces during rapid escape turns in lizards.

Body bending and appendage swinging can enhance maneuverability by exchanging angular momentum between body segments, allowing an animal to change direction even in the absence of external impulses. Multi−segment, rigid−body dynamics models of the lizard, *Agama agama*, revealed that inertial forces from C−start−like body curling and tail swinging significantly increase rotation in the first stride of an escape turn. Here, we combine our earlier momentum model of turning with measurements of whole body and single leg ground reaction forces measured using a force platform. Turns from 90° to 180° were executed in under 300 ms. Whole body forces showed that lizards did not simply rotate in place, but developed significant net center of mass (COM) linear acceleration in the escape direction during the first step. Some faster turns exhibited an aerial phase, where animals jumped and spun about the vertical axis. Peak single leg forces ranged from 5−10 times body weight. Ground reaction forces were oriented such that all limbs contributed to both angular and linear impulse during the first step, with the outer front limb being the dominant source of impulse. Foot forces in the first step appear to be a compromise between turning and accelerating the animal. No limb generated a net negative angular impulse to turning, although hind limbs often resisted net COM acceleration. Results are inspiring the design of a horizontal back bending robot with rapid turn capabilities.

29.4 LIEBESKIND, BJ*; GHEZZI, A; HILLIS, DM; ATKINSON, NS; ZAKON, HH; Univ. of Texas at Austin; *bliebeskind@austin.utexas.edu*

Phenolog approach identifies a novel gene that interacts with sodium leak channels (NALCN) and affects Drosophila behaviour.

Behavioral plasticity in animals often depends on subtle changes in the intrinsic excitability of a subset of neurons. Small changes in membrane permeability that affect the resting potential can alter intrinsic excitability, and sodium leak channels (NALCN) have recently been implicated in this mechanism and in rhythmic behaviors in a variety of species. The full complexity of NALCN function is only just beginning to be appreciated, however. It is now known that NALCN channels can associate with numerous subunits in different tissues and can be activated, via poorly understood mechanisms, by several different peptides and second messengers. We show that NALCN channels are closely related to fungal calcium channels, which they functionally resemble. We then use this relationship to suggest an association between NALCN and a previously undescribed protein in *Drosophila* on the basis of homology with the yeast protein Mid1, the subunit of the yeast calcium channel. This novel gene is co−ordinately expressed with NALCN, and knockdown of either gene creates identical phenotypes in several behaviors associated with NALCN function. We therefore suggest a genetic association between this novel gene and NALCN in *Drosophila*. The conservation of this association between flies and fungi suggest that yeast can be a useful model for NALCN function in animals.

127.3 LIEBL, AL*; MARTIN, LB; Univ of Exeter, Cornwall, Univ South Florida; *a.l.liebl@exeter.ac.uk*

Behavioral plasticity in response to novelty is dependent on stage of range expansion in Kenyan house sparrows

The introduction and range expansion of non−native species has significant ecological and economic impacts globally. Although many factors contribute to a species' spread, certain behaviors are particularly influential in range expansion success. One behavior, response to novelty, can influence the acquisition of novel resources but can also increase exposure to toxins, parasites, and predators. Therefore, the balance between approach and avoidance of novelty should be dependent on resource familiarity and thus population age. Here, we examined whether a population of introduced house sparrows (*Passer domesticus*) undergoing range expansion responded to novel items differently dependent on stage of expansion. We predicted that birds at the range edge would approach novel items more rapidly than birds at the site of introduction. We also expected that range edge birds would be more plastic in their behavioral response, thus adjusting their responses to each context, rather than reacting to all items the same way. Range edge birds indeed approached novel items significantly faster and also had significantly greater plasticity in their responses to each of the four novel items. Plasticity in response to novelty might offer protection from the risks associated with exploring novelty, while allowing individuals to respond appropriately to the many types of novelty potentially found in range edge habitats. Results such as these have ramifications for invasion biology and biology in general, as they elucidate the traits that influence a population's ability to survive unfamiliar habitats.

P3.122 LIGHTFOOT, H.A.*; MENDONCA, M.T.; GOESSLING, J.M.; ADDLA, A.S.; Auburn Univ., Auburn; *hal0004@tigermail.auburn.edu*

A comparison of parasites in native and invasive anurans: Can parasitic nematodes of invasive anurans survive in native North American anuran hosts?

The Cane toad, *Rhinella marina*, is native to South America and has become an invasive pest in tropical and subtropical regions globally, including Hawaii, Australia, the Caribbean, and peninsular Florida. Invasive Cane toads are highly toxic to many native predators and can act as predators on native anurans. We tested if the Cane toads serve as vectors of exotic parasites and transfer these parasites to North American anurans. To compare the parasites found in the lungs of Cane toads to the parasites found in the lungs of a sympatric Floridian toad species (the Southern toad, *Anaxyrus terrestris*), we amplified and sequenced the ITS5 nuclear gene of lungworms from Cane toads and Southern toads across a latitudinal gradient where both species of toad are sympatric, as well as one location where Cane toads are not yet found. A BLAST search indicated that all parasites sequenced from the Cane toad, in all locations collected, were *Rhabdias pseudosphaerocephala*. We found three different species of parasites in the Southern toad. In the site where Cane toads are absent, Southern toads were parasitized by *Rhabdias americanus* and *Rhabdias joaguinensis*. These lungworm species are those typically found in native toad species. Southern toad parasites sequenced from locations within the invasive species range were *Rhabdias pseudosphaerocephala*, the same species found in the invasive Cane toad. The extent of the cross−species infection of parasites to a native species suggests that the native anurans now harbor Cane toad lungworms. This is the first documented observation of invasive lungworm parasites being found in North American toad species.

85.1 LIN, H*; MISCHIATI, M; SIWANOWICZ, I; LEONARDO, A; HHMI Janelia Farm; *linh10@janelia.hhmi.org*

To pursue, or not to pursue, that is the question: A neuroethological investigation of dragonfly predation decisions

The dragonfly is an ancient aerial predator that specializes in capturing flying insects. Apart from their exceptional flying abilities, dragonfly predation success hinges on their target selection and pursuit decisions. With substantial metabolic investments at stake, these decisions are under high selective pressure. In this study, we focus on quantifying the rules underlying these takeoff and pursuit abortion decisions in the Common Whitetail (*Libellula Lydia*). We presented dragonflies with prey motion varying in speed profile and location using a custom robotic system. The dragonflies took off only after some prey, and some pursuits were aborted in mid−air. We captured the 3D kinematics of the dragonfly head and body, as well as the prey, using a customized motion capture system. These data allow us to reconstruct the exact time−varying projection of the prey in the dragonfly's visual field from prey detection to capture. We found that perched dragonflies made a rapid head saccade to any moving target above their body, bringing the target to within ±10° azimuth and ±30° elevation from the center of the fovea. Following the saccade, smooth head tracking refined the alignment in both axes. In cases of pursuit, the foveation at takeoff was within 5° and was maintained throughout the flight. Pursuit abortion tended to occur when the target drift rate was high. Prompted by these behavioral data, we investigated the role of the target selective descending neurons (TSDNs) in these critical decisions. We recorded extracellularly from TSDNs in immobilized dragonflies and examined their responses to reconstructed visual experiences from real prey capture events. Then we attempted to elicit head saccades and pursuits while recording from TSDNs via a telemetry backpack.

4.7 LIN, Y.F.*; HORNER, A.M. ; EKSTROM, L. J. ; ROBERTS, T. J. ; DUMONT, E.R. ; University of Massachusetts at Amherst, MA, California State University, San Bernardino, CA, Wheaton College, Norton, MA, Brown University, Providence, RI; *yifenlinOEB@gmail.com*

How moles destroy your lawn: the "lateral stroke" of Eastern moles (Scalopus aquaticus)

Animal locomotion on land, water and air has been studied comprehensively during the past one hundred years. However, we know very little about how animals move through the earth. Burrowing is an energetically costly form of locomotion that involves loosening and removing soil as an animal tunnels. Moles are an excellent system for studying the mechanics of burrowing because their unique "lateral strokes" generate powerful forces that efficiently loosen and remove soil in a single movement. In this study, we measured the forces generated by moles when they were allowed to burrow in the tunnels of different widths. The maximum lateral force was generated when the distance between the sides of the tunnel (hand span) was 70% of body width. Lateral forces decreased when tunnel was narrower or wider. We also examined a dorso−ventral x−ray video of a burrowing mole and calculated the angles of the wrist (palm−ulna), elbow (ulna−humerus) and shoulder (humerus−scapula) joints throughout the lateral stroke cycle. We plotted these angles against relative hand span to estimate the position of the joints at the point of maximum lateral force production (70% hand span). We found that shoulder abduction, which has been suggested to be the main driver of the powerful lateral stroke, occurred before 70% relative hand span. At 70% relative hand span, the angles of wrist and elbow joints were at their maximum. These findings differ from earlier descriptions of burrowing and set the stage for future analyses using substrates of different densities and alternative force plate configurations.

P1.6 LINKEM, CN*; BUTLER, MA; Univ. of Hawaii, Manoa; *cnlinkem@hawaii.edu*
Behavioral Responses to Visual Cues in Blackline Hawaiian Damselflies
The Blackline Hawaiian Damselfly, *Megalagrion nigrohamatum nigrolineatum* is a species that belongs to an adaptive radiation of damselflies in Hawai'i. Like dragonflies, damselflies have exceptional vision as they have large eyes, are aerial predators that capture their prey in flight, and are colorful with many sexual dimorphisms. This study aimed to test their color vision as well as to explore whether they use color as an important ecological signal. To test this, four different colored beads were presented to perched males: red, blue, green, and black. Both males and females of *M. n. nigrolineatum* can have these colorations on their eyes, thorax, and abdomen, so for each bead color, there was a variety of response types. We categorized their responses as attacking, tracking, avoiding, or no response. We tested to see if these damselflies are using the colors as a sensory cue to elicit the above behavioral responses. Other variables such as time of day, damselfly takeoff distance, and forward irradiance were measured to test if any of these factors determine damselfly response behavior.

59.3 LINN, M/L*; MOORE, P/A; Bowling Green State University; *mdlinn@bgsu.edu*
Orconectes rusticus growth and survival exposed to Bt corn
Bt crops are one of the mostly commonly utilized genetically modified crops. These Bt crops contain a gene that is derived from the bacteria *Bacillus thuringiensis*, producing the Cry1Ab toxin. Bt corn containing the Cry1Ab toxin is used throughout the midwest to control crop pests such as the European corn borer (*Ostrinia nubilalis*). Headwater streams in the corn−belt receive Bt corn detritus following the fall harvest, which is then consumed by a diverse community of stream invertebrates. The rusty crayfish (*Orconectes rusticus*) is a common invertebrate detritivore in these headwater streams and can be impacted by the consumption of Bt corn detritus. In order to assess the impact of Bt corn detritus on the health of this aquatic keystone species, rusty crayfish were exposed to 4 different types of detritus (Bt corn detritus, isogenic corn detritus, Bt corn + American sycamore (*Platanus occidentalis*) detritus, and isogenic corn + American sycamore detritus) for eight weeks. Both types of corn were grown under the identically controlled environmental conditions of a greenhouse and following senescence were tested for nutritional equality. Crayfish were housed in live streams with a water temperature of 12.8°C and identical photoperiod. Each week animals were removed to monitor survival and growth. Mortality was 31% higher in the Bt treatment than the isogenic treatment. Mixing Bt corn with American sycamore decreased mortality by 30%, while mixing isogenic corn with American sycamore increased mortality by 19%. After eight weeks of exposure there was no statistically significant difference in growth between Bt, isogenic, Bt mix, and isogenic mix treatments. These results suggest that the Bt and isogenic corn detritus have nutritional consequences that could increase mortality without influencing growth.

P1.188 LINNEY, MD*; MURRAY, JA; Mt. Holyoke College and Friday Harbor Labs, Cal. State U. East Bay and Friday Harbor Labs; *james.murray@csueastbay.edu*
Loss of scent while following plume results in search−like behavior with no evidence of reliance on geomagnetic cues in the nudibranch Tritonia tetraquetra
Although the nudibranch mollusk, *Tritonia tetraquetra* (a.k.a. *Tritonia diomedea*) is known to orient to the geomagnetic field, the purpose of this behavior and much of the underlying neurobiology is still unknown. It has been hypothesized that their magnetic sense is used in response to situations when primary navigational cues (odor and flow) become undependable. In the present work, we investigated the behavioral function by putting slugs in a flow−through arena with primary navigational cues and magnetic field distortion (with a permanent magnet). Before the slugs reached the field of magnetic distortion, primary navigational cues were turned off to test for the use of the magnetic sense. In these trials, it was found that slugs changed directional heading repeatedly and significantly more (~3X more) after odor was turned off than before odor was turned off. We speculate that the slug was searching for the lost odor plume. Although this increase in turning upon loss of the scent was not entirely consistent with the sole reliance on magnetic guidance, the slugs turned 1.7X more in the distorted magnetic field compared to the normal field in the 40 s after the odor was removed, consistent with magnetic influence on orientation. Additionally, we investigated how the nervous system encodes magnetic field direction. We performed sensory nerve (Cerebral Nerve 1, CeN1) and single neuron (pedal neuron 5 and 6) recordings in semi−intact preparations with 60° clockwise and counter−clockwise magnetic field rotations. Based on previous studies we expected to see an increase in spiking after magnetic rotations. We observed some increases in the sensory nerve activity, but little change in the motor neuron activity in our limited number of trials. The sensory nerve showed more increase with counter−clockwise rotations of the magnetic field.

5.6 LINSCOTT, T.M.*; ROCHE, E.; BONETT, R.M.; University of Tulsa, University of Minnesota; *mason−linscott@utulsa.edu*
The Effects of Diet, Ecology, and Physiology on the Evolution of Endothermic Gastrointestinal Tract Lengths
Vertebrates have diversified into a wide range of habitats, and consume many forms of organic material. Consequently, vertebrates have evolved many morphological and physiological adaptations to maximize digestive efficiency. As the primary site of nutrient uptake, the intestine's size has been proposed to be influenced by metabolic demands, diet, and locomotory restrictions [lifestyle]. We tested for the effect of these factors amongst birds and mammals using a phylogenetically informed approach. Diet was found to affect large intestine length in birds and mammals but not small intestine length. Lifestyle influenced small and large intestine length in both birds and mammals, supporting the notion that restrictions are placed on all endotherms intestinal lengths according to the substrate they locomote within or on. Metabolism had an effect on small intestine length but not on large intestine length in mammals. Metabolic rate had no effect on any intestine length measurements within birds, indicating that birds may have other mechanisms to accommodate elevated basal metabolic rate. Our analyses show the relative importance of these factors on the evolution of the gastrointestinal tract of endotherms.

P3.132 LIU, M.C.*; LUCAS, L.; ALLEN, D.; FISHER, R.E.; Arizona State University, The University of Arizona College of Medicine Phoenix; *mcliu2@asu.edu*

The functional anatomy of the hindlimb of the ringtail (Bassariscus astutus)

The ringtail (*Bassariscus astutus*), a member of the Procyonidae, is capable of 180 degrees of hindlimb reversal during headfirst descent on a vertical substrate. The goal of this study was to determine the presence or absence of myological adaptations related to hindlimb reversal in the ringtail. Data for *B. astutus* are presented, including muscle weights, moment arms, and muscle maps ascertained from the dissection of four hindlimbs. Data from the current study were compared to published accounts of close relatives of the ringtail, as well as other species capable of hindlimb reversal, including procyonids (raccoon, coati, kinkajou, olingo), viverrids (palm civet, mongoose), a mustelid (marten), the tree squirrel, common tree shrew, and Virginia opossum. The ringtail exhibits extensive fusion between m. gluteus superficialis and its bordering muscles, two heads of mm. semitendinosus and semimembranosus, well−developed muscle bellies of mm. flexor digitorum lateralis and flexor digitorum medialis, and a robust m. flexor digitorum brevis. These traits are present in the majority of species capable of hindlimb reversal. These characteristics, along with available muscle weight and moment arm data, indicate an emphasis on hip extension, abduction, and lateral rotation, as well as powerful plantarflexion of the ankle and greater digit flexion compared to extension. The aforementioned ranges of motion are integral to hindlimb reversal during headfirst descent; thus, the data support the presence of myological adaptations for hindlimb reversal in the ringtail.

113.1 LIWANAG, HEM*; PEARSON, LE; MARCOS, C; GMUCA, N; HAMMILL, MO; BURNS, JM; Adelphi University, University of Alaska Fairbanks, Maurice Lamontagne Institute, University of Alaska Anchorage; *hliwanag@adelphi.edu*

Thermoregulatory strategy shifts with development in harp seal pups (Pagophilus groenlandicus)

Mammals must balance heat production with heat loss to maintain thermoregulatory homeostasis. Animals born in polar regions face additional challenges because extreme environmental conditions and small body size intensify heat loss. Harp seals (*Pagophilus groenlandicus*) are born on pack ice, with little blubber and a wettable lanugo coat; twelve days later, weaned pups have a developed blubber layer and begin to molt their pelt. To determine if thermoregulatory capability and strategy change as pups develop, we examined 5 age classes of harp seal from birth to post−molt. We measured insulative capacity through percent blubber, blubber and pelt thermal conductivity, and thermal resistance. We assessed potential for additional heat generation by non−shivering thermogenesis (NST), through uncoupling protein 1 (UCP1) expression and mitochondrial density in brown adipose tissue (BAT). Blubber volume significantly increased with age ($P<0.001$), but there was no significant difference in blubber conductivity across age classes ($P=0.969$). Pelt conductivity also did not differ, except in 9−day old pups, which had higher conductivity ($P<0.001$). Although overall thermal resistance did not differ among ages ($P=0.948$), the contribution of blubber increased from 17.5±0.03% of resistance in neonates to 75.87±0.01% of resistance after 3 weeks. While BAT of younger pups expressed UCP1, expression and mitochondrial density quickly declined, and the ability to produce heat via NST was lost by weaning. UCP1 expression was negatively correlated with increasing percent blubber across age classes ($r^2=0.756$, $P=0.001$). Together, these findings suggest additional thermogenesis is no longer necessary when blubber, rather than wettable fur, is the main thermal barrier.

97.2 LOCKEY, JK*; WILLIS, MA; Case Western Reserve University, USA; *jkl60@case.edu*

One antenna, two antenna; big antenna, small: in walking odor−tracking insects, bilateral input isn't all.

Spatial tracking requires simultaneous comparisons across sensors to establish a spatial contrast in what is being tracked (e.g., light, sound, chemicals). American cockroaches (*Periplaneta americana*) are thought to use a spatial tracking strategy when searching for resources using windborne odor. *P. americana* uses its 4 cm−long antennae to locate odor sources, but it is not uncommon for individuals to lose portions of their antennae, yet still be able to track an odor to its source. In this study we asked what is the minimum antenna length needed to track an odor and how does loss of all or part of an antenna affect tracking behavior. **If *P. americana* uses bilateral comparisons to maintain contact with the plume, the animals with shortened antennae should have narrower tracks, and removing one antenna should bias their turns to the direction of the remaining antenna.** In a survey of 160 unilaterally antenectomized animals (80 left, 80 right) and 80 intact animals, with antennae of different lengths (4 cm, 2 cm, 1 cm, and 10 annuli), we found that animals with only one antenna are able to track to an odor source, suggesting that they are either not using a spatial tracking strategy, or there is a spatial map of the sensory hairs on each antenna. With the exception of the individuals with 10 segments in the flagellum of their antenna, all animals with bilateral inputs tracked to the odor source. The odds of unilateral−antentomized animals tracking decreased as antenna size decreased. Only four individuals (1.7%) with 10 annuli tracked. We demonstrate that while bilateral olfactory input is not necessary, it does improve tracking behavior. *We thank Heather Voss−Hoynes and Jen Milligan for their assistance. This study was supported by NSF grant IOS−1121498 to MAW.*

75.3 LOCKWOOD, B.L.*; MONTOOTH, K.L.; Indiana University; *bllockwo@indiana.edu*

The consequences of thermal stress on early embryonic development: from cells to the whole−organism

For ectothermic organisms like *Drosophila*, changes in environmental temperature alter cellular processes. During early development, a rapid series of mitotic divisions bring an embryo from having a single nucleus to having thousands of nuclei, before gastrulation occurs and cell differentiation begins to take place. These early mitotic divisions are driven by the cytoskeleton, and previous work in cell culture has shown the cytoskeleton to be sensitive to thermal stress. Does thermal variability disrupt developmental progression by adversely affecting the cytoskeleton? Here we use confocal fluorescence microscopy to investigate the effects of thermal stress on the cytoskeleton in vivo in early stage embryos of *Drosophila melanogaster*. We find that exposure of eggs to heat stress causes gross defects in cytoskeletal arrangement and leads to the disruption of mitosis and cellularization of the blastoderm, both key developmental events. Moreover, brief heat stress events experienced in early embryogenesis lead to a decrease in survival to adulthood. These findings suggest that the thermal sensitivity of the cytoskeleton plays a key role in determining thermal tolerance at both the cellular and whole−organism levels.

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Abiotic constraints on tropical lizard abundance

Most models aimed at predicting the response of biological populations to climate change consider only the effects of increasing temperature. At present, the vast majority of studies ignore other abiotic variables, despite their potential to affect the physiological performance, activity time, and population growth of many species. In addition to temperature, both precipitation and wind patterns are projected to change over the coming century in many parts of the globe. Here, I explore how daily variation in the thermal, hydric, and convective (wind) environments affect the abundance of two species of *Anolis* lizard from the Bay Islands of Honduras. One species, *A. lemurinus*, is a forest species, whereas *A. allisoni* is found in open habitat. For both species, individuals were most likely to be active when their operative thermal environments provided temperatures close to their optimum for sprinting. However, when wind speed was high, *A. allisoni* remained inactive, even when the thermal environment was optimal. Our data suggest that cutaneous water loss from exposure to convection may create a trade−off between the ability of open habitat lizards to achieve optimal body temperatures through basking and their ability to maintain water balance. Our results highlight the need to consider other factors besides temperature when constructing predictive models for the biological impacts of climate change.

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Natal Homing and the Geomagnetic Imprinting Hypothesis for Salmon and Sea Turtles

Several marine animals, including salmon and sea turtles, migrate across vast expanses of seemingly featureless ocean before returning as adults to their natal areas to reproduce. How animals accomplish these feats of natal homing has remained an enduring mystery. Accumulating evidence, however, supports the idea that such animals imprint on the magnetic field of their natal area and then use magnetic map information to guide themselves to their destination. Evidence for geomagnetic imprinting has been obtained in sockeye salmon from the Fraser River, which must detour around Vancouver Island to approach the river through either a northern or southern passageway. Recent analyses indicate that the proportion of salmon using each route is correlated with geomagnetic field drift: the more the field at a passage entrance diverges from the field at the river mouth, the fewer fish use the passage. Evidence for the use of magnetic maps during migration has been obtained in sea turtles, which use two magnetic field elements (inclination and intensity) that vary predictably across the globe and endow different geographic areas with unique magnetic signatures. When turtles are presented with particular magnetic signatures from their migratory route, they typically swim in directions that allow them to progress along their path. The ability to derive positional information from Earth's magnetic field thus appears to play a central role in salmon and sea turtle navigation. Similar navigational systems may be widespread among diverse long−distance ocean migrants.

113.6 LONATI, G.L.*; WESTGATE, A.J.; KOOPMAN, H.N.; UNC, Wilmington; *GLL9008@uncw.edu*

Nitrogen solubility related to lipid composition in toothed whale fats

Nitrogen (N_2) dynamics are physiologically important for air−breathing divers, as N_2 inhaled at the surface can saturate fatty tissues that receive blood flow during dives. Toothed whales use cranial acoustic fats to echolocate, but unlike terrestrial mammals, which store fat only as triacylglycerol, acoustic fats also contain wax ester (WE) and unique fatty acids (FAs). As blubber with higher WE content is known to absorb more N_2, the highly vascularized acoustic fats may accumulate N_2 during dives. We measured and compared tissue lipid composition, percent WE and N_2 solubility in blubber and intramandibular (jaw) fat of 3 individuals from each of 3 species: the Atlantic spotted dolphin, *Stenella frontalis*, and the short−finned pilot whale, *Globicephala macrorhynchus* (both Family: Delphinidae), and the pygmy sperm whale, *Kogia breviceps* (Family: Kogiidae). Pig (*Sus scrofa*) fat was used as a terrestrial comparison. Delphinid jaw fat was dominated (>31% of all FAs) by iso−5:0 − a unique, short−chain FA derived from leucine. Delphinid blubber was the only other tissue that contained iso−5:0 (0.38−4.64%). Kogiid fats contained mostly medium−chain saturated FAs (10:0 through 18:0), and pig fat was largely long−chain saturated FAs (16:0 through 20:0). Percent WE was positively correlated with N_2 solubility ($P=0.013$), although there may be a threshold (~15%) above which increasing WE content does not further affect N_2 solubility. For example, N_2 solubilities for *G. macrorhynchus* jaw fat and *K. breviceps* blubber were 0.0692±0.0004 and 0.0689±0.0010 ml N_2/ml lipid, while WE contents were 17.7±1.3 and 98.0±0.7%, respectively. FA profiles may influence tissue gas−loading properties, to compensate for WE content. These data are important for modeling whale diving physiology, as different whale species have different lipid profiles.

P3.17 LONG, JH; WASSERMANN, S*; SICILIANO, AM; PORTER, ME; Vassar College, Duke University, Florida Atlantic University; *sowassermann@vassar.edu*

When Fish School and When They Don't: Test of a Simple Radial Network Model

Coordinated group behavior such as flocking and schooling may help individuals evade predators, find food, and locate mates. In many situations groups transition between ordered and unordered structure. One way to track group structure is to measure the amount of coordination and correlation between individuals. In small groups, in particular, it's not always clear when an individual is operating independently or in response to cues from other members of the group. Our goal was to examine swimming behavior as a function of the size of the group and the behavior of a key individual in a schooling elasmobranch, the cownose ray, *Rhinoptera bonasus*. We measured the kinematics of individuals in groups of one, two, and five individuals before and after one individual was startled. Our hypothesis was that individuals would respond to the startled individual as a function of their distance from and bearing to that individual, as if in a simple radial network with a single, central node. From overhead videos of animals swimming in a 16−foot diameter tank, we measured group responses such as scatter, alignment of velocity vectors, and variance of speed; for individuals, we calculated distance from and bearing to the startled individual. Preliminary results show that (1) some individuals respond to the change in behavior of a startled individual, (2) group structure gains order in response to a single individual being startled, and (3) the magnitude of an individual's response depends, in part, on its distance from and bearing to the startled individual. This work was supported by NSF IOS−0922605.

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Modification of the hyoid apparatus in Syngnathiformes

Nearly all syngnathiform fishes (seahorses, pipefish, trumpetfish, etc.) are characterized by an elongated snout used for an unusual prey capture motion called pivot feeding: by rotating the head upwards, the mouth is quickly brought close to prey, which are then captured via the production of suction. Although all syngnathiforms are assumed to pivot feed, it has been shown that pivot feeding is further specialized for speed in seahorses and pipefish through power amplification. It is unknown whether other syngnathiform groups are capable of power amplification, in part because we do not know the mechanism in seahorses and pipefish. However, the key to power amplification has been hypothesized to lie in the conformation of the four−bar linkage mechanism coupling head elevation and hyoid depression. Morphological descriptions have noted that seahorses and pipefish have short knobby interhyals, which form a unique pivot joint with the suspensorium. By limiting the range of motion of the hyoid, this joint may play an important role in power amplification by allowing the four−bar linkage to become locked in place. To determine if other syngnathiforms possess this joint, I used clearing and staining and micro−CT scans to examine the hyoid apparatus and its association with the suspensorium across syngnathiforms (e.g., trumpetfish, razorfish, coronetfish) and key outgroup taxa (e.g., dragonets, goatfish). Reduced interhyals are characteristic of all syngnathiforms examined, while outgroups have long rod−like interhyals typical of suction feeding teleosts. Interestingly, a well−developed pivot joint between the interhyal and the suspensorium is present in razorfish, an early−branching syngnathiform lineage, but not as developed in some taxa more closely related to seahorses and pipefish.

S4.2−3 LONGO, A. V.*; BURROWES, P. A.; ZAMUDIO, K. R. ; Cornell University, Ithaca, NY, University of Puerto Rico, San Juan, PR; *avl7@cornell.edu*

Genomic Approaches to Understand Host Survival under Seasonally−Modulated Pathogen Dynamics

Pathogens act as agents of evolutionary change in host populations, altering host allele frequencies through selection. The mechanisms underlying these adaptive changes depend in which defense strategy the host adopts upon infection. With increased anthropogenic change and biodiversity loss, ecological impacts on adaptive processes may reduce the ability of hosts to evolve resistance, or persist within their tolerance limits, thus increasing the capacity of pathogens to cause disease and mortality. Using the amphibian pathogenic fungus (*Batrachochytrium dendrobatidis*) and direct−developing frogs (*Eleutherodactylus*) as the focal host−pathogen system, we test hypotheses about how host genetics, skin microbiota, and their interaction with environmental conditions modulate disease dynamics by alternating the fitness advantage from host to pathogen, and vice versa.

75.4 LOPEZ−MARTINEZ, G*; WILLIAMS, CM; VISSER, B; HAHN , DA; New Mexico State University, University of Florida, Institut de Recherche sur la Biologie de l'Insecte; *gclopez@nmsu.edu*

Repeated anoxia exposures during the immature stages have hormetic effects that extend into adulthood

Organisms experience multiple environmental stressors in their habitat during the course of their life cycle. While there are multiple strategies ranging from tolerance to avoidance, animals with complex life cycles like insects have an immobile pupal stage that is confined and therefore subject to its environment during development. Additionally, animals experience multiple bouts of the same stressor and the effects that these bouts have on long−term organismal performance remain largely unknown, as stress physiology has largely focused on brief (24 to 48 hr) survival to traumatic single exposures. We studied the effects of repeated bouts of anoxia (3 hrs) during larval, pupal, and adult development in the Caribbean fruit fly, *Anastrepha suspensa*, while the insects were encased within the puparium for two weeks. We monitored metabolism, total antioxidant capacity, oxidative damage to lipids and proteins, and energy reserve consumption. We also tracked adult emergence, flight ability, mating success, fecundity and fertility, and longevity. We found that multiple bouts of anoxia had a hormetic effect that led to increased adult emergence, flight ability, and mating success and output. Additionally correlative patterns between metabolism and oxidative damage were elucidated.

59.7 LOVE, CN*; SCOTT, DE; NUNZIATA, SO; WINZELER, ME; LANCE, SL; Savannah River Ecology Laboratory, University of Georgia, Aiken, SC 29802, Department of Biology, University of Kentucky, Lexington, KY 40506; *love@srel.uga.edu*

Prevalence of the amphibian disease chytridiomycosis in contaminated and uncontaminated wetlands on the Savannah River Site, South Carolina

Increasing prevalence of infectious diseases is one cause of global amphibian population declines, yet the variable susceptibility of different amphibian species and populations remains unexplained. A variety of natural and anthropogenic stressors, including environmental pollutants, have been hypothesized to increase the emergence of wildlife diseases in amphibians via increased host susceptibility. A high incidence of *Batrachochytrium dendrobatidis* in bullfrog larvae was observed in constructed wetlands on the Savannah River Site (SRS), South Carolina, where there are also elevated levels of copper, zinc, and mercury. No studies to date have explicitly examined the linkages between metal contaminants and the disease ecology of chytridiomycosis in amphibians, and this knowledge gap impedes our understanding of disease susceptibility and transmission. We sampled adult and larval amphibians from three contaminated and 7 reference wetlands on the SRS. We are examining at least 512 individual amphibians representing 5 salamander, 5 frog and 2 toad species. Seventy−seven samples encompassing 8 species have tested positive for *B. dendrobatidis*. We have found a higher incidence of *B. dendrobatidis* in contaminated and constructed wetlands (20−24% of individuals sampled from these locations).

P2.134 LOVETT, D.L.*; WILLIAMS, M.; PULIDO, S.; GOLDFARB, A.M.; The College of New Jersey, Ewing; *lovett@tcnj.edu*

Effect of salinity on gene expression for enzymes in the methyl farnesoate synthesis pathway in the green crab Carcinus maenas.

We have previously reported that hemolymph levels of methyl farnesoate (MF) in the green crab *Carcinus maenas* increase in response to exposure of crabs to dilute seawater (< 26 ppt salinity) (Lovett *et al.*, 2001, 2006). In a study of isolated mandibular organs (MOs), MF secretion increased when the concentration of ions in the hemolymph (specifically Ca^{2+}) decreased (Lovett *et al.* , 2008). In a study of *Homarus americanus*, Li *et al.* (2010) found that eyestalk ablation, which typically stimulates MF secretion by the MOs, was accompanied by an increase in transcript level for farnesoic acid O−methyltransferase (FAOMeT), the terminal enzyme in MF synthesis. The current study examined transcript levels for enzymes in the MF synthetic pathway in MOs of *C. maenas*. Crabs either were acclimated to high salinity (32 ppt) or low salinity (10 ppt) seawater or were acutely transferred to low salinity after acclimation to high salinity. Exposure to dilute seawater resulted in an increase in transcript levels for FAOMeT in MOs. Thus, change in MF levels in response to salinity change appears to be regulated, at least in part, at the transcriptional level. This study was supported in part by NSF Grant DBI−0933977.

87.7 LOWE, E.K.*; BROWN, C.T.; SWALLA, B.J.; CHRISTIAEN, L.A.; STOLFI, A.; Michigan State University, Michigan State university, University of Washington, New York University; *elijahlowe@gmail.com*

Differential expression influences different body plan development in chordates ascidians

Molgula occulta and *Molgula oculata* are two closely related chordate ascidians that are almost indistinguishable in their adult stages. However, they have drastically different larval phenotypes. During the embryonic stage, only *M. oculata* forms a post−anal tail containing a notochord a group of cells organized in a rod shaped structure and one of the key features of the chordate phylum. In contrast, *M. occulta* is one of several species of *Molgula* to lose this feature. Hybrids, with a partially formed tail, have been produced through the cross fertilization of these two species, the only *Molgula* species known to hybridize. Using Next Generation Sequencing technology, we sequenced the embryonic transcriptomes of the two species and their hybrids at three developmental stages to study the mechanisms behind tail loss in *M. occulta*. A first look at genes associated with notochord development has shown most genes to be present and expressed during embryogenesis of both species. When analyzing differential expression patterns in the two species and the hybrid a shift in gene expression occurs starting at neurulation. This pattern shows genes being up−regulated in *M. oculata* and the hybrid, while begin down−regulated in *M. occulta*. The expression of these genes may be the key to the lack of tail development in *M. occulta*. In addition to the transcriptomes, we recently assembled the genomes for *M. occulta*, *M. oculata*, and another tailed molgulid, *M. occidentalis*. This study allows us to analyze tail loss in greater depth than previously done.

P3.144 LUJAN, SL; OWERKOWICZ, T; ELSEY, RM; HICKS, JW; MIDDLETON, KM*; CSU San Bernardino, Rockefeller Nat. Wildlife Refuge, UC Irvine, University Missouri−Columbia; *middletonk@missouri.edu*

Acute and chronic alterations in atmospheric oxygen do not alter femoral biomechanics in Alligator mississippiensis

Analyses of the microanatomy and cross sectional geometry of limb bones are often used to infer growth, locomotor ability, and life history strategies of fossil vertebrates. Although atmospheric oxygen has varied widely in the past, studies of extant relatives are typically carried out in a normoxic environment. Because acute hypoxia and hyperoxia have been shown to affect the growth of in a variety vertebrates, the utility of comparisons between extinct and extant taxa has been questioned. We studied the American alligator, *Alligator mississippiensis*, to test for effects of environmental oxygen on skeletal growth and biomechanics. Eggs were incubated and hatchlings reared in one hypoxic and three hyperoxic conditions. At regular intervals from 2 to 104 weeks, alligators were sacrificed and femora prepared for analysis. Undecalcified specimens were dehydrated, and morphometric whole−bone measurements taken prior to histological thin−sectioning. Using femur length as covariate to account for differences in body size, analyses of covariance on cross sectional area, second moment of area, and polar moment of inertia revealed no significant differences among oxygen treatment groups. Combined allometric analyses of all groups showed that cross−sectional area scaled with significant positive allometry and that all moments of inertia scaled with significant negative allometry. We hypothesize that the right−left shunt in the alligator heart allows the maintenance of optimal oxygen saturation across a range of ambient oxygen levels. Our result suggest that atmospheric oxygen may have negligible influence on basal archosaur bone structure.

P1.32 LUNARDI, P.N.*; DODGIN, S.R.; HRANITZ, J.M.; Bloomsburg Univ. of Pennsylvania; *pnl16991@gmail.com*

The Distribution of Anurans Among Pools on Assateague Island, Virginia

Barrier islands are dynamic systems with limited freshwater habitats in a relatively small area compared to other coastal landforms. The scarcity of favorable habitat results in an anuran community with low diversity and potentially unique solutions to niche overlap. As sea level rises, saltwater intrusion may accelerate suitable habitat loss. This study was conducted to determine the distribution of anurans in vernal pools present in the Chincoteague National Wildlife Refuge on Assateague Island. We determined the presence of larval, juvenile, and adult life stages in or around vernal pools of different areas and salinities. By doing this, we were able to examine the potential for interspecific competition and vernal pool partitioning. Species presence or absence for each site was recorded between May and August 2013. Out of the 87 vernal pools sampled, 40 pools were inhabited by anurans. Most pools (72.5%) contained a single species whereas the remaining 27.5% of the pools were inhabited by two or more species. Salinity of pools was determined using a refractometer in the field. Soil salinity of dried pools was not measured. Salinity was recorded for 44 pools, 24 of which were freshwater (0−1 ppt) and 20 of which were brackish (2−24 ppt). All species present on the island were found in freshwater and brackish pools. Juvenile toads were found with the vernal pool with highest salinity, which was 25 ppt. The highest salinity pool associated with Hyla cinerea or Rana occurred was 8 ppt. Overall, the life stages occurring at the highest salinities were juvenile anurans. Larval A. fowleri and Rana were recorded in the larger vernal pools ranging from 2.7m2 to 2996 m2, whereas H. cinerea larvae were found in smaller vernal pools ranging from 9 m2 to 60.8 m2.

7.5 LUND, R.*; GREENFEST−ALLEN, E.; GROGAN, E. D.; Carnegie Museum, Penn Center for Bioinformatics, University of Pennsylvania, Saint Joseph's University; *rdicklund3@gmail.com*

Ecomorphotypes and habitats in a Mississippian Bay

The 323 million year old Bear Gulch Lens of the Bear Gulch Member, Heath Formation, of Montana, USA is recognized for the preservation of its fauna in terms of quality and diversity. Here we capitalize on these factors and 40+ years of data collection to evaluate the relationship between functional morphology and ecology in these Upper Mississippian marine fishes. The vertebrate members of the bay fauna were scored for thirteen morphological characters demonstrated or inferred to be of functional significance in habitat utilization among extant fishes. Based on similarities in character coding, taxa were grouped into 16 ecomorphotypes, only one of which contained both osteichthyan and chondrichthyan taxa. Of the remainder, nine were comprised exclusively of chondrichthyans, one of coelacanths, one of Acanthodes, and four of actinopterygians. Chondrichthyans span a spectrum of grossly different feeding, propulsive, and sexually dimorphic adaptations, and the chondrichthyan ecomorphotypes showed strong distributional trends in relation to bay habitats. Neritic fusiform actinopterygians occupied one ecomorphotype, which was subdivided on the basis of feeding specializations. Uniquely specialized actinopterygians occupied the remaining ecomorphotypes. Actinopterygians display few ecologically sensitive morphological deviations from a fusiform body plan and generalized feeding mechanism, and the relative distribution of actinopterygian ecomorphotypes varied little across the bay habitats. Factors that could have contributed to the disparity of actinopterygian versus chondrichthyan responses to adaptive diversification are discussed.

65.2 LYNN, S.E.*; PERFITO, N.; GUARDADO, D.; BENTLEY, G.E.; College of Wooster, Univ. of California, Berkeley; *slynn@wooster.edu*

Food, stress, and circulating testosterone: cue integration by the testes, not the brain, in zebra finches (Taeniopygia guttata)

Ecologically relevant fasting stimulates glucocorticoid secretion and reduces testosterone (T) and sexual behavior in male zebra finches. This might provide a survival advantage without the need for complete inactivation of the hypothalamo−pituitary gonad axis. However, the mechanisms underlying these transient effects are unclear. Gonadotropin inhibitory hormone (GnIH), a neuropeptide present in the brain and gonads, is also influenced by glucocorticoids. Thus we sought to determine whether fasting stress activated the GnIH system in zebra finches, with the potential for downstream effects on reproductive physiology and behavior. We fasted males or fed them *ad libitum* for 10 hrs. Fasting increased corticosterone (CORT) and decreased T. To assess whether the decrease in T was mediated by changes in the hypothalamus and/or the gonads, we (1) quantified GnRH− and GnIH−positive neurons in the hypothalamus, (2) assessed hypothalamic gene expression for GnRH and GnIH, and (3) examined expression of testicular GnIH, StAR, LHR, and 17b−HSD in fasted and control birds. No measure of hypothalamic neuropeptides was related to treatment or circulating steroids. However, birds with higher CORT had higher testicular GnIH expression and lower circulating T. StAR and LHR were also expressed at lower levels in the testes of fasted birds than controls. Our data suggest that the decrease in T was not mediated by hypothalamic GnIH, but rather by direct actions of fasting and/or CORT on the testes, indicating that the testes can integrate and respond to cues of stress without direct hypothalamic input. Such local inhibition of T synthesis may allow for short−term changes in physiology and behavior when conditions are inappropriate for breeding.

P3.10 LYNN, E.J.*; NUGENT, B.M.; HOFMANN, H.A.; University of Texas at Austin, Austin, TX, Yale University, New Haven, CT; *ericajlynn@utexas.edu*

DNA methylation may contribute to social status in African cichlid fish

Social behavior is influenced by many factors such as the physiological and social status of an individual and the behavior of conspecifics. Research in Astatotilapia burtoni, a highly social African cichlid fish in which individual males may alternate between dominant or subordinate status, has led to many insights into the relationships between male social status, sex steroid hormone levels, and gene expression in the preoptic area (POA), a region of the brain known to regulate male sexual and aggressive behavior. Inhibiting sex steroid receptor activity differentially affects male behavior, circulating hormone levels, and gene expression in the POA depending on social status, suggesting that differences in epigenetic marks might contribute to these observed differences between dominant and subordinate males. DNA methylation is an epigenetic mechanism by which methyl groups are covalently bound to cytosine bases on a gene's promoter, typically resulting in gene silencing. We hypothesized that DNA methylation is negatively correlated with expression of candidate genes in the POA of dominant and subordinate males and that these differences lead to the differential gene expression patterns that underlie dominant or subordinate behavior. We quantified behavior of dominant and subordinate males, analyzed circulating gonadal hormone levels, and extracted RNA and DNA from the POA of each animal. We found that levels of testosterone and estradiol were significantly higher in dominant males compared to subordinates and that aggressive behaviors correlated with hormone levels. Ongoing analyses examine global DNA methylation levels in dominant and subordinate males. Our results will greatly improve our understanding of the molecular basis behind the rapid and distinct changes that contribute to social plasticity.

S3.3−4 LYONS, Diedre; MCINTYRE, Dan; MCCLAY, David R.*; Duke University; *dmcclay@duke.edu*

Ectodermal inputs into patterning skeletogenesis

Sea urchin larvae produce a skeleton using a limited number of skeletogenic cells, usually either 32 or 64 cells depending on the species. Each skeletogenic cell is capable of producing any piece of larval skeleton, depending on where that skeletogenic cell finds itself in the blastocoel of the embryo. Information for the pattern that cell produces originates from the ectoderm. Four known signals are produced by the ectoderm: VEGF, FGF, Wnt5 and Wnt3. Each of these signals operates at short range. The production of each of the signals depends upon specification of two bands of ectoderm: the ciliary band which forms at the boundary between the ventral and dorsal ectoderm, and the "border ectoderm" which forms orthogonal to the ciliary band and borders the endoderm. Skeletogenesis is initiated just beneath the site where the ciliary band and border ectoderm intersect. VEGF, FGF and Wnt5 are produced at that intersection. Absence of any one of the signals leads to the absence of, or to an abnormally patterned skeleton. Ectopic expression of VEGF or Wnt5 leads to ectopic production of skeletal elements, in each case, just beneath the cells producing the ectopic signal. Once skeletogenesis is initiated the skeleton grows either in parallel to the ciliary band or border ectoderm, or in the case of two sets of rods, is initiated in one of the two bands and grows perpendicular to the band producing long arms in many species. The sequence of specification is initiated by Nodal signaling to establish the site of the ciliary band, and by endodermal Wnt5 to induce the border ectoderm. The sequence of events from induction of ectodermal territories, to production of ectodermal signals, to the specific responses of the skeletogenic cells will be described based on a large series of perturbations of both transcription factors, and of the signals necessary for patterning the skeletons.

P1.98 LYONS, D/C; MARTIK, M/L; KIMURA, J/O*; MCCLAY, D/R; Duke University; *dcl.duke@gmail.com*
Evolution of ectoderm−mesoderm communication during skeletal patterning in echinoid larvae
The life cycle of indirect−developing echinoids (e.g. sea urchins and sand dollars) includes a ciliated pluteus larval stage supported by a calcium carbonate endoskeleton. The development of this skeleton is a classic model system for studying cell differentiation, tissue patterning, and morphogenesis, and for studying the evolution of patterning as larval skeletons are an apomorphy for the group, and each species has a unique skeletal pattern. Using immunohistochemistry, live cell imaging, and inter−species chimeras, we compared larval skeleton formation between sea urchin and sand dollar. The sea urchin skeleton arises from primary mesenchyme cells (PMCs) that form a syncytium within which the skeleton is secreted, then branches, and elongates. The pattern of the skeleton is determined by a conversation between the PMCs and the immediately overlying ectoderm. During early gastrula stages, discrete bilateral patches of ectodermal cells produce VEGF and FGF signals that attract clusters of PMCs, which produce a triradiate spicule rudiment. Later, a re−deployment of VEGF and other unidentified signals emanating from the ectoderm instruct the PMCs to elaborate the triradiate by growth and branching, resulting in a skeleton with a highly reproducible pattern. In contrast, in the sand dollar, it appears that there has been a heterochronic shift relative to the urchin in which the ectodermal signals for triradiate and branching skeletogenesis occur coincident at gastrula stages. In the sand dollar, there exists an extra, more anterior half ring of PMCs on the dorsal side, which corresponds with the location of branching. This suggests that ectodermal signals that control the spatiotemporal pattern of underlying PMCs have diverged between these two echinoids. Such data provide the framework for ongoing studies in both species that address the details of these two patterning systems at the molecular level.

47.2 LYONS, D/C*; PERRY, K; HENRY, J/Q; Duke University, University of Illinois, Urbana−Champaign; *dcl.duke@gmail.com*
Gastrulation and the fate of the blastopore in the snail Crepidula fornicata
Gastrulation is a critical morphogenetic process in metazoan development by which presumptive endoderm and mesoderm cells become internalized. Modes of gastrulation (e.g., ingression, invagination, epiboly) are particularly diverse among the bilaterian protostomes. However, lophotrochozoan gastrulation has been studied in very few species, despite its importance for understanding the evolution of this process. Here we summarize results from an investigation of gastrulation mechanisms in the snail *Crepidula fornicata*, a model system for development among lophotrochozoans. First we characterized the epibolic spreading of the micromere cap as it envelops the mesentoblast and other endodermal cells. These data allow us to directly compare epiboly between *Crepidula* and other clades. A controversial aspect of gastrulation is the fate of the blastopore (the site of endoderm formation). While in most deuterostomes the blastopore becomes the anus, in protostomes the blastopore can be the site of anus or mouth formation. In some species it has been argued that the blastopore gives rise to both mouth and anus. However, lineage tracing is necessary to confirm the fate of cells rimming the blastopore, as cell rearrangement there is highly dynamic. Live imaging and lineage tracing showed definitively that the cells ringing the blastopore (derived from 2a−c and 3a−d micromeres) form the mouth in *Crepidula*. The anus is derived from the 2d lineage that generates a remote clone located at the posterior end of the embryo and never contributes to the blastopore. These data provide the necessary framework for ongoing investigations into the molecular basis of gastrulation and fate specification of mouth and anal tissues, which are essential for understanding basic origins of metazoan body plans.

100.3 MACDONALD, I/A*; FERRY, L; SUMMERS, A; GIBB, A/C; Northern Arizona University, Arizona State University, University of Washington; *iam26@nau.edu*
Do Pacific sandfish (Trichodon trichodon) use a modified two−phase respiratory pump for rapid burial?
Many fishes bury themselves to evade predators and ambush prey. Unlike other species, which laterally undulate to embed themselves in the substrate, the Pacific sandfish buries itself ventral surface first. We hypothesized that Pacific sandfish use a modified two−phase respiratory pump to force water into the substrate during burial. We recorded 5 fish from dorsal and lateral views descending into white sand seeded with black sand particles. During a burial event, each fish produced a series of respiration−like movements and these movements were associated with pulsatile periods of descent into the substrate; rapid descent occurred in concert with compression of the paired opercles. A cycle of burial behavior differed from a normal respiratory cycle in that the gape and opercular compression cycles took twice as long as a typical respiratory cycle. Pacific sandfish also produced repeated cycles of large−amplitude dorsal rotation of the cranium, which are not seen during respiration. Cranial rotation likely increases the volume of water passing through the head by first enlarging the buccal cavity and then by forcing the water posteriorly, into the opercular cavity. Subsequent compression of the opercles forces water out of the head and into the substrate. By forcing water into the sand, it appears that Pacific sandfish increase the interstitial space between sand grains, enabling sand to behave like a fluid. In this fluid−like state sand exhibits a decrease in frictional forces as well as a decrease in its ability to support weight, which will combine to allow the sandfish to descend rapidly into the substrate and hide from its predators.

S2.1−4 MACDOUGALL−SHACKLETON, SA*; MACDOUGALL−SHACKLETON, EA; SCHMIDT, KL; KUBLI, SP; Univ Western Ontario, London, Canada; *smacdou2@uwo.ca*
Developmental Stress, Condition, and Sexually Selected Traits in Song Sparrows
Sexual selection theory posits that ornaments and displays reflect signaler condition, which in turn is affected by both recent and developmental conditions. Moreover, developmental conditions can induce correlations between sexually selected and other traits if both types of traits are susceptible to developmental stressors. Thus, sexually selected traits may reflect recent and/or developmental characteristics of signalers. Here we review data on the relationships between birdsong, a sexually selected trait, and developmental and current condition of birds from a long−term study population of song sparrows (*Melospiza melodia*). Field studies of free−living birds indicate that song complexity reflects the size of the song−control brain region HVC, and is correlated with body size and several immune parameters, specifically investment in protective proteins. However, song performance is not correlated to immune investment. Song complexity is correlated with the glucocorticoid stress response, and in some years this stress response predicts overwinter survival. Experimental manipulations have revealed that early life stressors impair development of HVC, but that HVC recovers in size by adulthood. These manipulations result in impaired song complexity and song learning, but not song performance. Experimental developmental stressors also affect growth, endocrine physiology, and metabolism, often in a sex−specific manner. Combined, these studies suggest that song complexity provides reliable information about early developmental experience, and about other traits that have critical developmental periods. Birdsong thus provides a multi−faceted sexually−selected trait that may be an indicator of both developmental and recent conditions.

64.7 MACLEAN, HJ*; HIGGINS, JK; BUCKLEY , LB; KINGSOLVER, JG; University of North Carolina, Chapel Hill , University of Washington, Seattle ; *hmaclean@live.unc.edu*

Thermal stress and heat tolerance in Rocky Mountain butterflies

Short−term exposure to high temperatures can reduce activity and survival in many ectothermic organisms. Populations and species of *Colias* butterflies in the Rocky Mountains exhibit local adaptations in morphology , which enable them to achieve the body temperatures needed for flight activity along elevational gradients. We conducted lab and field experiments to compare behavior and tolerance to high temperatures between adults from high−elevation *C. meadii* (3.5km) and two populations of lower−elevation *C. eriphyle* (1.5 km and 2.2 km).Common−garden experiments at the low elevation field site showed that high−elevation *C. meadii* had significantly greater heat−avoidance behavior and higher mortality than lower−elevation *C. eriphyle* in sunny, hot conditions. We then quantified thermal stress tolerance as survival following a one hour exposure to a constant temperature ranging from 25 to 47C. Surprisingly, the high elevation species (*C. meadii*) had greater survival at higher temperatures relative to the low elevation species (*C. eriphyle*). This suggests the importance of coping with acute thermal stress events associated with high radiation at high altitudes and highlights the importance of considering both acute and chronic thermal stress when examining responses to climate change.

P3.134 MACPHERSON, R.S.*; COLIN, S.P.; GEMMELL, B; COSTELLO, J; University of California, Berkeley; *rmacpherson@berkeley.edu*

3D Particle Tracking to Analyze Predator−Prey Interactions in Mnemiopsis leidyi

Mnemiopsis leidyi is a species of lobate ctenophore that has recently expanded its habitat to areas including the Black and Mediterranean Seas. This has piqued interest in the identification of environmental factors that can encourage or discourage its invasion of a region. Our lab is interested in the effects of low−level turbulence in the water, which can induce higher swimming speeds, on the fluid flow inside and around *Mnemiopsis* and on its prey capture efficiency. We define prey capture efficiency as the ratio of prey captured to prey encountered at the lobes. Because of the bilateral symmetry of *Mnemiopsis*, 2D techniques to image fluid flow are not reliable; unlike an organism with radial symmetry, the fluid flow in one plane will likely be very different from that in another plane. Therefore we developed a technique using specialized mirror tanks to take recordings with two orthogonal views in the same video. We then developed software in MATLAB allowing us to extract the x, y, and z information of objects in the tanks. This allowed us to reliably track particles and small organisms in and around *Mnemiopsis* in three dimensions. Once the technique was developed, we used the mirror method to analyze the variation of *Mnemiopsis*' prey capture efficiency with swimming speed by monitoring encounters between *Mnemiopsis* and *Artemia*, small brine shrimp that are typical prey for the ctenophore. It was found that capture efficiency did not change with higher swimming speeds, showing that *Mnemiopsis* in areas with low level turbulence in the water will be just as effective at catching their prey as the same organisms in areas with still water. Video of the fluid flow inside *Mnemiopsis* taken at different swimming speeds might elucidate the reason for this.

31.8 MACRANDER, J*; DALY, M; Ohio State University; *macrander.1@osu.edu*

The evolution of the sodium and potassium ion channel toxins in sea anemones: a combined RNASeq and bioinformatics approach.

Sea anemones (Cnidaria, Anthozoa, Actiniaria) use toxins in prey acquisition, predator avoidance and conspecific interactions. Although about 250 compounds have been identified from the venom cocktails of anemone species, relatively few toxin genes are known and their phylogenetic history is poorly understood. Of these genes, the voltage−gated Na+ (Nav) and K+ (Kv) channel toxins are the best characterized; however, the majority of these are characterized from members of family Actiniidae. To better understand toxin gene evolution throughout Actiniaria, we used RNASeq in combination with transcriptomes and genomes from Genbank to identify new candidate toxin genes for species previously investigated (*Anthopleura elegantissima*, *Aiptasia pallida*, *Metridium senile*, and others) and for species for which there are no known toxin genes (*Isosicyonis* sp, *Hormothia digitata*, *Bolocera tuediae* and others). Our phylogenetic analysis of the Nav genes revealed a pattern of gene family evolution contrasting the concerted evolution model previously proposed. Several Nav and Kv candidate genes are multi−copy, and sometimes these falling outside the same lineage as similar types previously described; whether these are pseudogenes or differential selection acting on toxin genes is yet to be determined. Additional sampling throughout Actiniaria is necessary provide an accurate understanding how these gene families evolve across sea anemones as a whole.

123.5 MADDIN, H.C.*; PIEKARSKI, N.; HANKEN, J.; Harvard Univ.; *hillary.maddin@gmail.com*

Experimentally induced homeotic shifts in anterior axial patterning mimic events in the evolution of the tetrapod skull

The occipital region of the skull incorporates the sclerotomal portions of several anterior somites. Among tetrapods, amniotes incorporate more somites (five) than amphibians (three, at most) and, therefore, have additional cranial nerves and foramina. This difference has led to the claim that increased occipitalization' characterizes the origin of amniote skull form. However, the fossil record suggests that the amniote condition evolved earlier, at the base of Tetrapoda, and that the amphibian condition is secondarily derived. The developmental basis of this transformation remains poorly understood. Here we show the number of occipital segments can be modified experimentally in the axolotl. In normal development the head−trunk boundary is located within somite 3 (S3). Treatment with retinoic acid (RA) produces additional vertebral segments anterior to the first cervical vertebra, which is suggestive of a homeotic shift in segment identity. This shift is confirmed by somite transplantation experiments in which S3 forms only vertebral segments when exposed to RA. The opposite is true when embryos are treated with RA inhibitors: additional segments are recruited into the occiput. These experimentally induced homeotic shifts mimic events that took place in the evolution of the tetrapod skull, such as the secondary transformation of occipital somites into trunk somites during the origin of amphibians. Perturbation of the RA signaling pathway may underlie the evolution of cranial diversity in tetrapods.

72.8 MADHAV, M.S.*; STAMPER, S.A.; FORTUNE, E.S.; COWAN, N.J.; Johns Hopkins University, New Jersey Institute of Technology; *manusmad@jhu.edu*

Closed−loop stabilization of the Jamming Avoidance Response reveals its locally unstable and globally nonlinear dynamics

The Jamming Avoidance Response, or JAR, in the weakly electric fish has been analyzed at all levels of organization, from whole−organism behavior down to specific ion channels. Nevertheless, a parsimonious description of the JAR behavior in terms of a dynamical system model has not been achieved at least in part due to the fact that "avoidance" behaviors are both intrinsically unstable and nonlinear. We overcame the instability of the JAR in *Eigenmannia virescens* by closing a feedback loop around the behavioral response of the animal. Specifically, the instantaneous frequency of a jamming stimulus was tied to the fish's own electrogenic frequency by a feedback law. Without feedback, the fish's own frequency diverges from the stimulus frequency, but appropriate feedback stabilizes the behavior. After stabilizing the system, we measured the responses in the fish's instantaneous frequency to various stimuli. A delayed first−order linear system model fit the behavior near the equilibrium. Coherence to white noise stimuli together with quantitative agreement across stimulus types supported this local linear model. Next, we examined the intrinsic nonlinearity of the behavior using clamped−frequency−difference experiments to extend the model beyond the neighborhood of the equilibrium. The resulting nonlinear model is composed of competing motor return and sensory escape terms. The model reproduces responses to step and ramp changes in the difference frequency (dF) and predicts a 'snap−through' bifurcation as a function of dF that we confirmed experimentally.

P3.12 MAGUIRE, SM*; YU, S; HOFMANN, HA; UT Austin, Austin TX; *smmaguire@gmail.com*

The Effects of Social Status on Activity Patterns of the Social Decision−Making Network

Social decision making requires animals to evaluate external cues from a stimulus in relation to internal information such as their past experience, current condition or hormonal state. In vertebrates, social decision making is linked to the pattern of activity across 12 conserved brain areas called the Social Decision−Making (SDM) network. Behavioral decisions vary across physiological contexts. For example, an animal may tend to approach an intruder during the breeding season but may avoid that same stimulus in the non−breeding season. This variation in response may be influenced by changes in the patterns of activity across the SDM network that covary with behavioral phenotype. *Astatotilapia burtoni*, an African cichlid fish, is an ideal model to study the mechanisms underlying social decision−making. *A. burtoni* males display several distinct phenotypes: dominant, subordinate, and intermediate. These phenotypes are associated with differences in behavior, hormone levels and brain gene expression patterns. We quantified the behavior of males in naturalistic communities and used discriminant functions to create a dominance index that captures the range of subordinate to dominant phenotypes. We then measured metabolic activity in the SDM network using histochemistry of cytochrome oxidase, an enzyme critical for energy metabolism whose activity correlates with neuronal activity. We used linear models to identify the brain areas that are correlated to social status and behavioral patterns. Furthermore, we constructed covariance networks across the nodes of the SDM network and used the quadratic assignment procedure to assess how these patterns relate to social status. Future studies will determine how these status−dependent activity patterns influence neural activity and behavior induced by social stimuli.

P1.93 MAH, J; CHRISTENSEN−DALSGAARD, KK; LEYS, SP*; University of Alberta; *sleys@ualberta.ca*

A structural and functional comparison of the collar−flagellar systems in the choanoflagellate Monosiga brevicollis and freshwater sponge Spongilla lacustris

The similarities between choanoflagellates and the choanocytes of sponges have been discussed for over a century, and yet few studies exist that allow a direct comparison between the two. We compared the structure and function of the collar and flagellum of the choanoflagellate *Monosiga brevicollis* and the sponge *Spongilla lacustris*. There were basic similarities in the pumping mechanism. The flagella maintained contact with the microvilli along most of the length of the collar, suggesting that the collars and flagella were integrated systems rather than independent units. In *M. brevicollis* the microvilli were joined by a ring−like structure allowing the opening of the collar to flare; in *S. lacustris* a mesh of glycocalyx joined the microvilli, forming a tube. Flagellar vanes composed of glycocalyx fibrils perpendicular to the flagellar axis spanned the base of both collars; vanes continued for the full length of the flagellum but were ragged beyond the collar in *M. brevicollis*. There were fundamental differences in the integration of the collar−flagellum system of the two cells, however. In *S. lacustris* the flagellum bent upon contact with the collar; the flagellar amplitude was fitted to the collar diameter. In *M. brevicollis* the flagellar amplitude was unaffected by the presence of the collar; the collar diameter may have been fitted to the flagellum instead. Our results suggest that though choanocytes and choanoflagellates may be homologous, this cannot be taken for granted. Similarities in the collar−, vane−and−flagellum pump system in such different organisms separated by 600 million years of evolution suggests that it is an important adaptation for optimising fluid flow through micro−scale filters.

80.6 MAIA, A.*; SHELTZER, A.P.; TYTELL, E.D.; Eastern Illinois University, Tufts University; *amresendedamaia@eiu.edu*

Streamwise Vortices Destabilize Swimming Bluegill Sunfish (Lepomis macrochirus)

In their natural environment, fish must swim stably through unsteady flows and notices. Fish can correct heading rapidly, but the corrections take energy. Previous studies have examined the kinematics and energetics of fish interacting with vertical vortices and horizontal cross−flow vortices, but little is known about the effect of streamwise vorticity. Streamwise vortices are produced by ships' propellers and axial turbines, but also commonly shed by bluff bodies in streams. We set to test the effect of these vortices on swimming bluegill sunfish by introducing an array of four turbines with similar diameter to the experimental fish inside a sealed flow tank. We measured oxygen consumption for seven sunfish swimming at 1.5 body lengths (L)/s for a period of 2.5 hours with the turbines rotating at 2 Hz and with the turbines off (control). Simultaneously, we filmed the fish ventrally and recorded the fraction of time spent maneuvering and accelerating. Separately, we also recorded lateral and ventral video for a combination of swimming speeds (0.5, 1.5 and 2.5 L/s) and turbine speeds (0, 1, 2 and 3 Hz), immediately after turning the turbines on and 10 minutes later to test for accommodation. Bluegill sunfish are negatively affected by streamwise vorticity. Spills (loss of heading), maneuvers, and accelerations were more frequent when the turbines were on than in the control treatment. These unsteady behaviors, particularly acceleration, correlated with an increase in oxygen consumption with streamwise vorticity. Bluegill sunfish are generally fast to recover from roll perturbations and do so by moving their pectoral fins. The frequency of spills decreased after the turbines had run for 10 min, but was still markedly higher than in the control, showing that fish are capable of adapting to streamwise vorticity, but not completely.

P1.121 MAIE, T.*; MEYER, S.; SCHOENFUSS, H.L.; BLOB, R.W.; St. Cloud State University, Clemson University; *tmaie@g.clemson.edu*

Feeding kinematics and performance of the Hawaiian sleeper, Eleotris sandwicensis (Gobioidei: Eleotridae): modulation between prey species and implications for selective pressures on Hawaiian stream ichthyofauna

A species of piscivorous eleotrid, *Eleotris sandwicensis*, inhabits lower reaches of streams in the Hawaiian Archipelago, where it feeds on juveniles of native amphidromous gobiid fishes migrating upstream from the ocean. This ambush predator relies on suction to capture its prey. Using high−speed video and geometric modeling we evaluated the kinematics and performance of suction feeding for *E. sandwicensis* on free swimming gobiid juveniles, comparing performance between successful and unsuccessful strikes, and testing the extent to which *E. sandwicensis* modulates its predatory behavior between prey species that differ in size, behavior, and muscle physiology. With fast jaw movements as well as a highly expansive buccal cavity, *E. sandwicensis* achieves high performance that enables the capture of elusive prey. Our analyses indicated that the species with larger juveniles (*S. stimpsoni*) could be captured from up to 18.6% body length (BL) of the predator away from the mouth, but capture of the smaller species (*A. guamensis*) required a closer distance (12.2% BL). Predator−prey distance appears to be the predominant factor determining strike outcome during feeding on juvenile *A. guamensis*. However, during feeding on juvenile *S. stimpsoni*, *E. sandwicensis* demonstrates a capacity to modulate strike behavior. The ability of *E. sandwicensis* to capture larger prey fish from longer distances suggests a potential biomechanical basis underlying observations that predation by eleotrids imposes selection against large body size in juvenile gobies. NSF−IOS 0817911, 0817794.

P3.30 MAINE, AR*; DAYGER, CA; RICHARDS, DY; RAMIREZ, LM; LUTTERSCHMIDT, DI; Portland State University, Oregon; *d.lutterschmidt@pdx.edu*

Migration to summer feeding grounds is associated with changes in plasma glucocorticoids and glucose in red−sided garter snakes (Thamnophis sirtalis).

Transitions between life history stages are often characterized by dramatic switches from one behavior mode to another and include examples such as reproduction, migration, and foraging. The neuroendocrine mechanisms that regulate these behavioral transitions, however, are poorly understood. We previously showed that male red−sided garter snakes (*Thamnophis sirtalis*) dispersing to summer feeding grounds have significantly lower baseline corticosterone concentrations than courting males at the den. Because sex differences exist in both the timing of dispersal from the den and activation of feeding behavior, we asked whether intra−seasonal changes in plasma corticosterone and/or glucose differ between male and female snakes. Snakes were collected from the den or a road along their migratory route, approximately 1 km from the den; blood samples were collected immediately upon capture. Both male and female snakes collected from the den had significantly higher baseline corticosterone compared to dispersing snakes ($P < 0.001$). In contrast, dispersing snakes had significantly higher glucose concentrations than den−collected snakes, suggesting that the activation of foraging behavior is linked to dispersal from the den. However, den−collected female snakes had significantly lower glucose concentrations than those of den−collected males ($P = 0.003$), suggesting that changes in blood glucose alone do not induce migration and/or foraging behavior. We are currently examining whether seasonal changes in neuropeptide Y are associated with the switch between reproduction and foraging behavior in garter snakes. These data will provide insight into the neuroendocrine mechanisms that regulate life history transitions.

P1.25 MAINE, J.J.*; BOYLES, J.G.; Southern Illinois University; *jjmaine@siu.edu*

Top−down Suppression of Herbivory by Insectivorous Bats in a Midwestern Agroecosystem

An important factor mediating ecosystem function is regulation of populations through trophic cascades. Trophic cascades are dampened by compensatory foraging and omnivory, so they mainly transpire in simple ecosystems with distinct trophic levels. Agricultural ecosystems may thus represent an ideal area to assess such interactions. Bats in particular are thought to be important in suppressing crop pest insect populations. Models place the value of pest control services by bats at greater than $3 billion annually, but these models are built on completely untested assumptions about the nature of top−down effects of bats in agroecosystems. Further, many studies suggest that generalist predators cannot provide enough predation pressure to suppress prey populations. To test these assumptions, we directly assessed the strength of pest suppression by bats using six large exclosures and paired control plots in corn fields in the Midwestern United States. The exclosures prevented bats from foraging over corn, but were opened during the day to allow birds to forage normally. Crop pests, crop damage, and bat activity were sampled at weekly intervals. In blocks where crop pest larvae were found, damage was almost universally more severe and crop pests were more prevalent in the exclosure plot than in the paired control. This suggests that insectivorous bats do in fact provide top−down suppression of herbivory in agroecosystems and contradicts assumptions about population regulation by generalist predators.

2.3 MAJORIS, J.E.*; D'ALOIA, C.C.; BUSTON, P.M.; Boston University, MA; *jmajoris@bu.edu*

Settler habitat preferences and post−settlement processes combine to explain the distribution of a coral reef fish

In the marine environment, many organisms produce dispersive larvae that develop offshore before settling on benthic habitat. The distribution of newly settled larvae (here on designated settlers') are often non−random, suggesting that processes at settlement or post−settlement affect the distribution of settlers on the reef. Experiments have shown that the larvae of many reef fishes exhibit specific habitat preferences at settlement, however few empirical studies have linked fine scale habitat preferences with the observed distribution of settlers in the field. Here we investigated 6 alternative hypotheses to determine whether habitat preferences at settlement and a post−settlement process could help to explain the observed distribution of the sponge dwelling neon goby, *Elacatinus lori* on sponge habitat. Specifically, we utilized an *in situ* choice arena to compare multiple combinations of habitat stimuli and establish the habitat preferences of *E. lori* settlers. We then isolated visual and olfactory habitat cues independently to determine if their absence alters settler preference behaviors. Finally, an eviction experiment was conducted to determine if post−settlement interactions between residents and settlers affects settler habitat use. We found that *E. lori* settlers are capable of making fine−scale discriminations between settlement habitat utilizing visual, but not olfactory cues. These habitat preferences, in combination with post−settlement interactions with resident *E. lori*, can explain the observed distribution of settlers on the reef.

S10.3−4 MAKI, K.L.*; ROSS, D.S.; HOLZ, E.K.; Rochester Institute of Technology; *kmaki@rit.edu*

A New Model for the Suction Pressure Under the Contact Lens

We study the dynamics of the contact lens to better understand how the design of the lens can be optimized for patient comfort and ocular fit. When a contact lens is inserted on an eye, it is subjected to forces from both the tear film in which it is immersed and the blinking eyelid. In response, the lens bends and stretches. These forces center the lens, and they produce the suction pressure that keeps the lens on the cornea. In this presentation, we couple fluid and solid mechanics to determine the most prominent forces acting on the lens. We present a mathematical model that predicts the suction pressure. We explore the influence of contact lens properties on the suction pressure.

70.3 MALLERY JR., C.S.*; DZIALOWSKI, E.M.; University of North Texas; *christophermallery@my.unt.edu*

Metabolic Demand of Ovoviviparous Reproduction in the Guyana Orange Spotted Cockroach Blaptica dubia

Cockroaches display a variety of reproductive modes, from viviparity to oviparity to ovoviviparity. The Guyana Orange−spotted Cockroach, *Blaptica dubia*, is an ovoviviparous species that lays an egg sac (ootheca), which is retracted into a brood sac for the duration of incubation, and subsequently gives live birth to nymphs (observed at day 46 in this study). Ovoviviparity presents a tradeoff between protecting the eggs and providing a proper hygric environment, and utilizing excess resources not necessary in the more common insect reproductive mode, oviparity. We studied changes in metabolic rate of developing embryos and gravid females to assess the extent of this increased energy expenditure. Gravid female cockroaches increased in mass throughout the duration of incubation, and metabolic rate per unit mass of the females increased. This increase is not exclusively due to females facilitating gas exchange of the developing embryos, as the metabolic demand of eggs increased throughout development but did not fully account for the female's metabolic rate increase. This increase in metabolic rate of female *B. dubia* during the course of incubation can serve as a measure of the reproductive tradeoff to maintain the eggs in a brood sac.

76.1 MALISKA, M.; LOWE , E.; WEBER, C.; STOLFI, A.; PEYRIERAS, N.; CHRISTIAEN, L.; BROWN, C.T.; SWALLA, B.J.*; Univ. of Washington, Seattle, Michigan State University, East Lansing, New York University, New York, Institut de Neurobiologie Alfred Fessard, Gif sur Yvette; *bjswalla@uw.edu*

Molgulid Ascidians have a Radical Heterochronic Shift in their Metamorphic Gene Network

Transcriptome and genomic data offer an exciting new approach to examine the origin and evolution of the chordate body plan. One system for studying chordate body plan evolution are two tunicate species with radically different larval body plans the tailed ascidian *Molgula oculata* and the tailless *M. occulta*. Tailed *M. oculata* embryos, like most solitary ascidians, have 40 notochord cells that are converged and extended in the tadpole larvae. The larvae also have tail muscle cells flanking the notochord in the tail, and, in the head, an otolith, a gravity sensory organ. The tailless *M. occulta* does not form a tail in their larval stage, and have only 20 notochord cells that do not converge and extend during larval development. We show by transcriptome analyses that the ascidian metamorphosis program begins earlier in molgulid ascidians. This radical heterochronic shift has been documented in another tailless ascidian, *M. tectiformis*, and is now reported for both the tailed, *M. oculata* and tailless *M. occulta*. Furthermore, both species have already formed siphons at the time of hatching, so morphologically metamorphosis has began as well. Functional data is necessary to determine if this pronounced heterochrony is the necessary preadaptation for tailless tadpole to evolve in molgulid ascidians. However, we forecast that these studies will facilitate the elucidation of the metamorphic signal in ascidian tadpole larvae, which is still currently unknown.

P3.88 MALOIY, G.M.O.; RUGANGAZI, B.M.; ROWE, M.F.*; Univ. of Nairobi, Nairobi, Kenya, Univ. of the West Indies, Kingston, Jamaica; *ndovuman@hotmail.com*

Energy Expenditure and Minimum Cost of Transport During Incline Locomotion in Dromedary Camels Camelus dromedarius and Domestic Donkeys Equus asinus

Dromedary camels (*Camelus dromedarius*) and domestic donkeys (*Equus asinus*) are utilized by nomadic tribesmen as working ungulates in hot arid regions of Africa and the Middle East. Both species can encounter mountainous terrain characterized by steep gradients. Energetics of incline locomotion has been well described in equines, and briefly examined in camels and donkeys. However, no published data exists describing mass−specific energy expenditure (Wkg^{-1}) and total horizontal and vertical cost of transport, the energy required to move one−kilogram body mass one meter ($Jkg^{-1}m^{-1}$) horizontally and vertically, in camels and donkeys and over a wide range of walking speeds and incline gradients. We performed open−system measurements of oxygen consumption in two adult female camels (average body mass 240 kg) and three adult male donkeys (average body mass 170 kg) while walking at range of tread speeds (of 0.56, 1.11, 1.67 and 2.22 ms^{-1}) and incline gradients (of 3°, 5° and 7°) on a motorized treadmill. In both species, energy expenditure increased in a nearly linear fashion with increasing running speed and incline. On average, compared with locomotion on the level, minimum total cost of horizontal transport increased by approximately 1.8−, 2.2− and 2.4−fold in both species at inclines of 3°, 5° and 7°, respectively. Efficiency of incline locomotion at 3° and 5° gradients were approximately 64% and 37% in camels, and 54% and 42% in donkeys, respectively.

72.4 MANAHAN, D.T.*; APPLEBAUM, S.L.; PAN, F.; Univ. Southern California; *manahan@usc.edu*
Genes, genomes and proteins − the challenge of making physiological predictions
Dramatic advances in nucleic acid sequencing technology are providing unprecedented abilities to quantify gene expression and abundances of mRNA in organisms. Beyond the study of single genes, genome science is opening up new understandings of "non−model" organisms that are of great interest to comparative biologists. A common assumption in many of these studies is that changes in mRNA abundance are an indicator of physiological activity. Recent tests of this assumption, however, show that steady−state transcript levels are often poor predictors of protein abundances and physiological rates. Our studies of epithelial transport processes in developing sea urchins have shown that (1) gene expression of ion transporters did correspond to the amount of protein (Na^+, K^+−ATPase) in some stages, but not all, and (2) the amount of total protein never corresponded to the measured physiological rate of ion transport. Genome analysis reveals that many more genes than those commonly identified are involved in single transport processes. In the bivalve *Crassostrea gigas* there are several gene families, one of which (Solute Carrier Family 6) contains ~30 gene predictions for amino acid transporters, each expressed in larvae. This situation is similar to the genetic complexity regulating other physiological responses: e.g., the *C. gigas* genome contains 88 heat shock protein 70 genes. Genome science is providing important insights into the biological complexity underlying physiological processes. It seems unlikely, however, that gene or protein expression assays alone will provide useful predictions of many physiological rate processes. Rather, elucidation of the physiological function of individual genes and defining the relative contribution of multiple genes to single physiological processes, is required.

P3.120 MANCIA, S.I.*; HUANG, X; CHOW, M.H.; MCMILLAN, B; JACOBS, M.W.; McDaniel College, Bryn Mawr School; *sim001@mcdaniel.edu*
The Effect of a Nature Trail on Soil Invertebrate Recolonization
A nature trail is a man made path penetrating the ecology of the forest floor. The soil in nature trails is more compacted, dryer, and has less vegetative cover than nearby forest floor soil. These physical differences in soil composition may affect the movement of soil invertebrates and the composition of soil invertebrate communities. We tested the hypothesis that recolonization rates into sterile soil would differ depending on the proximity of the soil to a nature trail. We placed cylindrical mesh traps containing sterile soil near and far from a nature trail, and measured recolonization rates after days 5 and 10. We observed substantial recolonization by day 5, and total abundance continued to increase until day 10. Shannon−Wiener biodiversity was significantly higher in experimental samples compared to nearby controls on both days 5 and 10, suggesting that disturbance attracts a greater diversity of soil invertebrates. Proximity to the path was negatively correlated with total abundance in recolonized soil but not in nearby control samples, although this trend was not significant. These results suggest that nature trails may serve as barriers between invertebrate communities. Our recolonization assay will serve as an effective tool for further tests of this hypothesis.

44.3 MANESS, TJ*; ANDERSON, DJ; Louisiana Tech University, Wake Forest University; *tmaness@latech.edu*
Nestling growth rate and juvenile survival
The survival probability of birds during the juvenile period, between the end of parental care and adulthood, is highly variable and has a major effect on population dynamics and parental fitness. As such, a large number of studies have attempted to evaluate potential predictors of juvenile survival in birds, especially predictors related to parental care. The hypothesis linking body reserves accumulated from parental care to the survival of näive juveniles has organized much of this research, but a variety of other predictors have also been investigated and received some support. We used path analysis to test potential predictors of juvenile survival of 2631 offspring from seven annual cohorts of a seabird, the Nazca Booby (*Sula granti*). Fledging age was the most important predictor of juvenile survival: fast−growing offspring survived best, when all other variables were held constant. Offspring sex was the next most important predictor, with juvenile males (the smaller sex) surviving better than females did. Hatching day, an index of body weight, and wing length also showed important predictive ability, but cohort size, culmen length, and an index of clutch size and hatching success did not. Nestling growth was compromised under poor rearing conditions: overall weight fell, the number of days needed to reach fledging status increased, and growth of some structures, but not others, were reduced. These effects were more pronounced in females, and the higher juvenile mortality of females accounts for most of the male bias in the adult sex ratio and its attendant "mate rotation" mating system in this population.

P3.3 MANESS, TJ*; ANDERSON, DJ; Louisiana Tech Univerity, Wake Forest University; *tmaness@latech.edu*
Immune investment, muscles, and female mate choice
Mate choice hypotheses are based on the premise that choosers exploit phenotypic cues that accurately predict the potential mate's fitness. Behavioral ecologists traditionally link "individual quality" with exaggerated secondary sexual characteristics or suites of phenotypically variable cues or behaviors. Life history theory suggests that high quality individuals are better able to afford investment in breeding than are low quality individuals, and so should express these relevant cues in a more attractive manner. Populations with biased operational sex ratios provide opportunities to investigate mate choice since the bias offers members of the limiting sex the opportunity to choose among competing potential mates. We investigated mate choice in a male−biased population of Nazca boobies and tested the hypothesis that males selected as mates are in better condition than are males not selected as mates. We weighed and collected serum samples from males two months prior to the egg laying period and performed a clinical health screen of serum enzymes, proteins, and metabolites. We also measured baseline corticosterone (stress hormone), testosterone, and immunoglobulin IgY. Males with low current investment in immune defense and greater muscle mass/exertion were much more likely to be selected as mates than were males with high immune investment and lower muscle mass/exertion.

131.2 MANN, W.T.*; BURGE, C.A.; STACY, C.; BEACH−LETENDRE, J.; MYDLARZ, L.D.; The University of Texas at Arlington, Cornell University; *wtmann@uta.edu*

The arms race between host and pathogen in Caribbean sea fan pathosystems

A host and its pathogen are consistently at an arms race to develop new defenses against each other and shifting environmental conditions can have a significant impact on this relationship. When conditions favor the pathogen, chances of infection increase leading to the development of diseases. In many coral systems, higher disease prevalence is linked to rising sea surface temperatures, associated with global climate change. This has been particularly true for the Caribbean sea fan coral *Gorgonia ventalina*, where over the past few decades a variety of diseases have emerged. In multiple studies, chronic stress has been observed in several experimental and field observations. Individuals were exposed to temperatures >30°C for a period of 2 weeks (experimental) to 10 weeks (field). Experimental exposure to temperature stress demonstrated heightened levels in immune activity. Similar patterns were observed in the field during early time points of the stress period, however immune activity decreased as the duration of stress continued. The integration of these data suggests that although sea fans possess the immunological repertoire to fight infection induced by elevated temperatures, longer and chronic durations of temperature stress can eventually lead to disease. Elevated temperatures may also present an advantage to the pathogen, creating likelihood for infection. These data illustrate how coral diseases may be developing and can help in future predictions of how coral populations may endure projected climate change scenarios.

P1.54 MARGOTTA, J.W.*; ROBERTS, S.P.; ELEKONICH, M.M.; University of Nevada, Las Vegas, Central Michigan University; *margotta@unlv.nevada.edu*

Understanding how honey bee flight and senescence are connected through oxidative stress.

The goal of this study was to exploit the tractability of the honey bee (*Apis mellifera*) model to understand how the physiological and cellular mechanisms that determine the onset and duration of senescence are shaped by behavioral development and behavioral intensity revealing how behavior can damage a cell and consequently limit lifespan. The honey bee represents the ideal model to address these factors because age, behavior, functional senescence, and lifespan are easily manipulated independently of each other while in its natural environment. First, we determined if there was a cause−effect relationship between honey bee flight and oxidative stress by comparing damage accrued from intense flight bouts to damage accrued from galactose treatment, which is a known proxy of oxidative stress in other insects. Second, we experimentally manipulated the duration and intensity of honey bee flight across a range of ages to determine their effects on ROS accumulation and the associated enzymatic antioxidant protective mechanisms. In bees fed galactose, lipid peroxidation (MDA) increased when compared to age−matched bees with high flight experience and negligible flight experience. We then found that a marker of oxidative DNA damage (8−OHdG) increased in flying bees with high amounts of flight experience. These data suggest flight−induced oxidative stress plays a significant role in functional senescence of foraging honey bees. We also observed an imbalance between pro−oxidants (superoxide and H_2O_2) and anti−oxidants (SOD and catalase) in bees with high amounts of flight experience. These data suggests that an imbalance of pro− to antioxidants is implicated in flight−associated oxidative stress.

92.4 MARION, ZH*; TESTER, A; FORDYCE, JA; FITZPATRICK, B; Univ. of Tennessee, Knoxville; *zmarion@utk.edu*

Characterizing the variation of multivariate chemical defenses in fireflies: a novel approach for chemical ecology

Throughout their evolutionary histories, organisms have evolved complex traits that defend against consumers. These phenotypes consist of multiple, subsidiary traits that behave as a single integrated unit, with individual components that are better suited for some predators than others, or that are differentially expressed at different stages of ontogeny. Closely related populations or species may employ qualitatively and quantitatively different defense strategies because of chance or from past histories in different environments. Chemically−mediated defenses are no exception, but historically, chemical ecologists have often been guilty of ignoring the qualitative variation as either unimportant or analytically intractable, instead focusing on the total amount or concentration of a particular functional class of molecules. In this study, we used LC−MS to explore the defensive chemotypes of multiple populations of several species of North American fireflies (Coleoptera: Lampyridae). The complexity of firefly chemical phenotypes was characterized as the diversity or effective number of distinct compounds making up an individual's cocktail of chemical defenses, while taking relative amounts into account. We demonstrate that there is substantial chemical variation both within and among populations and species, as well as alternative life−history strategies. We also show how our unified, hierarchical view of complexity and diversity suggests the use of analytical methods developed in population genetics and community ecology to characterize complex phenotypes, and helps place questions about the evolution of complexity in a population/community context.

38.4 MARKHAM, M.R.*; SINNETT, P.M.; BAN, Y; AHADIZADEH, E.N.; Univ. of Oklahoma; *markham@ou.edu*

Energetics of active sensory and communication signals in the weakly electric fish Eigenmannia virescens: Organismal, cellular, and molecular perspectives.

Electric fish generate brief electric organ discharges (EODs) for electrolocation and communication. The EOD is generated by the synchronized action potentials (APs) of the electric organ cells (electrocytes) which generate large membrane currents and incur correspondingly high energetic demands. These energetic demands are driven primarily by the activity of the Na^+/K^+ ATPase which requires ATP to actively transport Na^+ and K^+ across the cell membrane following each AP. The gymnotiform electric fish *Eigenmannia virescens* generates a quasi−sinusoidal electric organ discharge (EOD) at frequencies of 300−600Hz. These high firing rates further amplify the energetic demand of EOD production, potentially consuming up to 30% of the animal's energy budget. We have identified physiological adaptations at the organismal, cellular, and molecular levels through which *Eigenmannia* manages energetic requirements of the EOD during normal conditions and under metabolic stress. *Eigenmannia* reduces EOD amplitude during food deprivation and restores signal amplitude following feeding, a change mediated by circulating endocrine factors that regulate electrocyte function. Electrocytes possess several design features that reduce energetic requirements of signal production including the compartmentalization of the ion channels and Na^+/K^+ ATPases that generate the electrocyte AP and restore ion gradients following the AP, as well as the expression of Na^+−activated K^+ channels that terminate the AP. We found also that the Na^+/K^+ ATPase shows several amino acid substitutions associated with increases in pump turnover rate in other organisms, a feature that further shapes energy demand at high EOD rates.

P1.192 MARKHAM, M.R.; The University of Oklahoma;
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Electrophysiology of the Neuron 2014: Open access neural simulation software to promote active learning in neurobiology.
Neural simulation software allows students to interactively learn how neurons work and learn the mechanisms that neurons use to encode and transmit information. The most widely used simulation packages are commercial products that must be purchased by the student or the institution. We have revised and updated the open access program Electrophysiology of the Neuron (EOTN; John Huguenard and David McCormick) that is no longer compatible with current operating systems. The EOTN 2014 package is compatible with both Windows and Mac OSX operating systems, and is available as a free download. EOTN consists of two programs, one to simulate current−clamp experiments on neurons while manipulating variables such as ion channel density, synaptic inputs, and ion concentrations inside and outside the cell to discover how these changes affect firing properties. The program allows users to see the underlying channel gating, conductance changes, and ion movements that generate the action potentials. The package also features a voltage−clamp simulator that allows students to simulate voltage clamp experiments to witness the behavior of ion channels and characterize the kinetics and voltage dependence of half a dozen different ion channels that shape the electrical activity neurons. The program was designed as a tool for active learning as students interact with the program to discover the biophysical principles that govern neuronal function through a series of structured inquiry−based modules. It also can be used in more traditional lecture−based classes as a demonstration tool. I will present an overview of the program's capabilities and features, as well as demonstrating some of the available learning modules.

P1.105 MARSHALL, CD*; WIESKOTTEN, S; MARSH, A; KOT, B; HANKE, W; HANKE, FD; DEHNHARDT, G; Texas A and M University, University of Rostock; *marshalc@tamug.edu*
Feeding Kinematics, Suction, and Hydraulic Jetting Capabilities of Harbor Seals (Phoca vitulina)
The feeding performance of harbor seals was characterized during controlled feeding trials. Trials used feeding apparatuses that allowed subjects to choose between suction and biting feeding modes, but also presented food that could only be ingested using suction. Animals were videotaped while feeding and pressures exerted were simultaneously measured directly. Kinematic analysis showed that the mean gape cycle duration during suction events was significantly shorter (0.15±0.09s S.E.; $P<0.01$) than biting events (0.18±0.08; $P>0.05$). Subjects favored a suction feeding mode (84% of all events), but biting was also important (16% of all events). Suction and biting were kinematically distinct. Suction was characterized by a significantly smaller gape (1.3±0.23 cm; $P<0.001$) and gape angle (12.9°±2.02; $P<0.001$), pursing of the rostral lips to form a circular aperture, and pursing of the lateral lips to occlude lateral gape. Biting was characterized by a large gape (3.63.0±0.21 cm) and gape angle (28.8°±1.80°; $P<0.001$) and lip curling to expose teeth. Subjects often alternated suction with hydraulic jetting to remove fish from the apparatus. The maximum subambient and suprambient pressures recorded were 48.8 and 53.9 kPa, respectively. Suction and hydraulic jetting were employed 90.5% and 9.5%, respectively, during feeding events. Harbor seals used a wide repertoire of behaviorally flexible feeding strategies to ingest fish from the feeding apparatus. Such flexibility of feeding biomechanics likely forms the basis of their opportunistic, generalized feeding ecology and concomitant breadth of diet in the wild.

P1.47 MARSON, KM*; EARLEY, RL; Univ. of Alabama;
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Insights into the significance of epidermal club cell variation using a self−fertilizing hermaphroditic fish
Many fish species possess epidermal club cells (ECCs), which appear to serve the animal through supporting its immune system, enhancing resistance to parasitic infection and offering protection from UV exposure. Chemicals within the club cells, which are only released into the environment when the epidermis is damaged, also indicate predation events and cause conspecifics to freeze or flee. Recently, it has been shown that there is a great deal of within− and among−population variation in the number of ECCs, some of which remains even when animals are raised under common garden conditions. Interpretation of variation in the presence and adaptive value of ECCs is complicated by genetic variation within and among populations. Mangrove rivulus fish exist as self−fertilizing hermaphrodites and multiple unique isogenic strains exist within each population. They occur over a wide geographic range (northern Brazilian coast throughout the Caribbean to the Florida coasts) and in diverse microhabitats. This species thus offers an opportunity for examining the abundance of ECCs in relation to environmental and social conditions without the genetic noise unavoidable in most wild populations. Preliminary evidence supports the presence of epidermal club cells in this species. Previous evidence indicates that the number of ECCs increases as a function of population density due to the potential increase in exposure to pathogens and parasites. Extending from the fact that significant differences in our catch−per−effort exist between populations from the coasts of Belize and central Florida, we hypothesize that high−density populations originating in Belize will have a significantly greater number of ECCs than low−density populations originating along the central coast of Florida.

47.4 MARTIK, ML*; MCCLAY, DR; Duke University;
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Mechanisms of primordial germ cell migration in the sea urchin, Lytechinus variegatus
The sea urchin small micromeres arise at the vegetal pole from an unequal 5th cleavage, and their progeny are specified to become the primordial germ cells of the embryo. We show, by high−resolution time−lapse microscopy, that the small micromeres reach the coelomic pouches via a directed homing mechanism. Throughout gastrulation, small micromeres adhere to one another by LvG−cadherin−mediated adherens junctions. Once gastrulation nears completion, the tip of the gut undergoes basement membrane remodeling that allows the small micromeres to undergo an epithelial−mesenchymal transition (EMT) and migrate over the archenteron to the posterior half of the forming coelomic pouch. Small micromere progeny that will become the primordial germ cells preferentially migrate to the left coelomic pouch while a smaller number reach the right coelomic pouch and are apoptosed with the larval support system during metamorphosis. Ectopically placed small micromeres also home to the coelomic pouches. When placed at the equator of the 16−cell embryo, the small micromeres undergo a precocious EMT at the mesenchyme blastula stage and actively migrate to the tip of the early archenteron during its invagination. Ectopic insertion of 32−cell−stage small micromeres into the blastocoel of an early gastrula host embryo is followed by attachment of the small micromeres to the archenteron tip as soon as they become motile, independent of LvG−cadherin adherens. Current aims are to understand the signaling and chemoattractant mechanisms by which the small micromeres undergo such a dramatic feat of finding their way home.

P2.84 MARTIN, G.G.; Occidental College, Los Angeles; *gmartin@oxy.edu*

Does chitin line the open circulatory systems of crustaceans and mollusk?

Chitin is the second most abundant organic compound in nature, behind cellulose and billions of tons sink from molted crustacean exoskeletons to the ocean floor every year. More piles up as waste at culture facilities. In addition to exoskeletons, chitin is found in egg coverings of nematodes, radulae of mollusks, peritrophic membranes, nudibranch epidermal cells, tubes of the hydrothermal vent worm *Riftia*, and the squid pen. A rather surprising location is its recent description in vesicles and granules in circulating hemocytes of mollusks and crustaceans. The identification of chitin is typically based on its insolubility in concentrated potassium hydroxide and its selective staining with the lectin wheat germ agglutinin, especially its succinylated form. WGA binds to N−acetyl −D−glucosamine the precursor of chitin. Although it is possible that hemocytes migrate to and deposit chitin on the tissues listed above, we have asked if the hemocytes may be involved in producing the intima that lines blood vessels and sinuses in animals with open circulatory systems. This poster presents results showing the staining of the lining of some blood spaces with fluorescently labeled WGA and complementary TEM images of a variety of tissues including heart, gills, and blood vessels, in the shrimp *Sicyonia ingentis* and the giant keyhole limpet , *Megathura crenulata*. Our results suggest that the N−acetyl −D−glucosamine contained within hemocytes from these two phyla may indeed participate in producing the boundary layer between hemolymph and tissues which is relevant to circulation and immune responses. Future work will ask if hemocytes may also deposit chitin in the nodules they form around encapsulated foreign materials.

114.7 MARTIN, LB*; LIEBL, AL; Department of Integrative Biology. University of South Florida, Centre for Ecology and Conservation, School of Biosciences, University of Exeter; *lbmartin@usf.edu*

Individual physiological plasticity in an avian range expansion

The mechanisms that enable animals to colonize new areas are little known, but growing evidence indicates that the regulation of stress hormones is important. Stress hormones probably influence invasions because they are pleiotropic, enabling organisms to adjust their phenotypes cohesively contingent on environmental context. Here, we asked whether plasticity in the regulation of one stress hormone, the steroid corticosterone, was related to colonization success in one of the world's most successful avian invaders, the house sparrow (*Passer domesticus*). We studied Kenyan house sparrows, as the species was introduced there around 1950 and has since expanded westward. Previous work in this system revealed that younger populations released more corticosterone during a restraint stressor than older populations. Our first goal was to discern whether such population differences were fixed or plastic in adulthood; our second goal was to determine whether population−level plasticity was consistent or heterogeneous among individuals within populations. The latter goal was motivated by recent discoveries that individual plasticity is ecologically important but sometimes constrained by personality. We found that both baseline and stress−induced corticosterone measures were plastic at the population level; moreover, populations differed in plasticity of baseline corticosterone. We found evidence for corticosterone regulatory personalities too, but we found little evidence for covariation (constraint) among regulatory elements. Altogether, our data suggest that the colonization success of Kenyan house sparrows might be due to stress hormone regulatory plasticity.

7.3 MARTIN, S. D.*; BONETT, R. M.; Univ. of Tulsa; *samuel−martin@utulsa.edu*

Body Size Evolution and Species Diversity in North American Minnows

Body size is one of the most important traits influencing an organism's ecology and is often a major axis of evolutionary change. Among freshwater fishes, body size may influence patterns of biogeography and macroevolution. Smaller fishes can occupy smaller streams, are generally poorer dispersers, and are thus more likely to become isolated among drainages. Since isolation can promote speciation through allopatric divergence, small fishes may have higher diversity in a region. We tested for a relationship between body size and diversity in a highly speciose endemic clade of North American minnows (Leuciscinae), which exhibit diverse body sizes. We developed a time calibrated, species level phylogeny based on 7 mitochondrial genes and 12 nuclear genes. We then used this phylogeny to reconstruct ancestral body sizes, compare rates of size evolution among subclades, and examine whether body size has influenced the species richness of North American minnows.

47.1 MARTIN−DURAN, J.M.*; PASSAMANECK, Y.J.; MARTINDALE, M.Q.; HEJNOL, A.; Sars International Centre for Marine Molecular Biology, Univ. of Bergen, Norway, Kewalo Marine Laboratory, Univ. of Hawaii, Honolulu, HI, The Whitney Laboratory for Marine Bioscience, Univ. of Florida, FL; *chema.martin@sars.uib.no*

Evolution of protostomy in the Brachiopoda

The blastopore, the orifice of endomesoderm invagination during gastrulation, can form the mouth (protostomy), the anus (deuterostomy), both gut openings (amphistomy), or none (blastopore closure) in bilaterians. The relationship between these openings was used to divide the Bilateria into the Deuterostomia and Protostomia, a split also supported by molecular phylogenies. However, there is a strikingly vast diversity of blastoporal fates within the Protostomia, even between closely related species. To understand the evolution of different gastrulation modes and cell fates in this group, we compared the development of a protostomic brachiopod (*Terebratalia transversa*) with that of a deuterostomic brachiopod (*Novocrania anomala*). In late blastula embryos, anterior/oral markers (*six3/6*, *otx*), posterior markers (*cdx*, *evx*) and endomesodermal genes (*foxA*, *twi*, *GATA456*) are radially expressed along the animal−vegetal axis in a similar pattern in both brachiopods. The blastopore is located at the vegetal pole, and initially posterior/anal markers are detected here in both species, as in deuterostome embryos. In *N. anomala*, the blastopore remains in the posterior region of the embryo, whereas in *T. transversa*, part of the blastopore moves anteriorly to meet animal oral ectoderm and form the mouth. It is the expression of anterior markers (*six3/6*, *NK2.1*, *otx*, *gsc*) in this region of the blastopore that represses the posterior markers, allowing the blastopore to move. Our data explains protostomy and amphistomy as gastrulation modes derived from an original deuterostomic condition, contrary to what most accepted theories about metazoan evolution propose.

112.3 MARVI, H.*; GONG, C.; GRAVISH, N.; MENDELSON, J.; HATTON, R. L.; CHOSET, H.; HU , D. L. ; GOLDMAN, D. I.; Georgia Tech, Carnegie Mellon, Georgia Tech and Zoo Atlanta, Oregon State; *hamid.marvi@gmail.com*

Sidewinding as a control template for climbing on sand

Desert dwelling snakes like sidewinder rattlesnakes *Crotalus cerastes* sidewind to rapidly traverse granular media like loose sand. While sidewinding has been studied on hard ground, little is known of the detailed mechanics of interaction with granular media. In addition, controlling robots over such terrain remains a challenge: a field−tested limbless robot (the Modsnake) suffers significant performance loss when ascending sandy inclines. To understand how the animals effectively interact with such substrates, and to design a new control template for robots, we conduct the first study of the detailed mechanics of sidewinding on sand. We use a tiltable air fluidized bed to prepare loosely packed states of desert sand at different inclination angles. We challenge the animals to ascend these inclines and record 3D kinematics using multiple high−speed cameras. On level granular media, the contact length occupies 23±4% of the snake length (*N*=6). As the incline angle increases to 20 degrees, the contact length increases to 38±4% (*N*=6). To understand these mechanics, we measure the downhill drag forces on plates, and find that the granular yield stresses decrease by 50% over the range of incline angles. We therefore hypothesize that the increase in contact length is a neuromechanical control template such that the animals actively maintain contact stresses below the yield stress to avoid slipping. We implement the anti−slip control template in the Modsnake, and find that it generates effective climbing on granular inclines in the laboratory as well as in a simulated field environment.

P2.140 MASCARENHAS, F.E.*; MALLERY JR., C.S.; DZIALOWSKI, E.M.; University of North Texas, Denton; *fancinemascarenhas@my.unt.edu*

Physiology of the Pekin duck (Anas pekin) ductus arteriosus

In developing avian embryos, the left and right ductus arteriosus shunt pulmonary blood away from the lungs to the systemic circuit and chorioallantois. In mammals and birds studied to date, the ductus arteriosus are oxygen sensitive vessels that constrict in response to increasing oxygen levels. In this study, we examine the physiology of the ductus arteriosus from Pekin duck (*Anas pekin*) in internal and external pipped embryos. The *in vitro* contractile response of the left ductus arteriosus was measured using wire myography. The duck ductus contracted in response to oxygen at both the internally and externally pipped stages. The ductus relaxed in response to high levels of NaS only in the presence of high oxygen. Under low oxygen levels, the relaxing response was muted. In response to phenylephrine, both the internally and externally pipped ductus contracted. At low concentrations, norepinephrine resulted in a weak contraction followed by relaxation at higher concentrations. The physiology of the duck ductus arteriosus is similar to that of the chicken ductus. This research was funded in part by an HHMI grant to Lee Hughes. Supported by NSF IOS 1146758 (EMD).

60.1 MASLAKOVA, S.A.*; VON DASSOW, G.; Oregon Institute of Marine Biology, University of Oregon; *svetlana@uoregon.edu*

How the pilidium larva escapes an ancient constraint

The pilidium is a planktotrophic larva with unique morphology, development and metamorphosis, found only in pilidiophoran nemerteans (an order−level taxon with ~ 450 species). Nemerteans, a.k.a. ribbon worms, share a conservative developmental program called spiral cleavage with several other phyla of marine invertebrates collectively referred to as spiralians (including the familiar annelids and mollusks). Primary trochoblasts are a set of four embryonic cells at the 16−cell stage − 1q2 in the scheme of spiral cleavage. In a typical spiralian these cells undergo one or two cell divisions, become multiciliated and contribute to the prototroch − the primary larval ciliated band, used for swimming, and, sometimes, feeding. But not in pilidiophorans. By labeling 1q2 cells in embryos of the pilidiophoran *Micrura alaskensis* and tracking their fate in larvae, we show that, unlike in typical spiral cleavage, primary trochoblasts in a pilidiophoran embryo continue to divide far more than just once or twice. Not only that, but their progeny contribute to the main growth zones of the pilidium, the axils, found in the recesses between the larval lobes and lappets. Earlier we demonstrated that the axils give rise to both the growing larval body (including the primary ciliated band) and the imaginal discs, which give rise to the juvenile body inside the pilidium. To sum it up, in a typical spiralian, the primary trochoblasts are quintessentially larval − they form the larval ciliated band, which is lost during metamorphosis, and they have no future in adulthood. In the pilidium larva, quite the opposite, the trochoblasts escape the constraint on cell division imposed by the multiciliated fate, and, instead, allow the larva to grow, and, also form the adult body.

S8.1−1 MATEO, Jill M.; The University of Chicago; *jmateo@uchicago.edu*

Developmental and maternal effects on behavioral plasticity

Social, hormonal and genetic processes interact reciprocally, and differentially affect behavior depending on ecological and social contexts. Multiple developmental processes would be expected when individual differences are favored either between or within environments. Parental effects provide a rich source for phenotypic plasticity, including anatomical, physiological and behavioral traits, because parents respond to dynamic cues in their environment and can influence offspring accordingly. Because these inter−generational changes are plastic, parents can respond rapidly to changing environments and produce offspring whose phenotypes are well suited for current conditions, more rapidly than change based on evolution through natural selection. I will review studies on developmental plasticity and resulting phenotypes in Belding's ground squirrels (*Urocitellus beldingi*), an ideal species given their annual cycles of hibernation and intense energy demands, and their need to learn survival behaviors due to high predation. I will show how local environments and perceived predation risk influence not only foraging, vigilance and anti−predator behaviors, but also adrenal functioning, which may be especially important for obligate hibernators that face competing demands on glucose storage and mobilization. Mammalian behavioral development is sensitive to the social and physical environments provided by mothers during gestation and lactation. Therefore maternal effects on offspring phenotypes, both positive and negative, can be particularly strong.

P1.208 MATSUDA, S.S.*; GOSLINER, T.M.; California Academy of Sciences and San Francisco State Univ., California Academy of Sciences; *smatsuda@calacademy.org*

Sea slug geometry and toxic chemical defense: a novel application of 3D imaging

Brightly colored sea slugs that live in the most biodiverse and threatened coral reefs on the planet also possess unique evolutionary novelties in defense and shape. A group of opisthobranch molluscs called nudibranchs have evolved hyperbolic geometry, a unique structural shape characterized by negative curvature. This is evident in the elaborate undulations surrounding their bodies that provide a higher surface−area−to−volume ratio than flat or positive curvature. Nudibranchs have also developed the unique ability to reuse toxic chemical defense compounds stolen from their prey for their own defense. These compounds are stored in glands lining the edge of the undulations in the best position to fend off an attacker. These toxic chemical compounds aid in nudibranch prey identification and some have been discovered to have biomedical properties. The relationship between nudibranch geometry and types of chemical compounds will be examined by i) updating the *Glossodoris* phylogeny with mitochondrial genes CO1 and 16S and nuclear genes H3 and 28S, ii) reviewing the literature for chemical data for described and new species of *Glossodoris*, and iii) measuring hyperbolic geometry by creating a new 3D imaging technique for soft bodied invertebrates and analysis via geometric morphometrics. Uncovering a relationship between geometry and distribution of defensive glands in nudibranchs would reveal insights into the evolution of shape and chemical defense sequestration, the role local environmental pressures play in chemical sequestration and shape, and the effectiveness of defense mechanisms located within nudibranchs' tissues.

P3.49 MATTHEWS, J.M.*; EDWARDS, T.M.; Louisiana Tech University, Ruston; *jmm104@latech.edu*

Effects of BPA on Growth and Development in Arabidopsis thaliana

Anthropogenic activities have resulted in the contamination of terrestrial and aquatic environments with many industrial chemicals, several of which possess endocrine disrupting properties. Bisphenol−A (BPA), an industrial chemical used in the production of plastics, binds estrogen receptors and elicits an estrus response in rodents. Most research has focused on the effects of BPA on humans and wildlife, while very little has been devoted to its effects on plants. Understanding the mechanisms by which BPA affects plant life will allow for the further assessment of the risks of BPA exposure to all aspects of an ecosystem. This project used *Arabidopsis thaliana* to examine the effects of BPA on plant growth characteristics regulated by flavonoids, cytokinins, and auxins, which work together to determine root and shoot branching patterns. Previous studies illustrate that BPA exhibits cytokinin−like activity in a dose−dependent manner in a cytokinin bioassay. Additionally, some flavonoids exhibit estrogenic activity, suggesting a common mode of action between flavonoids and BPA in plants. We exposed wildtype and flavonoid deficient (*transparent testa (tt4−13)*) *Arabidopsis* to environmentally relevant concentrations of BPA early in plant development. The two varieties exhibit very different branching patterns due to variance in flavonoid production. We monitored plant branching patterns and timing of inflorescence formation to determine if BPA could be classified as an endocrine disruptor in plants.

37.5 MATUS, DQ*; CHANG, E; MAKOHON−MOORE, SC; SHERWOOD, DR; Duke University; *david.matus@duke.edu*

Targeted cell cycle arrest halts basement membrane gap expansion during nematode uterine−vulval attachment

The creation of large gaps in basement membranes (BM) is a critical component of tissue construction and normal physiology, as well as disease states such as cancer. Still, how large BM breaks are generated and stabilized remains poorly understood. *C. elegans* uterine−vulval attachment is a visually and experimentally tractable model to elucidate mechanisms underlying BM gap formation. During *C. elegans* larval development the gonadal anchor cell (AC) breaches the BM and initiates a connection between the uterine and vulval tissues. Following invasion, the vulval cells invaginate and expand, generating forces that widen the gap in the BM. The BM moves past the dividing vulE and vulF cells and stabilizes, in an integrin−dependent manner, over the post−mitotic vulD cell. To understand the evolution of the mechanisms that underlie BM gap formation we have examined uterine−vulval attachment in twenty species of rhabditid nematodes, representing several hundred million years of evolution. We find that in all nematodes surveyed, the AC breaches the BM, initiating uterine−vulval attachment. Strikingly, the expanding BM gap always stabilizes over the post−mitotic vulD cell, the only vulval cell across rhabditid nematodes that never divides. In *C. elegans*, we find that causing excess divisions of vulD expands the BM gap, and inhibition of the interior vulE and vulF divisions contracts it. Visualization of the cell−BM interaction reveals that dividing vulval cells lose BM contact, allowing the BM gap to expand. Finally, we show that this integrin−dependent adhesion is directed by a concentration of laminin at the lip of the BM gap. Together, our studies reveal a new mechanism for stabilizing expanding BM gaps by using targeted cell cycle exit and BM gap−mediated integrin localization.

P1.155 MAUCH, E*; SCHREIBER, A.M.; St. Lawrence University, NY; *aschreiber@stlawu.edu*

Synergistic effects of thyroid hormone and glucocorticoids on thymus gland involution in Xenopus laevis tadpoles

Metamorphosis in anurans is accompanied by a dramatic loss of larval thymocytes as a new adult antibody repertoire is formed. Rising levels of glucocorticoids (GC) during metamorphosis have been shown to inhibit lymphocyte proliferation and induce thymus lymphocyte cell death. Although increased thyroid hormone (TH) concentrations are known to mediate most aspects of metamorphosis, the influence of TH on the larval thymus, either directly or in combination with GC, remains unclear. Nieuwkoop−Faber stage 50 and 54 tadpoles were treated with TH (5nM T3) and dexamethasone (DEX, 2uM) individually and in combination for 4 days, after which thymus sizes were measured in vivo using image analysis. Treatment with either TH or DEX alone resulted in approximately 40% reductions of thymus size. In comparison, treatment with TH+DEX produced a 60% decrease in size. The kinetics of programmed cell death was evaluated in NF50 stage tadpoles using whole−mount immunohistochemistry against active caspase−3. Maximum thymus immunoreactivity following treatment occurred at 72 hours (TH), 48 hours (DEX), and 24 hours (TH+DEX). These findings suggest that TH and GC each separately induce larval thymus involution and apoptosis, and together exhibit a synergistic effect that accelerates these processes.

70.7 MAUSBACH, W/E*; DZIALOWSKI, A/R; Oklahoma State University; *bill.mausbach@okstate.edu*

A Conflict between Hatching and Survival in a Halophilic Fairy Shrimp (Crustacea: Anostraca)

Branchiopods are well known for their dormant eggs and the specific cues required to break dormancy (temperature, dissolved oxygen, light, or water chemistry). These cues are thought to be conservative to insure high survival in unpredictable environments like ephemeral pools or playas. *Branchinecta potassa* Belk 1979, is an endemic fairy shrimp that has only been collected in alkaline/saline ephemeral pools in the Nebraska Sandhills, Nebraska, U.S.A. Over the past three years, we conducted regional surveys showing that this species can occur in saline environments ranging in conductivity from 3.32 − 37.9 mS/cm and that presence varies annually due to fluctuations in precipitation and temperature. We aimed to identify the range of environmental conditions *B. potassa* can survive in by exposing its eggs to three temperatures (5, 20, and 35^{o}) and 3 levels of conductivity (freshwater, low salinity, and high salinity). We also compared developmental rates, fecundity, and egg viability of *B. potassa* at the three levels of conductivity. No eggs hatched at the 5 or 35^{o}C, but when the eggs were moved to 20^{o}, hatching occurred within 24−36 hours at all conductivity levels. More *B. potassa* individuals hatched in the freshwater and low alkaline treatments than the high alkaline treatment, though there were no significant differences between the treatments. The nearly equal hatching rates of *B. potassa* in freshwater (<1mS/cm) and low salinity water were of particular interest, because it has yet to be found in freshwater habitats.

11.2 MAYERL, C.J.*; VAN DAMME, R.; Clemson University, SC; *cmayerl@clemson.edu*

Thermal Ecology of Podarcis tiliguerta (Lacertidae) Across an Altitudinal Gradient

Most aspects of behavioral and physiological performance in lizards depend on body temperature (T_b). Environmental temperatures (T_es) are among the most important external factors influencing T_b in ectotherms. Elevation has a powerful impact on T_es, and organisms exhibit many responses to the colder T_es experienced at high elevation. There are two contrasting views on the evolutionary adaptability of thermal physiology: the 'static' view, which predicts that thermal physiology is resistant to directional selection, and the 'labile' view, which predicts susceptibility to directional selection. Size, condition, thermoregulatory behavior, T_b, skin absorptivity, heating rate and abundance of two populations of the Tyrrhenian Wall lizard, *Podarcis tiliguerta* (Lacertidae) at two altitudes in Corsica, France (250 m and 1,450 m) were studied, and predation pressure and the quality of the thermal habitat at both elevations were estimated. High elevation lizards showed no shift in thermoregulation, and did not absorb more solar radiation than conspecifics at low elevation, resulting in them having lower T_bs with equivalent heating rates. Despite this, the abundance of lizards at each location was equal, and lizards at high elevation were both larger and in better body condition than those at low elevation. Predation pressure was also lower at high elevation. Although previous research concluded that the thermal physiology of *P. tiliguerta* is static, this study questions the strength of that claim, suggesting instead that decreased predation risk at high elevation may reduce the pressure to respond to the thermal environment. These data highlight that studies on lizard thermal ecology should consider a breadth of factors when evaluating adaptability.

S10.1−4 MAYSER, M.J.*; BARTHLOTT, W.; GILET, T.; University of Liege, University of Bonn; *m.mayser@ulg.ac.be*

The hairy, superhydrophobic surfaces on the water fern Salvinia − underwater air retention and raindrop impacts

Superhydrophobic surfaces are of high scientific and economic interest because of their remarkable properties. Recently the immense potential of air−retaining superhydrophobic surfaces has started to be explored, e.g. for low−friction fluid transport and drag−reducing ship coatings. A major problem of superhydrophobic surfaces mimicking Lotus leafs is the limited persistence of the air retained, especially under rough flow conditions. However, a variety of floating or diving plant and animal species do exist. They possess hairy, air−retaining surfaces optimized for durable water−repellency. In particular, water ferns of the genus *Salvinia* have developed superhydrophobic surfaces that are capable of maintaining air layers for months.

Here the retained air volume of different *Salvinia* species is precisely measured and monitored over time. The rate of air loss is not necessarily proportional to the air−water interface area, but is also well correlated with the respective micro structure of different species. In a second set of experiments, we investigate the influence of the sophisticated hair architecture of *Salvinia* on raindrop impacts. Several regimes of rebounding, separation and splashing are observed for different drop sizes and impact velocities.

58.4 MüLLER, T.*; WINDSOR, S.P.; TAYLOR, G.K.; University of Oxford, UK, University of Bristol, UK; *tonya.muller@zoo.ox.ac.uk*

Characterization of nonlinear mechanisms in the optomotor system of the tobacco hawkmoth

Flying insects are known to use optic flow information to stabilize their flight; however the functional properties of the optomotor system and its relation with an insect's flight dynamics are not well understood. The focus of this work was to explore how tobacco hawkmoths (*Manduca sexta*) use wide−field vision to stabilize their motion. In order to characterize the relationship between optic flow and flight response, we used a virtual reality flight simulator where a moth was exposed to oscillating wide−field, sinusoidal gratings. During these open−loop experiments, moths were tethered to a 6 degree of freedom force sensor, allowing us to measure their corresponding flight responses. The optomotor system was characterized in the frequency domain, where we explored the properties of homogeneity and additivity. The roll, pitch and yaw magnitude responses demonstrated different sensitivities to changes in the amplitude and frequency of the stimulus motion. We explored this phenomenon further by applying a model selection process, and found that the responses were best predicted by nonlinear combinations of stimulus parameters. These models suggest that roll, pitch and yaw stabilization are elicited by different combinations of stimulus amplitude, frequency and angular velocity as control inputs. We conclude that although quasi−linear models account for a large proportion of the response, nonlinear models are needed to capture many of the salient features of the response behaviour. The variation in sensitivity to roll, pitch and yaw motions is discussed both in terms of saturation effects in the visual system and in the context of the insect's flight dynamics.

P2.40 MCBRAYER, L*; FARMER, S; MCELROY, E; Georgia Southern University, College of Charleston; *lancemcbrayer@georgiasouthern.edu*

Facultative use of large accelerations for bipedal running in lizards

In amniotes, bipedal locomotion has evolved repeatedly in various lineages. In many instances, a bipedal running posture evolved from a quadrupedal ancestor. The vast majority of lizard species are quadrupedal, yet many often employ a bipedal locomotor posture for several strides at the start, or during, a sprint. Numerous studies have tested hypotheses regarding why lizards may use a bipedal posture, yet its functional basis remains elusive. At least two hypotheses exist for why facultative bipedalism exists. One hypothesis suggests that it is a byproduct of high accelerations generated by the hind limbs at the start of a run, while another suggests that bipedal posture is used to overcome obstacles. These hypotheses are not mutually exclusive as high accelerations would be likely needed to transition from quadrupedal to bipedal running. Here we will present data comparing quadrupedal and bipedal postures of lizards while sprinting toward a single obstacle. Velocity and acceleration data were collected for each step during the lizard's locomotion toward the obstacle. The data show that lizards can take several quadrupedal steps before transitioning to bipedalism, and that acceleration is highest on either the last quadrupedal, or the first bipedal, step. Hence, high accelerations are involved, but they do not always occur during the initial steps. This finding implies that the use of a bipedal posture is not only a spandrel of large accelerations, but rather, an individual may control when, or how, to use this posture.

P3.40 MCCARTY−GLENN, M.C.; Stony Brook University; *mica.mccarty−glenn@gmail.com*

The effect of parasites on predator−prey interactions

Parasites often modify aspects of their host's ecology, but how this affects the intra− and interspecific interactions of the host is often unknown. Many intertidal snails that are infected with flatworm parasites display altered behavior and move to the top of rocks or move higher up the shoreline. This may be beneficial to the parasite if this behavior makes the snails easy prey for predators that are secondary parasite hosts. This experiment tests how the chemical cues from two common intertidal predators influences the movement of parasitized snails. *Ilyanassa obsoleta* was collected from four different sites across Long Island, New York. These snails were then placed in a sloped tank in the laboratory to determine whether the snails would move up− or downshore, followed by dissection to determine whether or not they had parasites. There were three different treatments used to determine whether the presence of predator chemical cues affected snail behavior. The snails were either exposed to seawater without predator cues (control), water with green crab (*Carcinus maenas*) chemical cues, or water with seastar (*Asterias forbesi*) chemical cues. Preliminary results show that having parasites did not correlate with movements in the experimental setting; although, my field collection data suggests that snails collected higher on the shoreline were more likely to be parasitized.

51.3 MCCAULEY, DW*; LEE, E; YUAN, T; NGUYEN, K; Univ. of Oklahoma, Norman; *dwmccauley@ou.edu*

Differential Activity of SoxE Transcription Factors in Neural Crest Development and Evolution

SoxE genes arose by duplication and are key regulators of neural crest cell (NCC) development. Sea lampreys are primitive vertebrates and also possess three SoxE genes, all expressed in neural crest. In order to address how gene duplication has influenced their roles, we examined the ability of lamprey SoxE genes to regulate NCC differentiation in zebrafish lacking expression of Sox9a and Sox10. Lamprey SoxE genes are able to rescue the differentiation of melanogenesis and neurogenesis in zebrafish *Sox10* mutants. The lamprey *Sox9* ortholog, *PmSoxE3*, was unable to promote cartilage differentiation in zebrafish *Sox9a* mutants. Surprisingly, lamprey−specific *PmSoxE1*, was able to promote the differentiation of small cartilage nodules in *Sox9a* mutants. Our data suggest an early *SoxE* gene already possessed melanogenic, neurogenic and chondrogenic regulatory capabilities prior to gene duplication. Further, melanogenic and neurogenic activities were partitioned to *SoxE2* in lampreys and *Sox10*in jawed vertebrates, whereas the chondrogenic role was partitioned to *Sox9* in gnathostomes but to *SoxE1* in lampreys. Morphogenesis of pigment cells and neurons in *Sox10* mutants rescued by heterospecific SoxE expression appeared normal, but *PmSoxE1* did not rescue morphogenesis of the craniofacial skeleton in *Sox9a* mutants. This result suggests lamprey SoxE genes may lack the regulatory ability to direct morphogenesis of the gnathostome craniofacial skeleton. We speculate that the lamprey Sox9 gene, *SoxE3*, acquired lamprey−specific roles in cartilage morphogenesis through neofunctionalization. Our study demonstrates the differential adaptation and specialization of SoxE proteins across the agnathan−gnathostome boundary, and reveals that phylogenetic signal is not always a reliable predictor of functional conservation.

P2.60 MCCLINTOCK, JB; Univ. of Alabama at Birmingham; *mcclinto@uab.edu*

Taking your research to the public: leveraging a popular book to educate millions of people about climate change and ocean acidification

Authoring a popular book with an important environmental narrative can synergize opportunities to educate the general public that greatly exceed direct readership. In this presentation, I describe how a friendship with Edward O. Wilson encouraged me to author a book about my research and adventures in Antarctica set against a narrative of the ecological impacts of rapid climate change. To maximize the book's educational outreach, I recruited internationally renowned authors, entrepreneurs, and scientists to contribute book jacket blurbs. This, in turn, facilitated interviews on NPR including the "Diane Rehm Show" and "On Point with Tom Ashbrook", along with book promotion tweets by Bill Gates, Al Gore, and Sylvia Earle. Media attention surrounding the book spawned book reviews in magazines including Smithsonian and Nature, and newspaper articles on climate change and ocean acidification. Invitations followed to write Op Ed pieces for the Birmingham News and the Huffington Post. An appointment to the Advisory Board of the E.O. Wilson Biodiversity Foundation resulted in the production of a video narrated by Harrison Ford based on a chapter of the book that describes the dramatic decline in Adelie penguins on the Antarctic Peninsula (the video is being featured in aquariums and zoos across America). In summary, while sales of the book are likely to number in the tens of thousands, in the larger picture the book has facilitated the education of several million Americans on the pressing issues of climate change and ocean acidification. Supported by an Endowed University Professorship to J.B.M.

P2.91 MCCORKELL, FA*; TAYLOR, GK; BOMPHREY, RJ; Univ. of Oxford; *fergus.mccorkell@zoo.ox.ac.uk*

Flow sensing for flight control in the desert locust Schistocerca gregaria

In the absence of much passive stability, flying insects rely upon active stabilisation, necessitating the provision of rich sensory feedback across a range of modalities. Mechanosensors for measuring aerodynamic flows are the most ubiquitous systems on the bodies of flying insects; in our model species, the desert locust, *Schistocerca gregaria*, approximately 430 flow−sensitive hairs (trichoid sensilla) on the front of the head provide a highly directional response to the oncoming flow. The directional sensitivity of these hairs may allow them to sense changes in angle of attack and sideslip, and are thus potentially important in both lateral and longitudinal flight stability. We aim to test hypotheses about these sensory structures by establishing the exact flow stimuli they are experiencing, understand how the information they obtain is used in the stabilization and control of locust flight, and explain their highly specific placement and directional sensitivity. Here we characterise the flow stimulus around the head using particle image velocimetry and computational fluid dynamics data.

P2.139 MCCORMICK, S.D.*; REGISH, A.M.; O'DEA, M.F.; USGS, Conte Anadromous Fish Research Center; *mccormick@umext.umass.edu*

The evolutionary consequences of staying in freshwater: seawater performance, physiological and endocrine differences between landlocked and anadromous salmon.

Landlocked populations of anadromous fish have evolved frequently in some species, but the effects of this altered life history on traits associated with survival in seawater have not been well established. Landlocked Atlantic salmon usually maintain a migration from streams to lakes, similar in timing to the seaward migration of anadromous strains. Thus, there is relaxed selection on traits associated with ocean entry but not necessarily on other life history changes such as migration and niche shift. In this study anadromous and landlocked Atlantic salmon were reared under identical conditions after fertilization and examined for differences in seawater performance and its underlying physiological and endocrine control during the time of spring downstream migration. We found that salinity tolerance as judged by plasma chloride after direct transfer to 35 ppt increased in both strains in spring but was highest for the anadromous strain. Survival and growth in the first two weeks of seawater exposure was also greater for the anadromous strain. We also examined several of the critical traits associated with seawater tolerance, including gill Na+/K+−ATPase (NKA) activity, the abundance of seawater and freshwater isoforms of NKA in the gill, and circulating levels of hormones that control these physiological changes.

98.8 MCCUE, M D*; CARDENTEY, A; St. Mary's University; *mmccue1@stmarytx.edu*

Isotope labeled metabolic tracers are not created equal: comparing the oxidative kinetics of free− versus biochemically−integrated dietary nutrients

Clinicians and researchers are increasingly using $^{13}CO_2$−breath−testing to diagnose metabolic disorders, especially those related to protein and lipid metabolism. Breath testing involves giving an oral dose of a ^{13}C−labeled nutrient and tracking the rate at which it is oxidized by collecting exhaled CO_2− and measuring the recovery of ^{13}C atoms. In this study we examined how the extent to which the tracer atom is biochemically integrated into larger macromolecules affects the outcome of the breath tests. Specifically, we compared the oxidative fates of 1) an amino acid tracer (^{13}C−Leucine) that was dosed as a free amino acid and the same tracer molecule integrated into ^{13}C−ovoalbumin protein or 2) a fatty acid tracer (^{13}C−1−palmitic acid) that was dosed as a free fatty acid and the same tracer molecule integrated into a triacylglyceride (i.e., ^{13}C−1,1,1−tripalmitin). Although the time courses of tracer oxidation were species−specific and differed between the protein and lipid tracers, we found clear differences in oxidative kinetics among all three species of animals. In every case, the recovery of ^{13}C−atoms in the breath was substantially lower (e.g., by an order of magnitude) from metabolic tracers that were integrated into larger macromolecules than when the tracers were dosed as monomers of macromolecules. We conclude that 1) characterization of the oxidative kinetics of small tracer molecules may not be representative of typical' dietary nutrients when these monomers are biochemically integrated into larger macromolecules and 2) direct comparisons of studies that examine the oxidative kinetics between integrated and nonintegrated tracer molecules will yield misleading outcomes.

115.2 MCCULLOUGH, E.L.; University of Montana, Missoula; *mccullough.e@gmail.com*

Beetle horn diversity: does shape affect performance during fights?

Rhinoceros beetles exemplify the elaborate morphologies that can result from sexual selection. Males have long horns on their head and prothorax that they use in fights over reproductive access to females. Species vary dramatically in the shape and size of their horns, yet this variation is poorly understood. Species also fight in different ways, and males sometimes fight vigorously enough to break their horns. Here, I used finite element analysis to assess whether variation in horn shape affects performance during combat. Specifically, I constructed finite element models of the head horns of three rhinoceros beetle species (*Trypoxylus dichotomus*, *Golofa porteri*, and *Dynastes hercules*), and compared the patterns of stress distribution and total strain energy under loading conditions that mimicked typical and atypical fights. In all three species, typical loading conditions produced the lowest stress distributions and the lowest total strain energies. These results indicate that horns are the least likely to fail, and the most efficient at transmitting fighting forces under conditions that mimic typical fights. More importantly, these results suggest that the variation in horn morphology among species reflects differences in fighting style, and that horns have been selected to maximize fighting performance.

P1.70 MCDANIEL, DK*; DAVIS, J; Radford University; *dkmcdaniel@radford.edu*
Stress as a modulator of immune function and sickness behavior in Passer domesticus
The vertebrate HPA axis is responsible for responding to external stressors that may or may not threaten the life of an organism. It does this by releasing glucocorticoids that regulate aspects of the stress−coping response, one of which is the immune response. Lipopolysaccharide (LPS) is commonly used in the lab to induce an immune response in animals. Once an immune response is induced, the animal will exhibit sickness behaviors, increased white blood cells, and increased hemagglutination and hemolysis. An invasion of a pathogen is considered an external stressor and is therefore coupled with the release of glucocorticoids. Glucocorticoids decrease immune function and are thought to be protective, by not allowing the immune system to damage healthy tissue. Because previous research has shown that stress attenuates the immune response, we hypothesized that birds pretreated with corticosterone would have a weaker immune response and exhibit less sickness behaviors than birds given LPS alone. This situation is analogous to a bird experiencing a stressor, such as a predator, prior to an infection. In order to further elucidate the interaction between the HPA axis and the immune response, house sparrows (*Passer domesticus*) were either pretreated with dimethylsulfoxide (DMSO) and corticosterone and then given LPS, or received a DMSO control treatment alone followed by LPS. Blood was taken from the subjects at various time points and measured for heterophil:lymphocyte ratio, hemagglutination, and corticosterone (via ELISA). Alterations in movement, feeding and water intake were recorded and quantified using Ethovision XT.

P1.102 MCELROY, E.J.*; BERGMANN, P.J.; College of Charleston, Clark University; *mcelroye@cofc.edu*
Many−to−many mapping of phenotype to performance: an extension of the F−matrix for studying functional complexity
An organism's functional system is defined by the relationships between its suite of morphological traits and performance capacities. The functional system is important because it influences ecology, behavior and fitness and thus the organism's evolutionary trajectory. How the functional system influences other aspects of the organism's biology is determined by the type of relationships between morphology and performance. These relationships include: one−to−one, trade−offs, facilitations and redundancies. The F−matrix is an intraspecific matrix of measures of statistical association between morphology and performance that is used to quantify the type of relationships present within a functional system. However, the F−matrix is underutilized and, as such, we extend it in two ways with the goal of increasing usage. First, we use the F−matrix to describe how different morphology−performance relationships can occur simultaneously and interact to impact the evolutionary potential of a functional system; we call this many−to−many mapping. Second, we compile species' F−matrices into an interspecific F−array and using this F−array we develop statistical methods to compare F−matrices among species. We compute an evolutionary variance−covariance matrix for each performance measure, allowing us to determine if the functional system underlying different types of performance evolved similarly. We compare morphology−performance relationships at microevolutionary and macroevolutionary levels using a modified Mantel test to compare each intraspecific F−matrix to a clade−wide F−matrix computed using the F−array and phylogenetically independent contrasts. We demonstrate the expanded F−matrix approach with a dataset of eight phrynosomatine lizard species, including seven morphological traits and two measures of locomotor performance.

65.7 MCEWEN, B.S. ; The Rockefeller University; *mcewen@rockefeller.edu*
Protective and Damaging Effects of Mediators of Stress and Adaptation
An ever−changing environment requires an organism to adapt via a process called "allostasis" using the neuroendocrine, autonomic, immune and metabolic systems that interact with each other and function in a non−linear manner. The long term consequence of allostasis is cumulative changes in brain and body, leading to adaptation to a new challenge, often referred to as a stressor. Referred to as "allostatic load and overload", such structural and functional changes are often used in the natural world for successful adaptation and survival of an individual or species. Yet, in humans and also in animals in captivity, allostatic overload in the form of cardiovascular disease, diabetes, depression and other disorders represent the cost of a sedentary lifestyle where caloric intake exceeds utilization, but also may include the consequences of poverty,crowding, social isolation and other forms of deprivation and adversity. The brain is the central organ of stress and adaptation to stressors and it is a plastic and vulnerable organ throughout the life course. Among the many interacting mediators that affect brain and body function, glucocorticoids stand out because they are involved in so many different processes and via multiple cellular and molecular mechanisms, in which epigenetic mechanisms are prominent. Their actions follow a U−shaped (hormetic) dose response relationships and they have both trophic and protective effects at one end and damage−facilitating effects at the other. This will be discussed in relation to the role of the hippocampus, amygdala and prefrontal cortex in effects of acute and chronic stress in animal models and in humans. Implications for therapy of stress−related disorders will be discussed.

17.5 MCGOWAN, C.P.; University of Idaho; *cpmcgowan@uidaho.edu*
Net joint work provides limited insight into muscle−tendon unit function during incline hopping by kangaroo rats
In a recent inverse dynamics analysis of incline hopping, we showed that the proportion of net joint work supplied by each joint is similar across a wide range of slopes (10−25 degrees). This suggests that unlike tammar wallabies, there is not a division of labor between proximal and distal muscles of kangaroo rats. However, inverse dynamics analyses alone may provide limited insight into the functional roles of specific muscle groups. In a previous analysis of acceleration mechanics, we showed that because the major ankle extensor muscle−tendon units (MTUs) are biarticular, coupling of knee and ankle flexion (but not extension) resulted in the MTUs doing relatively little negative work, despite the ankle joint itself absorbing a substantial amount of energy in the first half of stance. In this study, we sought to determine if a similar coupling of knee and ankle kinematics leads to a decoupling of MTU work and net joint work during incline hopping over a range of slopes. We used a combination of inverse dynamics and geometric modeling to calculate ankle extensor MTU work during hopping on slopes of 10, 15, 20, and 25 degrees. Our results show that despite an increase in both positive and net joint work at the ankle across slopes, the net work done by the ankle extensor MTUs actually decreased with increasing slope from a maximum of 0.237 J/kg at 15 degrees to 0.188J/kg at 25 degrees. The energy absorbed by the MTUs was relatively low (mean: −0.048 J/kg) and did not vary with slope. Therefore the decrease in net work was due to a reduction in positive work done by the MTUs. These results reinforce the need to use a combination of approaches to understand the functional roles of individual muscles or MTUs during dynamic movement tasks.

S2.3−1 MCGRAW, KJ*; GIRAUDEAU, M; Arizona State University; *kevin.mcgraw@asu.edu*
Sex and disease in the city: links between coloration, parasites, and urbanization
Expanding urban conditions across the globe continue to impose unique environmental constraints on organisms. Condition−dependent sexually selected traits are useful for revealing how animals cope with stress, including anthropogenic disturbances. Ornamental coloration of some bird species has been shown to be depressed in cities compared to rural/natural areas, but there are many plausible mechanisms that could underlie this pattern (e.g. pollution, diet, CORT stress). Since 2008, we have been studying factors related to the expression of carotenoid−based sexual coloration in house finches (*Haemorhous mexicanus*) along an urban gradient in Phoenix, AZ, USA. Among free−ranging birds, we have found close associations between plumage color intensity, degree of infection with two parasites (avian pox and intestinal coccidians), and degree of urbanization (i.e. human population, % disturbed land); male finches are less colorful and infected with more parasites in urban areas. We have also conducted common−garden experiments to test for latent (i.e. phenotypic plasticity) v. lasting (i.e. developmental/genetic) mechanisms underlying the links between color, parasites, and urbanization. Rural finches show superior ability to endure infection with some parasites, but we have not uncovered sustained urban/rural differences of color expression. These findings highlight the subtleties of assessing wildlife health along different axes of 'condition' and in urban environments.

58.2 MCHENRY, M.J.*; NAIR, A.M.; STEWART, W.J.; CHANGSING, K.; SOTO, A.; U.C. Irvine; *mmchenry@uci.edu*
How zebrafish larvae sense and evade fish predators
Prey fish use the visual and lateral line systems to evade predators, but it is unclear how this sensory information is integrated to successfully anticipate a predatory strike. Prior experiments established that zebrafish (*Danio rerio*) larvae survive by initiating an escape response during a predator's approach. We replicated this condition with a robotic predator, which consisted of a dead fish that was actuated to move toward larvae at a constant speed. By measuring the high−speed kinematic responses of larvae in 3D, we learned that larvae are capable of evading a predator in the dark by sensing the water flow generated by the approach. Under illumination, we found that larvae were capable of responding to the looming stimulus created by a predator at a greater distance than possible by the lateral line system. In response, larvae exhibited relatively slow avoidance swimming at greater distance and with an escape response in close proximity to the approaching predator. By mathematically modeling sensory cues for both lateral line and visual stimuli, we developed algorithms for behavioral decisions that depend on both modalities. Therefore, this study offers a basis for understanding the sensory cues that facilitate the survival of prey fish.

P3.178 MCHORSE, B.K.*; HOPKINS, S.S.B.; Harvard University, University of Oregon; *bmchorse@fas.harvard.edu*
Comparing skeletal characteristics of fossil Equus and modern mustangs
Modern horses (genus *Equus*) provide an opportunity to investigate the morphological effects of differing selective pressures. For example, domesticated horse breeds (*E. caballus*) experience strong artificial selection in different directions depending on their intended use; free−ranging feral horses (*E. caballus*) were previously domesticated, but are now under natural selection; and wild equids (*E. kiang*, *E. grevyi*, and others) have undergone natural selection without domestication. Modern horses also provide a useful data−rich study system for investigating the transition from three toes to a single toe in the fossil record of equids (e.g., by providing a source of information on soft tissues and gait dynamics in addition to the skeleton). North American mustangs are feral horses that range free on government land in the western United States. They are abundant and periodically collected in roundups, where individuals from the herd are auctioned to the public to be tamed; this makes it possible to collect data from naturally selected horses that are also accustomed to being handled. Previous work has shown mustangs differ significantly in gross skeletal structure from a group of artificially selected competition horses, but it is unknown how morphologically similar mustangs are to wild horses. We compare postcranial measurements of mustangs and fossil *Equus* specimens to gain a broad−level insight on this question. If they are not significantly different from wild horses in their skeletal structure, mustangs represent an abundant, convenient source of modern data that may be better suited to answering evolutionary questions than data from artificially−selected domestic horses.

P3.155 MCINROE, B.M.*; GOLDMAN, D.I.; Georgia Institute of Technology; *bmcinroe3@gatech.edu*
Construction of a mudskipper−inspired robot to study crutching locomotion on flowable ground
Throughout history, many organisms have used flipper−like limbs for both aquatic and terrestrial locomotion. Modern examples include mudskippers (*Oxudercinae*) and sea turtles (*Chelonioidea*); extinct examples include walkers such as the early tetrapods *Tiktaalik* and *Ichthyostega*. In the transition from an aquatic to a terrestrial environment, early walkers would have had to adapt to the challenges of locomotion over flowable media like sand and mud. While the limb−joint morphology of *Ichthyostega* has been recently described, and it has been hypothesized that its mechanism of locomotion may have been similar to the symmetric gait of a mudskipper [Pierce et. al. 2012], the relationship between form and function in flowable environments has not yet been elucidated. Previously, we discovered that a flipper with a wrist which could passively flex and extend toward and away from the body improved the performance of a sea turtle−inspired robot crawling on dry granular media [Mazouchova et. al. 2013], a result related to the jamming of material behind and beneath the flipper. To gain insight into how an additional degree of freedom of the wrist affects flipper−based locomotors, we have built a robotic model with limb−joint morphology inspired by the reconstruction of Pierce et. al. We add to our previous limb design a passive degree of freedom that allows for up−down flexion and extension of the flipper about a variable insertion angle. Springs at the joints restore the flippers to equilibrium positions after interaction with the media. We study the crutching locomotion of the robot performing a symmetric gait, varying limb cycle frequency and insertion angle.

P2.149 MCKEE, A*; NEWTON, S; CARTER, A; California State University, Long Beach; *biologymajor8@gmail.com*

Influence of Inbreeding on Female Mate Choice in Two Species of Drosophila

Many organisms have been reported to choose their mates in order to increase the heterozygosity of their offspring by avoiding mating with relatives or homozygous individuals. Most previous studies using *Drosophila melanogaster* have used artificial chromosomes or extreme inbreeding treatments, situations unlikely to be matched in nature. Additionally, few studies have examined the interaction between female inbreeding status and her choice of mate. Using females and males from populations that had experienced either random mating or one generation of sib−sib inbreeding, we measured the preferences of females for males. Our results indicate that outbred males were chosen more often than inbred males and that this preference may be more pronounced in outbred females than in inbred ones.

86.2 MCKENNEY, EA*; RODRIGO, A; YODER, AD; Duke University, NESCent, Duke Lemur Center; *eam50@duke.edu*

Species−specific assembly of the gut microbiota in lemurs

Microorganisms begin to colonize the infant gut soon after birth and play a crucial role in facilitating gastrointestinal (GI) and immune development. Gut microbial communities also protect against invasive pathogens and unlock indigestible food components such as fiber as infants begin to consume solid foods. Yet, despite the importance of the initial colonization of the sterile GI tract, little is understood of the assembly process. Our project examines the GI colonization process in three species of lemurs, *Varecia variegata* (frugivores), *Lemur catta* (generalists), and *Propithecus coquereli* (folivores). These three deep lineages have evolved distinct GI tract morphologies coupled with distinct feeding strategies. Fifty−eight fresh fecal samples were collected from infant lemurs at birth, weaning, introduction of solid foods, regular intake of solid foods, weaning I, weaning II; and from dams at parturition to assess the impact of maternal signatures and to compare infant succession trajectories. All samples were stored at −80°C until bacterial DNA was extracted with the QIAamp Stool Mini Kit (QIAGEN). Universal PCR primers 515F (GTGCCAGCMGCCGCGGTAA) and 806R (GGACTACHVGGGTWTCTAAT) were used to amplify a region of 16S rDNA for paired−end sequencing on the Illumina MiSeq platform. The 16S reads were analyzed using Quantitative Insights Into Microbial Ecology (QIIME) software to classify microbial constituents and compare membership between samples. Results show that samples from birth and nursing contain predominantly the phylum Proteobacteria, while Firmicutes and Bacterioidetes are dominant and biodiversity increases after infants begin eating solid foods. Gut communities converge with age toward putative species−specific core microbiomes.

P2.122 MCKIBBEN, TP*; KRAJNIAK, KG; Southern Illinois Univ. Edwardsville; *tmckibb@siue.edu*

The Effects of FMRFamide on the Isolated Pharynx of the Earthworm

Our laboratory has been examining the effects of FMRFamide−related peptides (FaRPs) on the digestive tract of the earthworm, Lumbricus terrestris. Many FaRP sequences have been isolated from annelids. The tetraptide FMRFamide previously has been shown to regulate the contractions of smooth muscle of the crop−gizzard. So we decided to examine the effects of FMRFamide on the pharynx preparation. The pharynx was removed from the animal, placed in a tissue bath filled with earthworm saline and attached to a force transducer. The force transducer was connected to a computer. We used IWorx software to record the contractions of the crop−gizzard. Increasing concentrations of FMRFamide were injected into the tissue bath and the resulting changes in contraction rate and amplitude were used to create log−dose response curves. The pharynx has complex contractile pattern that includes large contraction interspersed within regions of smaller contractions. We investigated the effects of FMRFamide on both the large and the small contractions accordingly. Prelimary results show that FMRFamide causes a slight decrease in contractile rate of the large contractions, but nothing significant. As for the amplitude of the large contractions a slight increase in amplitude is seen with a threshold concentration of 0.1 uM. The little contractions in contrast showed a much more significant response to FMRFamide. The rate of the smaller contractions increased in rate with a threshold concentration of 0.1 uM and then immediately returning to baseline for the rest of the experiment. The amplitude of the smaller contractions the rose to an average of 150 percent with a threshold concentration of 10 nM . These results show that FMRFamide does regulate the contractility of the pharynx. We are now examining the responses of the pharynx to the annelid peptide APKQYVRFamide and other worm FaRPs.

P1.5 MCNEIL, E.R.*; SKINNER, M.A.; SMITH, G.T.; Indiana Univ.; *erimcnei@umail.iu.edu*

Sociality, Reproductive Condition, and Communication in a Weakly Electric Fish

South American knifefishes produce weak electric organ discharges (EODs) for communication and electrolocation. EOD frequency (EODf) varies across species and can signal sex and social rank. Few studies have examined the social ecology of knifefishes, but field and laboratory observations of group size and behavior suggest that some species are territorial, while others live in social groups. We examined changes in signaling during the formation of social groups in *Adontosternarchus devenanzii*, a sexually monomorphic knifefish species. Fish (n=18) were initially housed individually in 38−l tanks and were moved as a group into three 568−l tanks connected by tubes that allowed movement between tanks. Each tank had two sites with shelter tubes and artificial plants. Food was provided uniformly at all shelter sites. EODf and the location of each fish were measured throughout the study. After 1 month, water conductivity was reduced to induce gonadal recrudescence. The fish formed distinct social groups. During the first week of group housing, fish were evenly distributed across the 6 shelter sites and the 3 tanks (Ç^2, p=0.48). After 2 weeks, however, most fish aggregated into two shelter sites in one tank (Ç^2, p<0.001). EODf did not change in response to social housing, but increased significantly when conductivity was reduced (ANOVA, PLSD, p<0.001). EODf was not correlated with mass (r^2<0.01, p>0.5). The fish spawned during the experiment, and the fry showed developmental changes in EODf and EOD waveform similar to those in other ghost knifefish. Our results demonstrate that *A. devenanzii* forms stable social groups, that conductivity and reproductive condition influence EODf, and that EODf is not a reliable signal of body size as it is in some territorial knifefish. ERM and MAS contributed equally. Supported by NSF IOS 0950721.

P3.156 MCNEILLY, LE*; SRIDHAR, R; COMBES, SA; Bunker Hill Community College, Harvard University; *lukemc7@gmail.com*
MEASURING TURBULENCE ON THE SPATIAL SCALES OF INSECT FLIGHT

Experiments on insect flight are generally restricted to the confines of laboratories where there is no external flow (i.e. still air) or in very smooth flow produced by laminar wind tunnels. However the vast majority of insects reside in the outdoor environment, within the Atmospheric Boundary Layer (ABL) that extends to a few hundred meters above the Earth's surface. The airflow within the ABL can be very unsteady and turbulent mainly due to the influence of terrain, various meteorological phenomena, Coriolis forces and convection from the surface. Obtaining an understanding of the flow structure in natural habitats of insects will elucidate the meteorological dynamics at small scales (or high frequencies) as well as strategic control mechanisms implemented by insects flying in turbulent winds. Here, we present a Turbulence Measurement Unit (TMU) which can be easily deployed outdoors and is capable of resolving wind velocity and direction at the spatial and temporal scale relevant for insect flight. The TMU consists of a hot wire anemometer coupled with an Inertial Measurement Unit (IMU) and temperature sensor which can align itself to the prevailing wind and take velocity measurements at rates >3kHz. Preliminary results indicate that while large scale turbulence dominate the velocity fluctuations occurring in wind, there exists considerable energy even at smaller scale i.e. higher frequencies that might adversely influence insect flight.

P3.188 MCPHERSON, D.*; COLLISSON, N.; IUPPA, A.; KATZ, R.; LOVETT, J.; SUNY Geneseo; *mcpherso@geneseo.edu*
Identification of a 5−HT7 receptor in the ABRM of the mussel Mytilus edulis

The anterior byssus retractor muscle (ABRM) of the blue mussel, *Mytilus edulis*, has been studied intensively for its ability to maintain prolonged contraction in a catch state with minimal expenditure of energy. Relaxation from the catch state can be induced by serotonin (5−HT). Serotonin acts in this system to stimulate adenylyl cyclase, increasing the synthesis of cyclic adenosine monophosphate (cAMP), which in turn activates protein kinase A (PKA). Phosphorylation of the giant protein twitchin by PKA then leads to muscle relaxation. Despite the high level of detail in our current understanding of the ABRM system, nothing is yet known regarding the identity of the receptor that mediates the effects of serotonin. We have isolated and cloned a portion of a gene in *Mytilus edulis* which encodes a 5−HT receptor, and we have evidence that the mRNA for it is expressed in the ABRM. Analysis of the predicted amino acid sequence for the receptor indicates that it belongs to the 5−HT7 family, and the activation of 5−HT7 receptors is known to stimulate adenylyl cyclase. This receptor is therefore a good candidate to mediate the catch−relaxing effect of 5−HT in the ABRM.

S9.2−2 MCWILLIAMS, S.R.*; PIERCE, B; University of Rhode Island, Sacred Heart University; *srmcwilliams@uri.edu*
THE FAT OF THE MATTER: HOW DIETARY FATTY ACID COMPOSITION AFFECTS ENERGY EXPENDITURE OF BIRDS DURING MIGRATION

Fatty acid composition of fat stores affects exercise performance in a variety of vertebrates although few such studies focus on birds. In theory, selectively feeding on certain long−chain unsaturated fatty acids may be advantageous because (1) such fatty acids may be metabolized more quickly and may stimulate key facets of aerobic metabolism; and (2) such fatty acids may affect composition and key functions of lipid−rich cell membranes. We outline these hypotheses in some detail, and then evaluate the evidence for what determines exercise performance of migratory birds. The predominate mechanism whereby fatty acid composition affects exercise performance of birds seems to be related more to the rate of fatty acid oxidation rather than membrane composition per se. Supported by NSF (IOS−0748349) and USDA (RIAES−538748).

65.4 MEDDLE, SL; The Roslin Institutte, University of Edinburgh; *simone.meddle@roslin.ed.ac.uk*
Behavioural neuroendocrinology in free−living wild Arctic breeding song birds: tales from the tundra&

Investigations into the neural mechanisms underlying complex male aggressive and reproductive behaviour in free−living wild birds are important as they provide a necessary compliment to captive studies; particularly since the context−dependency of complex behaviours is now recognized. We now have evidence that neuroendocrine adaptations underlie the unique behaviour required to maximize survival and reproductive success. Arctic−breeding birds, such as the white−crowned sparrow (*Zonotrichia leucophrys gambelli*) and Smith's Longspur (*Calcarius pictus*), adapt their behaviour to optimise reproductive success in a very short breeding season. The males of these species are behaviourally insensitive to experimentally elevated testosterone (T) and the stress hormone corticosterone (CORT) after courtship has terminated. Unlike most temperate species, which show heightened aggression when given T implants, these Arctic breeding male passerines appear to become non−responsive to T. This refractoriness is thought to be an adaptation to the short breeding season experienced at high latitudes and this insensitivity must require rapid and dynamic changes in the neuroendocrine system. Studies quantifying changes in the expression of aromatase, androgen and oestrogen receptors in the white−crowned sparrow brain have revealed that oestrogen−dependent rapid transitions in aggressive behaviour are mediated by differences in neural oestrogen synthesis. A lower latitude breeding song bird, the song sparrow (*Melospiza melodia morphna*), also demonstrates changes in aromatase expression in specific brain regions throughout the year suggesting that seasonal aggression is regulated by an oestrogen−dependent mechanism in other avian species too.

P2.64 MELICHER, DM*; TORSON, A; BOWSHER, J; North Dakota State University; *dacotah.melicher@my.ndsu.edu*
Expression analysis of a novel appendage in the Dipteran Themira biloba using mRNA−Seq
The evolution of novel traits allow organisms to make use of resources previously unavailable to them and generates new physiological pathways and behavior. Investigation of novel traits allows us to identify the evolutionary mechanisms responsible for producing such traits. The sepsid fly *Themira biloba* (Diptera: Sepsidae) has a novel, sexually dimorphic, jointed appendage that forms from histoblast nests in the fourth abdominal segment during pupation. The appendage is used for complex mating behavior and is absent in some sepsid species. Our objective is to identify the genes which pattern an appendage from histoblast nests which lack complex organization when compared to imaginal discs. *T. biloba* is a non−model species with limited sequence resources. We have obtained mRNA 454 sequence for whole organisms in egg, larva, and pupae stages and developed a transcriptomic reference. Further sequencing was performed for 3rd male, 4th male, and 4th female segments in wandering−phase larva using the Illumina platform to identify genes which are differentially expressed in these segments and may be implicated in patterning the appendage during pupation. Differentially expressed *T. biloba* sequences were annotated using *Drosophila* transcripts categorized by function.

43.4 MENEGAZ, RA*; SZCZODROSKI, AF; ROLD, TL; HOFFMAN, TJ; RAVOSA, MJ; Brown Univ., Truman Mem. VA Hosp., Notre Dame; *rachel_a_menegaz@brown.edu*
Variable diets affect mammalian mandibular development differently than stable diets with mechanically resistant properties
The diets of juvenile mammals are known to affect the morphology of the adult masticatory apparatus. Increased loading from mechanically resistant food items has been shown to influence the morphology of the mandible and its joints, the maxilla, and the muscle attachment sites in the skull. However, much of the current knowledge is derived from juveniles fed a non−variable diet for the duration of their postweaning growth period. Thus, it remains unclear how ontogenetic variation in diet, as may occur in seasonal habitats, affects the resulting adult morphology. To address this gap, we raised four dietary cohorts (n=10/cohort) of Sprague−Dawley rat from weaning to skeletal maturity. Two cohorts were fed a stable diet of either solid or powdered pellets. The other two cohorts were fed a variable diet consisting of either solid/powdered pellets for the first half of the study, followed by a shift to the opposite diet. Morphometric analyses indicate that a dietary signal is most apparent in the mandibular ramus of older subadult rats, whereas variation in mandibular morphology of younger juveniles is concentrated in the mandibular corpus and is related to dental development. Furthermore, adult morphology is correlated with the ontogenetic timing of the consumption of a mechanically resistant diet. The CMJ and coronoid process are influenced by the early postweaning diet, whereas ramus size and angular process morphology are related to the diet consumed later in the growth period. This research highlights the importance of more naturalistic models of mammalian feeding, and has ecomorphological implications for wild and fossil taxa with seasonal or temporally variable diets.

81.4 MENINZOR, D.; ASAHINA, A.; HADFIELD, M.G.*; University of Hawaii at Manoa; *hadfield@hawaii.edu*
Who makes the settlement cue for larvae of Phestilla sibogae?
For more than 40 years, researchers in the Hadfield laboratory have made "metamorphic inducer" for larvae of the nudibranch *Phestilla sibogae* by soaking pieces of the nudibranch's prey coral, *Porites compressa*, in a small volume of seawater and filtering the water. The assumption has long been that the inducer is a metabolite of the coral. But is it? As now well known, any hermatypic coral is a community of coral, symbiotic dinoflagellates and bacteria, any one of which might produce the small, polar metabolite that induces the nudibranch larvae to settle and metamorphose. This study attempts to eliminate all but one of the possible sources. To eliminate the dinoflagellate as a source, live coral pieces were maintained in full darkness for 24 hrs and transferred to fresh seawater where they were maintained in continued darkness. The last batch of seawater was filtered and subjected to a larval assay for metamorphosis. Despite a shutdown in photosynthesis, the inducer was still present, thus partly eliminating the dinoflagellates as the inducer source. To examine a possible role for bacteria in production of the inducer, corals were steeped in seawater containing one of seven different antibiotics, representing five different modes of action and the resulting seawater tested for induction. All preparations remained strongly inductive. Thus, results to date support the hypothesis that it is the coral itself whose metabolite is the inducer of recruitment of its prey nudibranch. However, examination of the coral extracts after each of the antibiotic treatments revealed the presence of live, colony−forming bacteria, so none of the treatments was absolute. Experiments are on−going with combinations and serial treatment of coral with multiple antibiotics.

105.2 MENNING, DM*; GAREY, JR; University of South Florida; *dmenning@usf.edu*
Impacts of coastal spring discharge on a tidally influenced shallow marine estuary
Coastal areas around the world have undergone unprecedented population growth in the last few decades and thus are susceptible to sea level change and decreasing water quantity and quality. The relationship between surface and subsurface estuarine hydrologic processes in coastal regions has not been investigated fully and existing hydrologic models cannot easily integrate the inputs and outputs that occur through subsurface conduits that discharge into a myriad of coastal estuarine springs and seeps. Double Keyhole Spring is a brackish water system that is an example of a coastal spring that is influenced by both the Floridan aquifer and the surface estuary. Using ADV data we estimated water flow through the system varies with tidal cycle and seasonal rainfall from −1449 L/sec at high tide prior to TS Debby to 2577 L/sec at low tide after TS Debby averaging 648−1171 L/s. This flow rate is approximately one−tenth that of the Hillsborough River and demonstrates the important role coastal springs play in the interface of the Floridan aquifer and the Gulf of Mexico. Preliminary work on Double Keyhole Spring and surrounding surface sites includes mapping the spring, establishment of sampling locations, deployment of datasondes to monitor water velocity and physical water parameters, and the collection of water samples for chemical water parameters and microbial community analyses. Microbial community structure and water chemistry data from Double Keyhole Spring and the surrounding estuary indicate spatial and temporal differences between sites. Long term monitoring of Double Keyhole Spring and the surrounding estuary is necessary to show changes in water chemistry and community structure with the primary goal of determining the impacts Double Keyhole Spring discharge has on the surrounding estuary.

10.7 MENZEL, LP*; BIGGER, CH; Florida International University; *lorenzo.menzel@fiu.edu*

Characterizing the complement component C3 from the octocoral Swiftia exserta, opsonic activity and immunohistochemical localization

The third Complement component (C3) is the central protein of the complement cascade linking the three activation pathways (the antibody−dependent classical pathway, the lectin−dependent pathway, and the alternative pathway) with the lytic cascade. C3 is an evolutionarily ancient molecule involved with host defense: C3 genes have been found in many metazoan phyla. In fact our lab published the first report of C3 from a cnidarian, the octocoral *Swiftia exserta*. Functional studies of complement cascade activity began with Bordet and the burgeoning field of immunology, investigating mammalian complement systems. These studies include the end−of−cascade lytic pores developed by the membrane attack complex (MAC), opsonic functions of C3b (a fragment of C3 covalently bound to targets via a thiol−ester bond), and chemo−attraction assays of C3a (as well as C4a and C5a fragments from C4 and C5, respectively). Opsonization is the labeling of particles for phagocytosis, causing opsonized particles to be ingested faster than non−opsonized particles. Several groups have expanded functional studies of the lectin−dependent complement cascade to protochordates (T Fujita and M Nonaka) and echinoderms (LC Smith), but, to date, no functional assays have been published from more basal metazoan animals. Here we show, by cryo−immunohistochemistry, the localization of C3 in the basal metazoan *Swiftia exserta*, that SeC3 binds to target particles (the yeast*Candida albicans*), and that these zymosan particles are opsonized and ingested more rapidly by phagocytic cells from *Swiftia exserta* and by RAW 237.1 cells (a mouse macrophage cell line).

62.4 MERRILL, L*; GRINDSTAFF, J.L.; NAYLOR, M; Oklahoma State University; Illinois Natural History Survey, University of Illinois, Oklahoma State University; *loren.merrill@okstate.edu*

Early life experience influences adult zebra finch bill color before and after antigen challenge

Zebra finches (*Taeniopygia guttata*) have bright red/orange bills that are thought to be honest indicators of phenotypic quality. The red/orange coloration is due to carotenoids, which may provide a link between bill color and condition. Bill color can change rapidly following exposure to stressors, including immunological challenges, but little work has been done examining the effects of early life experience on the magnitude of change in coloration. In this study we examined the change in bill color in adult male and female zebra finches before and after exposure to two antigens: lipopolysaccharide (LPS) or keyhole limpet hemocyanin (KLH). Birds in this experiment were exposed to LPS, KLH or a control during development, and came from mothers who were exposed to LPS, KLH or a control prior to egg−laying. We found that baseline bill coloration and the change in color following exposure to LPS and KLH were affected by both maternal and young treatments. These results indicate that early life exposure to antigens can permanently impact carotenoid−dependent signal expression, and can also affect the magnitude of change in signal expression after antigen challenge.

S7.2−4 MESCHER, M.C.; Penn State University / ETH Zurich; *mcmescher@gmail.com*

Manipulation of host phenotypes by vector−borne pathogens of plants and animals

Parasite manipulation of hosts has been studied extensively, but relatively little work has explored the ways in which vector−borne pathogens may alter the phenotypes of their primary and secondary hosts in order to influence host−vector interactions and enhance transmission. Such effects are likely to have considerable relevance for human health, agriculture, and the ecology of natural systems, and recent studies have begun to document examples of manipulation by insect−vectored pathogens of plants and animals including direct effects on vector behavior, but also effects on host phenotypes that influence attractiveness or apparency to vectors (including pathogen−induced changes in host−derived olfactory cues). Such alteration of host phenotypes has implications not only for disease ecology but also for the development of diagnostic biomarkers of infection with applications in medicine and agriculture. I will discuss recent advances in this area and present findings from our own work on viral and bacterial plant pathogens and on human malaria, which suggest (i) that pathogens may frequently alter host phenotypes in ways conducive to transmission and (ii) that the mode of transmission plays a key role in shaping the evolution of such effects.

P2.54 MEYER, A.*; COLLIN, R.; Wesleyan University, Smithsonian Tropical Research Institute; *ammeyer@wesleyan.edu*

Growth rate increases with temperature but decreases with initial size in Natica chemnitzi larvae

Seasonal variation in environmental temperature influences egg size, hatching size, and growth rate in marine invertebrates. The effects of seasonal differences in hatching size on larval growth rates at environmentally relevant temperatures could have important effects on larval recruitment and survival. Two seasons (wet and dry) greatly affect the water temperature in the Bay of Panama. During the wet season, the water temperature is consistently 28 °C, but during the dry season, wind−driven upwelling brings colder water (23 °C) to the intertidal. Depending on when invertebrate larvae hatch, they will experience very different water temperatures. In this study, we investigate temperature−mediated differences in moon snail (*Natica chemnitzi*) larval growth and measure the plastic response of larvae produced in both seasons to temperatures typical of each season. To determine the effects of temperature and mother on larval growth, we raised larvae from ten females collected during the wet season. Hatchling larvae were marked with calcein and measured after 5 days growing at 28 and 23 °C. Larvae raised in 28 °C water were significantly larger at the end of the experiment and had grown significantly more than their siblings raised at 23 °C. There were significant differences in larval growth between females but no significant effect of the interaction between female and temperature on growth. One unexpected result was that hatchlings with large initial sizes grew less than those with small initial sizes. This experiment will be repeated in the dry season of 2014 to determine if the larvae produced in the dry season show the same patterns of temperature−mediated plasticity.

P3.168 MICHAEL, J. L.*; ESSNER, JR., R. L.; Southern Illinois University Edwardsville; *ressner@siue.edu*

A comparison of aquatic and terrestrial landing in leiopelmatid and lalagobatrachian frogs

Terrestrial jumping in frogs generally involves rapid hindlimb extension and loss of forelimb contact followed by mid−flight limb recovery. During landing, forelimbs make initial contact with the substrate, forming a pivot that helps with stabilization and support. Simultaneously, hindlimbs are rotated under the body so that the frog is in position to initiate another jump. Frogs of the family Leiopelmatidae (Tailed Frogs and New Zealand Frogs) differ from this general terrestrial condition by their exclusive use of "bellyflop" landings, with delayed hindlimb recovery. These frogs diverged from all other extant frogs (Lalagobatrachia) as long ago as 200 mybp. Anuran jumping is hypothesized to have evolved in a riparian context, with the earliest frogs leaping into water to flee terrestrial predators. Thus, the bellyflop landing of leiopelmatids, which appears to be an aquatic diving behavior, may provide insight into the ancestral condition. We compared aquatic and terrestrial landing in a leiopelmatid, the Rocky Mountain Tailed Frog, *Ascaphus montanus*, and a basal lalagobatrachian, the Fire−bellied Toad, *Bombina orientalis*. Frogs were filmed with high−speed video at 250 fps (n=6 individuals per species) jumping from a platform into water. Three−dimensional kinematic analysis indicated that aquatic landing behavior was generally similar to terrestrial landing behavior for both species, with *A. montanus* exhibiting delayed limb recovery and *B. orientalis* exhibiting mid−flight limb recovery regardless of context.

105.6 MIDDLEBROOKS, ML*; CURTIS, NE; SCHWARTZ, JA; PIERCE, SK; University of Tampa; University of South Florida, Rollins College, University of South Florida, University of South Florida; *mmiddlebrooks@ut.edu*

Algal chloroplast source modifies the duration of photosynthesis of kleptoplastic sea slugs

Many species of sacoglossan sea slugs are kleptoplastic, the ability to sequester photosynthetically able chloroplasts, taken up from food algae, inside certain digesive cells. Photosynthetic activity provides these slugs with an alternative energy source and may reduce their dependency on continual feeding during times of famine. Many kleptoplastic species are monophagous, feeding on only one species on algae. Other species, such as *Elysia clarki*, can feed on multiple algal species. Here we examine the effects of algal diet on the photosynthetic ability of *E. clarki* using pulse amplitude modulation fluorometry (PAM) over an increasing period of starvation, ranging from 0 to 12 weeks. Initially there was no detectable difference in photosynthetic activity between slugs fed different diets; however slugs fed a diet of *Penicillus lamourouxii* were able to maintain photosynthetic activity for 4 weeks longer than slugs fed a diet of *Bryopsis plumosa*. Additionally, two other sacoglossan species, *E. patina* and *Placida kingstoni* with lesser photosynthetic ability were compared with *E. clarki*, which feed on the same algal species. The results suggest that slug adaptation rather than algal donor determine the photosynthetic longevity of the plastid.

P3.81 MILBERGUE, M.*; CORTES, P.A.; BLIER, P.; VEZINA, F.; Univ. du Quebec à Rimouski, CEN, BOREAS, CSBQ; *myriam.milbergue@live.fr*

Does thyroid hormone T3 correlate with maximal thermogenic capacity in small passerines wintering at northern latitudes?

In small passerine birds wintering in cold climates, maintenance of body temperature is achieved through physiological adjustments leading to improvement of heat production capacity. Cold acclimatization is associated with an increase in metabolic performance where basal metabolic rate (BMR) and maximal thermogenic capacity (Msum) are elevated during the cold season. Changes in these parameters are often interpreted as reflecting changes in mass or activity of internal organs. However, variation in organ mass only explains part of the variability in metabolic performance, likely because animals can also modulate tissue metabolic intensity. Thyroid hormone triiodothyroxine (T3) is known to increase in response to cold temperatures and to stimulate basal thermogenesis in birds, which suggest that basal levels of heat production may be modulated in response to cold. However, the potential effect of T3 on maximal thermogenic capacity is unknown. We studied a free−living population of black−capped chickadees (*Poecile atricapillus*) where more than 100 birds were captured several times over a complete winter to measure their BMR, Msum and plasma T3 levels. Samples are currently being processed. We are expecting positive correlations between T3 levels and both BMR and Msum at the level of the population and within individuals.

1.5 MILES, D.B.; Ohio University; *urosaurus@gmail.com*

Variation in thermal sensitivity of sprint speed, thermal behavior and evaporative water loss

Recent studies have highlighted the susceptibility of ectotherms to altered thermal niches arising through climate warming. Determining the projected responses of a species to climate warming requires data on the thermal tolerance of a species, variation in body temperature, preferred temperature and sensitivity of physiological performance to temperature. I estimated CTmin, CTmax, Tpref, and the thermal performance curve for sprint speed for two populations of *Urosaurus ornatus* that differed in substrate preferences and elevation. I sampled lizards at Saguaro National Park, AZ (elev. 870m) and Sevilleta National Wildlife Refuge, NM (elev. 1780). I also deployed dataloggers to characterize the operative thermal environment at each location. The thermal landscape was warmer at the low elevation site with temperatures exceeding CTmax between 2 − 6 hr per day during the summer. Te rarely exceeded CTmax at Sevilleta. Despite a difference in the thermal environment lizard populations exhibited similar values for CTmin and CTmax. However, I observed a 1&degC shift in Tpref for the Saguaro population between 1998 and 2013. The shape of the performance curves were generally similar, but lizards from Saguaro had faster speeds at warmer temperatures. These results suggest that *U. ornatus* may be buffered from climate warming. However additional data from other populations at other elevations and latitudes are necessary for ascertaining the potential to adapt to a warmer environment.

P2.131 MILLAN−HERNANDEZ, CA*; BURNETT, KG; BURNETT, LE; College of Charleston; *c_millan.01@hotmail.com*

Effects of environmental hypoxia and elevated CO_2 on the hemocyanin oxygen binding properties of the Atlantic mud crab, Panopeus herbstii

The changes in hemocyanin (Hc) O_2 binding properties with exposure to chronic environmental hypoxia and hypercapnia were investigated in the Atlantic mud crab. Crabs (mean wt. 5.31 g) were exposed to one of four treatments for 2 weeks: normoxia (>80% air saturation), hypoxia (20% air saturation), hypercapnia (2% CO_2, > 80% air saturation), and hypercapnic hypoxia (2% CO_2, 20% air saturation). Hemocyanin concentration in crabs freshly collected from the field was 5.9 g/100 mL ±0.6 SEM, N = 29; this did not change as a result of treatment. Hc of normoxic controls displayed a Bohr shift with a slope of −0.51 and a P_{50} of 1.47 kPa at pH 7.4. Hypoxia did not change the size of the Bohr shift, but resulted in an overall increase in O_2 affinity (P_{50} = 1.29 kPa, pH 7.4). The addition of CO_2 resulted in a larger Bohr shift (−0.66) compared to the normoxic control. Treatment with a combination of hypoxia and CO_2 also increased the Bohr shift (−0.61) compared with its hypoxia control (−0.47). Neither CO_2 treatment increased the O_2 affinity. The interaction between the O_2 binding sites on Hc, cooperativity (=n_{50}), was not influenced significantly by pH in normoxia and hypoxia with the mean n_{50} of 3.2 at pH 7.4. n_{50} decreased with pH in the two CO_2 treatments and was 2.9 at pH 7.4 in both treatments. There was a small effect of lactate in the normoxia treatment (−0.07 = Δlog P_{50}/Δlog [lactate]) at pH 7.4 and there was no significant change with any treatment. Hc was insensitive to urate. *P. herbstii* Hc O_2 affinity clearly increased as a result of chronic treatment with hypoxia. However, environmental CO_2 canceled the adaptive benefits of the hypoxia treatment, especially at low pH. (NSF DBI−1062990, IOS−1147008)

41.4 MILLER, L. A.*; FOVARGUE, L.; University of North Carolina at Chapel Hill, Rensselaer Polytechnic Institute ; *lam9@unc.edu*

Fluid scaling effects near the ctenes of ctenophores

A distinctive feature of the phylum Ctenophora are their comb plates or ctenes. The ctenes are groups of cilia that are fused at their base to form plates and are used to direct flow for swimming and feeding. An interesting fluid dynamic feature is that the ctenes operate at Reynolds numbers on the order of 10. Unlike other ciliary forms of locomotion, ctene driven flows have significant inertia. In this presentation, flow around the ctenophore *Mnemiopsis macrydi* is quantified using particle image velocimetry. The bulk flow generated by the eight rows of comb plates and the flows generated near the ctenes themselves are measured. The spatially and temporally reconstructed flow fields are then used to validate two− and three−dimensional direct numerical simulations of the fluid. These simulations are performed using an adaptive version of the immersed boundary method, IBAMR, to solve the fully−coupled fluid structure interaction problem. The effects of Reynolds number and ctene flexibility on the formation of vortices and the amount of fluid transport generated are quantified.

129.4 MILLER, TC*; WEN, L; CHIU, J; SHI, YS; Eunice Kennedy Shriver National Institute of Child Health and Human Development; *millertc@mail.nih.gov*

Thyroid hormone driving larval cells Mad: the role of c−Myc gene family in intestinal stem cell development

During *Xenopus (X.) laevis* metamorphosis, a remodeling of the larval intestinal epithelium occurs which is analogous the maturation of the mammalian intestine from birth to weaning. Thyroid hormone (TH) is critical for the formation of adult epithelium in the intestine for both mammals and amphibians but the tadpole provides an opportunity to examine the molecular mechanisms of TH action independent of maternal influences. Genome−wide analysis of *X. laevis* revealed the Max dimerization protein 1 gene that encodes for the Mad protein, a bHLH/Zip transcription factor that competes with cMyc to heterodimerize with Max, was upregulated in the intestinal epithelium during stem cell formation. Previous studies have shown that Mad/Max dimers inhibit transcription leading to differentiation while cMyc/Max binding induces proliferation. qPCR of tissue specific Mad expression confirmed epithelial specific induction during metamorphosis and demonstrated that in both naturally and TH induced metamorphosing intestines, there is strong induction of Mad just prior to cMyc expression and adult stem cell formation. *In situ* hybridization and immunohistochemical analyses revealed high levels of Mad expression in apoptotic larval cells while cMyc expression is localized in newly forming adult stem cells. Our findings indicate TH induced Mad plays a novel role of initiating or enhancing apoptosis in the maturing intestine, which was further supported by high levels of Mad in other apoptotic tissue. Consequent examination of Mad expression during mouse intestinal development showed transcript levels peaking at birth, further suggesting conservation of function in mammals. Thus, cMyc/Mad balance is likely critical for cell fate determination during TH−dependent, postembryonic adult stem cell development.

P3.33 MILLER, B.D.*; TAMONE, S.L.; Georgia Southern University, University of Alaska Southeast; *bm03548@georgiasouthern.edu*

The Effect of Eyestalk−Ablation on Ecdysteroids and Vitellogenins in Three Sexual Stages of the Spot Prawn (Pandalus platyceros)

The objective of this project was to investigate the role of eyestalk neurohormones in the regulation of molting and reproductive physiology of the spot prawn *Pandalus platyceros*. The molting hormone, ecdysone and the egg yolk precursor protein vitellogenin were measured using an ELISA and SDS−PAGE respectively. Hemolymph concentrations were compared between male, female, and transitional shrimp. Hemolymph from 9 transitional, 19 male, and 14 female prawns was sampled to determine baseline ecdysone and vitellogenin concentrations. Transitional shrimp had significantly higher ecdysone concentrations (172.2 ± 49.9 ng/ml) than males (10.7 ± 4.25 ng/ml) and females (39.8 ± 19.8 ng/ml). Protein bands associated with vitellogenin in female and transitional shrimp hemolymph were significantly denser (indicating higher concentrations) than those measured in male hemolymph. Concentrations of ecdysone and vitellogenin in male and female spot prawns in response to eyestalk−ablation (EA) were also examined. Hemolymph was sampled one day before and one week after EA and analyzed for ecdysteroids and vitellogenin. All transitional shrimp molted prior to the EA experiment so there were no transitional shrimp for the EA experiment. Eyestalk−ablation resulted in significantly higher circulating ecdysteroids in males (n=5; P<0.003) when compared to sham−operated controls demonstrating that the molt−inhibiting hormone regulates secretion of ecdysteroids from the y−organ. Females did not respond to EA (n=4; P=0.08). Eyestalk−ablation did not result in significant changes in male and female vitellogenin levels. This research provides further information concerning molting biology of these shrimp.

86.3 MILLER, A.W.*; DEARING, M.D.; University of Utah; *aaron.w.miller@utah.edu*

Toxin Degradation is a Community Effort in the Gut Microbiota of Mammalian Herbivores

Mammalian herbivores are routinely faced with toxic challenges resulting from the regular consumption of plant secondary compounds (PSCs) in their diet. The PSC oxalate is widely produced by plants and can have significant physiological consequences e.g., kidney stones. Oxalate−degrading bacteria (ODB) in the gut microbiota of mammals metabolize oxalate thereby decreasing absorption by the host. We expanded upon our understanding of the role that gut microbes play with respect to oxalate degradation using a mammalian herbivore, the white−throated woodrat (*Neotoma albigula*), which naturally consumes a diet rich in oxalate. We inventoried the distribution of ODB along the gastrointestinal tract, isolated bacteria from each of the chambers, and assayed in vitro oxalate−degrading efficiencies. Finally, we transferred the gut microbiota into hyperoxaluric Sprague−Dawley rats and quantified the change in oxalate excreted in the feces and urine. We found that ODB were primarily concentrated in the foregut, which is where oxalate concentration is greatest. ODB were dominated by the genus Lactobacillus, but rare taxa were distributed throughout the gastrointestinal tract. Oxalate−degrading efficiencies of isolates ranged from 18.4−40.3% over 48 hours. Dietary oxalate degradation in *N. albigula* exceeded 90% across variable oxalate loads. Transfer of the microbiota from *N. albigula* to lab rats significantly increased dietary oxalate degradation from 17% to 52%. The results demonstrate that toxin degradation by the gut microbiota is facilitated by consortia of bacteria distributed differentially throughout the gut, which can be transferred between hosts to introduce the toxin degrading function.

64.1 MILLER, LP*; ALLEN, BJ; DENNY, MW; Hopkins Marine Station, Stanford University, California State University, Long Beach; *millerlp@gmail.com*

Changing environmental variability in a changing climate: the effects of thermal variation on growth rates and energy flow through an intertidal community

Increasing average air and sea temperatures have the potential to drive great changes in populations and communities, but global circulation models also predict substantial changes in temperature variability through time. Unfortunately, our current knowledge about the effects of increasing climatic variation on natural ecosystems is generally quite poor. In highly productive rocky intertidal communities, increasing temperature variability, particularly during low tide, has the potential to strongly impact the survival and productivity of many species at different trophic levels, particularly those already living near their thermal tolerance limits. At our central California field site, we implemented a set of field experiments to manipulate low tide temperature variability for a suite of microalgal and herbivorous grazing limpet species. By manipulating the thermal conductance between experimental plates and the rock surface, we altered the daily temperature range of a microhabitat without significantly affecting mean temperatures. High thermal variability treatments experienced more frequent and more intense heat stress events, similar to what is predicted in global circulation models. Coupled with intensive sampling of microhabitat thermal conditions and estimates of energetic costs for limpets under varying temperature conditions, we show that an increasing frequency of high temperature events, even without increases in average temperature, could negatively impact the growth of microalgae and limpet species, but that effects also differ with species identity.

P1.162 MILLER, AL*; MAKOWSKY, RA; COX, CL; FORMANOWICZ, DR; University of Tampa, University of Texas at Arlington, University of Virginia; *abraham.miller@ut.edu*

Phylogeography and ecological niche modeling of the wide−ranging scorpions species, Paruroctonus boreus, in the western US

Phylogeographic studies in western North America have revealed how a varied topography across the landscape coupled with historic climatic fluctuations can shape the genetic diversity within a species, create genetically isolated populations and affect dispersal and range expansion. Generally, the phylogenetics of taxa in the region are molded to varying degrees by both vicariance and dispersal. However, the influence of historical fluctuations in the climate is not well understood. The recent availability of historical climate data and the use of ecological niche modeling allowed us to more fully address the processes that have shaped the genetic diversity observed in a species. We modeled the distribution of a wide−ranging but poorly known vaejovid scorpion, *Paruroctonus boreus*, under current climatic conditions and two historic climatic conditions. We tested how historical distributions could shape the phylogeographic diversity in a species across a landscape with dynamic topography. We thoroughly sampled across the geographic range using ample sampling of mitochondrial DNA, and used maximum parsimony, maximum likelihood, and Bayesian Inference to reconstruct the phylogenetic relationships. Our findings show P. boreus has complex genetic relationships among populations, likely created by sequential range expansion and contraction with population isolation and contact brought about by historical climatic fluctuations. Our findings demonstrate how historical climatic variation can potentially create cryptic biodiversity and complex genetic relationships in a wide−ranging species that exhibits altitudinal restrictions.

85.2 MISCHIATI, M.*; LIN, H.; SIWANOWICZ, I.; LEONARDO, A.; HHMI Janelia Farm Research Campus; *mischiatim@janelia.hhmi.org*

Active head control and its role in steering during dragonfly interception flights

During high−speed interception flights, dragonflies make continuous head movements. These movements are hypothesized to hold prey foveated in a high acuity zone of the dorsal eye, and drift in foveation is thought to reflect unexpected prey movement and signal a need for steering (Olberg et al., 2007). However, drift in foveation is not merely a function of prey movement; instead, it also depends on the dragonfly's own body and head rotation, and on the dragonfly's movement relative to the prey. To investigate the effect of these factors on the quality of foveation, and the implications for steering control, we measured for the first time the full 3D head and body kinematics of the dragonfly *Libellula Lydia*, while it pursued actuated artificial prey. We found that prey were actively stabilized in the dorsal fovea by head rotations (RMS drift 5° in head coordinates, vs. 13° in body coordinates). Prey movement also drove changes in the dragonfly's interception course, except during the initial post−takeoff maneuver that the dragonfly performed to gradually orient its bearing towards the prey. Surprisingly, the dominant disturbance to foveation came from the dragonfly's own wing−stroke induced body oscillation. All self−induced drifts in foveation by rotation or translation of the dragonfly's body were actively damped with counter−phased head rotations that had virtually zero delay to the disturbance itself, suggesting a predictive or proprioceptive driving mechanism. Active head control thus ensures that the visual system only experiences significant prey drift when large and unexpected prey steering occurs. This implies that visual feedback is integrated with other mechanisms that maintain the interception course when the prey is not maneuvering.

P3.151 MISTICK, E.A.*; KLAASSENVANOORSCHOT, B; TOBALSKE, B.W.; Harvard University, University of Montana; *emilymistick@college.harvard.edu*

Aerodynamics of Morphing Wings in Flapping and Gliding Flight

Birds are capable of continuously altering the size and shape of their wings. This changing morphology is hypothesized to alter aerodynamic performance (i.e. maximum force production and/or efficiency, defined as lift:drag ratio) across flight modes such as steady flapping, gliding, and takeoff. We examined the differences between swept and extended wings in flapping and gliding flight for ten different raptor species in the orders Accipitriformes, Strigiformes, and Falconiformes. Wings were dried in swept and extended configurations, then held fixed in a wind tunnel at 14.1 m/s to simulate gliding flight and spun on a propeller at *in vivo* angular velocities to simulate mid−downstroke flapping flight during takeoff. Vertical and horizontal force production was measured for each wing through a range of angles of attack. We found that (1) extended wings produce more vertical and less horizontal force per unit area (higher L:D) than swept wings in flapping takeoff flight, and (2) swept wings outperform extended wings in gliding flight at attack angles above ~20 degrees. These results suggest the presence of leading edge vortex (LEV) formation on the swept wings in gliding flight, and also bring into question current thoughts regarding the importance of emarginated primary feathers in breaking up costly wing−tip vortices. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE−0809127 and DGE−1313190 and by the Herchel Smith Harvard Undergraduate Science Research Program.

1.4 MITCHELL, A*; BERGMANN, P; Clark University; *AlMitchell@clarku.edu*

The Effects of Environmental Temperature and Moisture on Temperature and Moisture Preferences in Green Frogs (Lithobates clamitans)

Environmental temperature and moisture play an integral role in determining body temperature and hydration state in amphibians. Amphibians try to select the environments with the optimal combination of temperature and moisture to perform tasks such as digestion and locomotion. The preferred temperature and moisture levels of amphibians under differing conditions can provide us with an understanding of how the interactive effects of the environmental temperature and moisture affect amphibians. This study assesses the influence of temperature and moisture interactions on green frog (*Lithobates clamitans*) environmental preferences by comparing data collected from manipulated thermal and moisture gradient experiments with data collected from the field. In general, frogs tended to select thermal and moisture conditions that minimize evaporative water loss through the skin. Under lab conditions, green frogs preferred wetter and colder environments when dehydrated, and only preferred warmer environments when they could meet moisture requirements. In the field, green frogs rarely strayed from standing bodies of water, even while basking, and did not experience dehydration below 95% of standard mass.

P2.135 MITCHELL, RT*; HENRY, RP; Auburn University; *rzm0015@auburn.edu*

Functional Evidence for Neuroendocrine Regulation of Carbonic Anhydrase in the blue crab Callinectes sapidus

Cytoplasmic Carbonic anhydrase(CA) has long been known to be an essential component of osmoregulation in euryhaline crustaceans, including the green crab *Carcinus maenas* and the blue crab *Callinectes sapidus*. Recent evidence in *C. maenas* suggests that CA is under inhibitory control by a peptide hormone located in the x−organ sinus gland complex (XOSG). This hormone is released from the XOSG in animals acclimated to full−strength seawater, and is subsequently downregulated following low salinity acclimation, allowing for CA induction to support branchial ionic uptake. In this study we take the first steps in determining if a similar system is in place in *C. sapidus*. Crabs were treated with eyestalk ligation (ESL), which resulted in a 1.8−fold increase in CA activity in the posterior ion−regulating gills. This was accompanied by a 100−fold and 3−fold increase in cytoplasmic CA (CAc) and Na+/K+−ATPase expression, respectively. ESL failed to potentiate CA induction in crabs transferred from 35−15 ppt, however it did increase CAc mRNA by 5−fold. Injection of ESL crabs with eyestalk homogenate abolished the effects of ESL, suggesting that there is an endocrine substance in the *C. sapidus* eyestalk that inhibits CA activity and expression

P2.77 MITCHELL, TS*; WARNER, DA; JANZEN, FJ; Iowa State University, University of Alabama at Birmingham; *timmitch@iastate.edu*

The influence of nest−site choice and nest temperature on hatchling painted turtle survival during hibernation

Many animals are exposed to wide temperature ranges and have behaviorally or physiologically adapted to survive thermal extremes. Yet thermal extremes can still be a major source of mortality and strong selective pressure in many natural populations. Hatchlings of many species of temperate turtles delay emergence from their nest until spring, thus spending their first winter in the maternally−selected, terrestrial nest where they are exposed to subzero temperatures. The mother turtle may be able to influence overwinter environmental conditions in the nest by selecting nest sites with particular attributes, thus ensuring her offspring avoid lethal conditions. We conducted an 8−year study of the hibernation ecology of painted turtles (*Chrysemys picta*) in western Illinois. Each year we measured vegetation cover above the nest at oviposition, and subsequently monitored nest temperature and hatchling survival over winter. Our study addresses two questions: 1) Does maternal nest−site choice in summer typically influence environmental conditions within the nest over winter? 2) What is the relationship between overwinter nest temperature and hatchling survival in the wild? Our results suggest nest−site choice at oviposition does not influence nest environmental conditions during winter in most years and is therefore unlikely to be under strong selection during this stage. Minimum nest temperature was a strong predictor of hatchling survival over winter suggesting that hatchlings in natural nests are frequently exposed to lethal temperatures. There is likely strong selection in some years on physiological traits that allow hatchlings to tolerate or avoid freezing.

56.1 MIYASHITA, T.*; PALMER, A. R.; University of Alberta; *tetsuto@ualberta.ca*

The cranial anatomy of living jawless fishes and the interrelationships of early vertebrates

No other structure better characterizes vertebrates than the head, with its massive skull, highly specialized muscles, and intricate innervations by cranial nerves. Did the first vertebrate possess all of those traits, or did early vertebrates acquire them in steps? Answers may lie in the basal grade of jawless vertebrates. Based on dissections, a histological analysis, and micro−CT imaging of cartilages, muscles, and nerves in hagfish and lampreys, we demonstrate that the biomechanics of the jawless vertebrate head differs from that of jawed vertebrates in two distinct ways: linear muscle antagonism and elastic recoiling of the skeleton. Homologues in the cranial musculature of hagfish and lampreys are established at more than one level of organization. That is, a group of muscles may withstand a test of homology, but individual muscles may or may not be compared. To highlight examples, we emphasize the muscle groups controlled by the trigeminal and facial nerves. After incorporating the nested patterns of homologues in coding of the characters, the cranial musculature neither supports nor rejects the hypothesis that hagfish and lampreys are each other's sister group. The solution to this problem lies in identifying possible correlates of the cranial muscles in fossil jawless vertebrate lineages. A phylogenetic bracket approach potentially changes the basal vertebrate phylogeny from the modern view of successive acquisition of gnathostome−like characteristics to a highly divergent, mosaic pattern of character evolution among the lineages.

31.4 MODI, C.K.*; CHANDLER, C.; MATZ, M.V.; The University of Texas at Austin, University of Michigan; *Chintan.Modi@utexas.edu*

Evolution takes baby steps: The mutational trajectory of the emergence of red fluorescence in coral fluorescent proteins

Epistatically interacting amino acids are hypothesized to be instrumental in the evolution of the structure−function relationship of many proteins. Our previous analysis of resurrected ancestral proteins identified 12 epistatically interacting historical mutations associated with the evolution of the complex autocatalytic pathway leading to red fluorescence in coral fluorescent proteins (FPs). How have such extensive combinations been assembled through natural selection? The goal of the present study was to determine the minimal set of historical mutations that led to the first appearance of detectable red fluorescence from the ancestral green state. By examining the effects of individual mutations and their combinations in the green−fluorescent ancestral FP we found that just three point mutations are sufficient to initiate red fluorescence evolution: one in the chromophore−forming tripeptide, another in its immediate vicinity, and the third in a cluster of C−terminal residues, reducing the protein's oligomerization tendency. Notably, two of these three mutations had a significant destabilizing effect on the protein, as evidenced by its reduced thermostability. Comparison of the mutants with the ancestral and extant FPs (a vertical phylogenetically based comparative method) allowed detection of the small effects of epistatically interacting residues on the initial evolutionary trajectories toward increased molecular complexity and novel molecular function. Our observations support the theory that evolution of even the most complex epistatic interactions could be initiated by few and therefore relatively probable mutations, and also highlights the need for destabilization of the ancestral structure to enable the evolution of novelty.

86.5 MOH, A.P.*; THONGSRIPONG, P.; BENNETT, S.N.; Virginia Tech, California Academy of Sciences; *annapm@vt.edu*

Dengue Adaptive Evolution: Measuring the Function of Natural Diversity in an Emerging Virus

Dengue is a tropical to sub−tropical viral disease transmitted through mosquitoes to humans and other primates. The dengue virus is classified as a flavivirus, a fast−evolving RNA virus that relies on an arthropod vector to disperse and transmit itself. There are four serotypes of dengue virus that co−circulate seasonally in many populations, in some years causing intense epidemics. Understanding the evolutionary mechanisms or reasons why some dengue viruses have greater epidemic propensities than others has become imperative in epidemiological and ecological studies of the virus. This study pits pairs of dengue viruses against each other in cell culture to determine their fitness differences in terms of replication rates as a representation of epidemic potential. Strains of dengue viruses from Puerto Rico during the large 1998 epidemic and an earlier lineage from a mild transmission year, 1994, were used to infect mosquito and vertebrate cell lines. In each of three replicates, a 1994 strain was paired with a 1998 strain in the same culture, and the relative dominance of one strain over another was determined. The results of this study reflect viral levels in both co−infections and single infections of the cell lines over seven days using qPCR probes to differentiate between the strains. These findings indicate higher initial levels of the 1994 strain, which appear contrary to the apparent dominance of the 1998 strain's epidemic spread. The results may only apply to the initial incubation period of the virus, and not necessarily viral levels throughout longer periods of infection. It is likewise possible that the 1994 strain is over−virulent, and therefore prevented its own spread.

119.7 MONAENKOVA, D.*; GRAVISH, N.; GOODISMAN, M.A.D.; GOLDMAN, D.I.; Georgia Institute of Technology, School of Physics, Georgia Institute of Technology, School of Biology; *dmonaen@physics.gatech.edu*

Pellet formation and transport by fire ants

The red imported fire ant, *Solenopsis invicta*, builds deep nests underground which house thousands of individuals. Nest construction for fire ants is a complex process consisting of soil excavation and transport from the nest depths to the surface through a network of self−excavated narrow tunnels. Thus, nest builders confront a dilemma. Rapid nest construction requires the excavation of large soil pellets. However, heavy traffic within naturally confined spaces favors formation of small pellets. We studied the strategy used by fire ants to construct nests in soils that differed in moisture content, which can influence pellet integrity during formation and transit through the nest. In our experiment 30 ants were isolated in a transparent plastic container filled with wet simulated soil (0.25 mm glass beads). The soil moisture content W was prepared to W=0.01 or W=0.1 by mass. Tunnel construction occurred along the transparent container walls and was recorded with a high speed camera in order to determine the number of grains carried by ants, ant mobility and social interactions between individuals. Our observations revealed that ants used mandibles, limbs and antennae in a stereotyped excavation behavior to remove, form, and transport soil pellets. Surprisingly, W had no significant effect on the average pellet size ($p = 0.078$). Although some ants were capable of carrying up to 22 grains, the mean pellet was composed of 6 ± 2 grains in both W treatments (N= 320 observations at W=0.01 and N=524 observations at W=0.1). We hypothesize that the preferred pellet size is not determined by soil cohesion but instead is engineered for transport in the confined and crowded conditions.

11.5 MONTOOTH, KL*; HOEKSTRA, LA; SIDDIQ, MA; Indiana University, Bloomington; *montooth@indiana.edu*

The thermal environment modifies mitochondrial−nuclear effects on insect metabolic performance and plasticity

Given that interactions between mitochondrial and nuclear genomes underlie energetic performance in eukaryotes, we expect that the effects of many mitochondrial mutations will be conditional on variation in the nuclear genome. In ectotherms, the effects of these mitochondrial−nuclear interactions are likely to depend upon the thermal environment, because temperature accelerates rates of biological processes and can increase demands on ATP pools. We have found that a mitochondrial−nuclear incompatibility between single nucleotide polymorphisms in a mitochondrial tRNA and its nuclear−encoded tRNA synthetase severely affects fitness via compromised mitochondrial protein translation in *Drosophila* (Meiklejohn et al. 2013 PLoS Genetics 9:e1003238). Here I present data showing that the deleterious effects of this interaction on development time, pupation height and reproduction − traits that are associated with energetic state − are ameliorated when larvae develop at 16°C and exacerbated at warmer temperatures, leading to complete sterility at 28°C. The incompatible genotype has a normal metabolic rate at 16°C but a significantly elevated rate at 25°C, consistent with the hypothesis that inefficient metabolism extends development in this genotype at warmer temperatures. Furthermore, the incompatibility decreases metabolic plasticity of larvae developed at 16°C, indicating that cooler temperatures do not completely mitigate the deleterious effects of this interaction. The expression of genetic interactions in some environments, but not others, weakens the efficacy of selection in removing deleterious epistatic variants from populations and may promote the accumulation of incompatibilities whose fitness effects will depend upon the environment in which hybrids occur.

30.3 MOORE, I T; Virginia Tech; *itmoore@vt.edu*

The biogeography of endocrinology

Natural historians have long known of the latitudinal variation in clutch size with tropical vertebrates laying fewer eggs and having smaller litters than higher latitude species. More recently, physiologists have described latitudinal variation in a variety of processes that suggest tropical species exhibit a slower pace of life than higher latitude species. Fortunately, enough environmental endocrinology studies have been performed that we can now look for broader endocrine patterns across species and habitats in a similar way that natural historians have investigated biogeographical patterns. Such patterns could serve to elucidate the how selection favors certain endocrine phenotypes. One prominent example has been the description of a positive relationship between testosterone and latitude in birds with tropical species typically having lower levels than higher latitude species. Similarly, a positive relationship between corticosterone and latitude has also been described in birds. In amphibians, testosterone and corticosterone are both positively related to latitude. Further, for both amphibians and reptiles, testosterone levels are negatively related to breeding season length. Thus, it appears that similar relationships between the hormones and geography do exist in a variety of taxa, suggesting that environmental factors may be a stronger determinant of hormone levels. As environmental factors also determine life history characteristics, it is likely that selection favoring certain life history traits also favors particular hormonal mechanisms and this is why we see relationships between geography, natural history, and endocrine mechanisms.

110.1 MOORE, TY*; VASUDEVAN, R; BIEWENER, AA; Concord Field Station, Harvard University, Massachusetts Institute of Technology; *talia@oeb.harvard.edu*

Measuring locomotor entropy to compare predator evasion ability in sympatric desert rodents

Both bipedal and quadrupedal rodents are native to Old World deserts. Despite divergent locomotion, they have overlapping food sources, predators, and activity period. While the quadrupedal rodents use largely 2−dimensional (horizontal) trajectories similar to other quadrupeds, the bipedal rodents (Jerboas of the family Dipodidae) use a diverse set of jumps, hops, and skips to move with erratic trajectories in 3 dimensions. These two "locotypes" have spatially partitioned their resources to limit competition and maintain sympatry, with bipeds foraging in open spaces far from burrows and quadrupeds in shrubs near burrows. We hypothesize that this spatial partitioning is made possible by the high predator evasion ability of the bipedal animals resulting from their more erratic 3D trajectories. To test this, we collected trajectories of bipedal jerboas (*A. elater, D. sagitta*) and sympatric quadrupedal jirds (*M. meridianus*) in the field and quantified the predictability of escape behavior of these species species in natural conditions by measuring the entropy of their locomotor motifs. We found that bipedal trajectories had significantly higher entropy than quadrupedal trajectories, making them less predictable. Rather than focusing on the extremes of animal locomotion, understanding how behavior is exhibited in nature can reveal locomotor adaptation to selective pressures, in this case allowing us to explain how these bipedal and quadrupedal desert rodents successfully live in sympatry.

130.7 MOORE, J. M.*; NISHI, E.; ROUSE, G. W.; Florida Museum of Natural History, University of Florida, Yokohama National University, Japan, Scripps Inst. of Oceanography, Univ. of California San Diego; *jmoore@ufl.edu*

Phylogeny of Chaetopteridae (Annelida)

Chaetopteridae is a globally distributed clade of polychaetes in need of thorough systematic revision. Most chaetopterids live in straight tubes in marine sediments and use a pair of long palps for suspension or deposit feeding. However, *Chaetopterus* sp. are well known for showing extremely specialized mucus−bag suspension feeding, and *Chaetopterus cf. variopedatus* is used as model organism, though the species delineation is very uncertain in this genus. The current taxonomy of Chaetopteridae recognizes four genera: *Phyllochaetopterus, Spiochaetopterus*, *Mesochaetopterus*, and *Chaetopterus*. In order to assess the relationships among chaetopterids, we constructed a phylogenetic hypothesis using a morphological dataset for 65 nominal species and DNA sequence data for 23 morphospecies, with representatives from the four accepted genera. Forty−four characters were developed using morphology and were mainly scored from the literature. For the DNA data, multiple specimens per morphological species were included to assess cryptic diversity. Specimens were collected from French Polynesia, Hawaii, Japan, Australia, Spain, Greenland, Antarctica, and both coasts of the United States. Several deep Pacific species were also included in the analysis. COI mitochondrial DNA, 18S nuclear DNA, and 28S ribosomal RNA were sequenced. Combined and individual datasets were used to build phylogenies using maximum parsimony and maximum likelihood approaches. The results consistently revealed extensive paraphyly in *Spiochaetopterus* and *Phyllochaetopterus. Chaetopterus* forms a clade nested within the *Mesochaetopterus* grade. There is cryptic diversity in several Indo−West Pacific morphospecies, and evidence for restricted geographic ranges in several nominal species unrecognized by past systematists.

30.1 MOORE, MC; Univ. of Delaware, Newark; *mcmoore@udel.edu*
The Inception of Field Endocrinology
Today Field Endocrinology, or Ecological Endocrinology as it is now more commonly known, is a well−established, vibrant discipline. This integrative discipline was pioneered by John Wingfield in the 1970's. This talk will take an anecdotal approach to reviewing the challenges and obstacles that had to be overcome to launch this new, integrative discipline in the early years. What arguments were advanced against this approach? How was this new discipline received, especially in the emerging climate of reductionistic, molecular biology of the 1970's? How did the field overcome the "falling between the cracks" problem faced by any integrative approach? Initially the approach was rooted in the paradigms of laboratory endocrinology. When did it switch to an approach more centered on field biology and begin to define its own questions? What personalities played key roles in shaping the directions of this new field? What seminal papers defined the directions of the field?

120.5 MOORE, BC*; GUILLETTE, LJ; Louisiana Tech University, Ruston, Medical University of South Carolina, Charleston; *bmoore@latech.edu*
Histological Investigation of the Adult Male American Alligator Phallus
Alligators are seasonal breeders with a courtship and breeding period occurring in April and May concurrent with a peak in circulating testosterone. However, the specific mechanics of the reproductive act are not fully understood. To address this question, we collected adult male phalli from animals captured at Merritt Island National Wildlife Refuge, Florida in April 2010 for paraffin histology analysis. Investigation of the collagen fiber architecture of the phalli using picrosirius red staining with circularly polarized light revealed pronounced structural differences in fiber thickness distribution and orientation between the shaft, cuff/glans, and distal tip. The morphology of the semen−conducting sulcus spermaticus displayed greater elaboration and convolution of its secretory epithelium, as compared to a previous investigation of the sulcus of immature male phalli. Further, pronounced muscle bundles lining the length of the sulcus speak to an ejaculatory function. Histochemical staining revealed a complex, mucin−rich glandular epithelium covering various regions of the phallus with numerous, differing adjacent cell types. The cuff and proximal tip of the phallus show evidence of an inflation function with an elaborate sinus defined by vascularized connective tissues. These and other morphological observations will be discussed in the context of a more comprehensive understanding of functional intromission and insemination.

63.2 MOORE, C.D*; FAHLMAN, A.; MOORE, M.J.; WILLOUGHBY, D.; ROBBINS, K.; TRUMBLE, S.J.; Baylor University, Texas A&M University, Woods Hole Oceanographic Institution; *colby_moore@baylor.edu*
Significance of Muscle Fiber Type in Biopsied Elephant Seals
Northern elephant seals (*Mirounga angustirostris*) are known to be elite deep divers, often thought to exceed the aerobic dive limit (ADL), a threshold utilized to measure the point at which depletion of oxygen and thus shift to anaerobic pathways of metabolism occur during a dive. It was found that most pinniped dives are within this ADL, and thus aerobic. Diving physiology often thought to reinforce the ADL are lung compression, bradycardia and peripheral vasoconstriction, among others. There are little data pertaining to fiber type ratios of diving mammal locomotory muscles. Research suggests an absence of Type IIb muscle fibers in pinniped locomotory musculature. In this study, Northern elephant seals were biopsied in the wild and succinate dehydrogenase (SDH) based fiber typing revealed the predominance of one fiber type in the *longissimus dorsi* (LD) muscle of elephant seals: Type I. Type IIb muscle fibers appeared to be absent altogether. Previously, any lack of Type II fibers has been attributed to the increased reliance on aerobic−based metabolism during dives, lower overall metabolic rate, and maintenance of low energy locomotion. Here, we concurred with previous findings, suggestive of our finding of large fiber diameters and elevated myoglobin concentrations, but further suggested the lack of Type IIb fibers, specifically, may provide a cautionary explanation for the apparent avoidance for ischemia reperfusion injury in vasoconstricted peripheral skeletal muscle during a dive.

105.5 MOORE, SR*; MOSEMAN−VALTIERRA, SM; GOVENAR, B; Rhode Island College, Univ. of Rhode Island; *smoore_6564@email.ric.edu*
Identifying gut microbiota in ribbed mussels with next−generation sequencing
Salt marshes have been considered as sinks for greenhouse gas emissions, but under conditions of climate change, may instead act as sources of carbon dioxide, methane, and nitrous oxide. As part of a larger project to understand the shifts in trophic dynamics and greenhouse gas fluxes that result from elevated temperatures and nutrient levels in estuaries, we are investigating the composition of bacteria and archaea in the gut contents of the dominant benthic invertebrate, the ribbed mussel *Geukensia demissa*, in coastal salt marshes, along the historic nitrogen−loading gradient in Narragansett Bay, Rhode Island. In 2012, we collected mussels from two marshes where greenhouse gas fluxes were measured. Then, in the laboratory, we dissected the digestive tract to extract DNA from different regions from the stomach and intestine to test the hypotheses that 1) the diet of the mussels would vary along the nitrogen−loading gradient, and 2) the foregut would include a greater proportion of ingested bacteria capable of denitrification and the hindgut would include a greater proportion of resident methanogens. From DNA extractions, we used PCR to amplify the V4 hypervariable region of the 16S ribosomal RNA gene for next−generation sequencing for taxonomic classification and comparison of microbial diversity, and we will use qPCR to quantify the abundance of denitrifiers and methanogens. This work will help us to identify the role of the gut microbiota in ribbed mussels in contributing to their nutrition and the shifts in greenhouse gas fluxes resulting from impacts of climate change in Narragansett Bay.

36.2 MOORE, S. L.*; OLIVA, O. M.; WILLIAMS, M. B.; POWELL, M. L.; MEADE, M. E.; ANTONY, V. B.; WATTS, S. A.; Univ. of Alabama, Birmingham, Jacksonville State Univ, Jacksonville, AL; *susan11@uab.edu*

Effects of Corexit 9500A on gill structure and oxygen consumption in Danio rerio

The oil dispersant Corexit 9500A was used during the Deepwater Horizon oil spill of 2010 in the Gulf of Mexico. Corexit is used to reduce oil into smaller bio−degradable droplets, facilitate oil degradation, and minimize biological impacts of oil rafts. Aerosol and liquid delivery of Corexit could expose organisms directly to high concentrations for short periods of time. To determine the direct effects of Corexit 9500A on aquatic organisms, zebrafish (*Danio rerio*) were exposed to a 400 ppm solution of Corexit for 24 hr (LC50 of 460 ppm). Gill tissue sections showed extensive edema and damage to the epithelial border of secondary lamellae. This damage increased as gills were exposed for 56 hr. Using immunohistochemistry, gill tissues stained strongly positive for heme oxygenase 1 (HO−1), suggesting a response to acute oxidative stress. Using 2',7'−dichlorofluorescein dye, formation of reactive oxygen species was also found in gill tissue exposed to a 400 ppm solution of Corexit for 30 minutes. Whole animal respirometry of adult male and female zebrafish indicated that oxygen consumption rates were not affected by exposure at normal incubation temperature (28 C). These data suggest that short−term structural damage induced by Corexit did not affect properties of oxygen uptake and/or transport. At elevated temperatures (32 C) oxygen consumption rates were significantly increased with Corexit exposure, suggesting that high temperature could exacerbate the negative effects of dispersant. Furthermore, these data can be used to support new recommendations for dispersant usage in future spills.

S7.2−2 MOORE, J; Colorado State; *janice.moore@colostate.edu*

Parasites, Behavior and Prevention (?): How to stop worrying and learn to love Zombies

I briefly review the ways in which parasites alter host behavior behaviors that benefit parasites and behaviors that benefit hosts. I then ask how we can use this information to understand patterns of transmission. In particular, what, if anything, are living vectors doing that makes their roles in disease transmission more predictable? I will focus on biting flies, but include other hosts as appropriate.

26.6 MOORE, AL*; BARNES, CJ; LEE, DV; Univ. of Nevada, Las Vegas; *moorea3@unlv.nevada.edu*

An X−ray−based transducer to measure burrowing biomechanics

The study of burrowing biomechanics has been limited by the technical challenges of 1) tracking motions and 2) measuring forces during subterranean locomotion. We solve the first challenge by using X−ray motion analysis to track skeletal motions of animals as they burrow through a core of soil. We address the second challenge by introducing a device called a Tunnel−Tube that measures the interaction between the animal and the surrounding soil. The Tunnel−Tube is made of a flexible rubber hose sealed inside a rigid outer tube. It measures soil compaction pressure using a pressure sensor mounted to the intertube space. Deflections of an array of ball bearings located at the perimeter of the rubber tube indicate the direction of the forces exerted by the animal. To measure net forces, the entire Tunnel−Tube is mounted on two six−axis load cells. The Tunnel−Tube is calibrated with two pneumatic pistons instrumented with a load cell in each orthogonal axis, providing a known force per unit pressure and millimeter of tube deflection. These calibration data are validated via comparison to a self−driving auger, the "Augerbot," that has known principles of operation. Our calibrations are applied to burrowing locomotion of a pocket gopher (*Thomomys bottae*) and compared with results from the Augerbot. The mechanics of burrowing are a function of anatomical specialization for chisel−tooth and/or scratch digging. *Thomomys* show more specialization for chisel−tooth digging but also use their forelimbs to dig.

41.5 MORAN, C J*; GIBB, A C; Northern Arizona University; *cmoran.mlml@gmail.com*

Convergent evolution of high−performance swimming morphology in an Arizona freshwater fish

Waterways in the lower Colorado River basin were historically defined by periodic flooding events as a result of snow−melt and seasonal rains. We examined the vertebral column morphology, red muscle location, and shape of the fins of roundtail chub (*Gila robusta*) and bonytail chub (*Gila elegans*), two species native to the Colorado River Basin, to test the hypothesis that native fish have evolved a morphology that enhances swimming performance. We compared the roundtail chub and bonytail chub to an invasive, low−performance swimmer from the same family, the common carp (*Cyprinus carpio*) and a high−performance swimmer from the marine environment, the chub mackerel (*Scomber japonicus*). Skeletons were cleaned and the vertebral column morphology was made visible by a colony of dermestid beetles. From intact fish, seven sections were cut along the axial body based on a percentage of standard length and the following parameters were measured: red muscle surface area and the ratio of red to white muscle for each section. Fin aspect ratio was measured as fin span squared divided by the surface area of the caudal fin using ImageJ. Native fish were not similar to mackerel in finess ratio or the red to white muscle ratio. However, caudal fin shape and the angle of the neural and hemal spines in the caudal peduncle in the bonytail and mackerel suggest that the bonytail caudal fin is modified to enhance swimming performance. A narrow caudal peduncle with folded over neural and hemal spines likely allows for hydrodynamic advantages during rapid swimming. The narrow caudal peduncle allows for minimal drag which causes the caudal fin to displace most of the water during swimming. This allows the caudal fin to do most of the work during propulsion while limiting drag forces caused by the body.

S2.2−2 MOREHOUSE, N.I.; University of Pittsburgh; *nim@pitt.edu*
Nutritional Stress and the Evolution of Sexual Ornamentation: A Life History Perspective
Nutritional stress is one of the most pervasive challenges that organisms face, with strong evolutionary leverage on all aspects of organismal life histories. Recent attention has focused on how sexual ornaments respond to nutritional manipulation. This research has provided a large number of case studies linking nutrition to sexual ornamentation. However, differences in ornament expression can result from individual variation in the capacity to acquire resources across environments and/or the strategies used to allocate those resources to ornaments versus other life history traits. Thus, the extent to which responses to nutritional stress are mediated by acquisition versus allocation is central to understanding how ornamental traits interact with other life history characters, and therefore their information value as sexual signals. Experimental attempts to separately quantify these two key aspects of resource use have been few, particularly in relation to sexual ornamentation. I first argue why attention to the difference between resource acquisition and allocation is critical to understanding the evolution of sexual traits. I then highlight recent work on the butterfly *Pieris rapae* to illustrate how the genetic architecture of resource use dictates specific relationships between male investment in sexual ornamentation versus other reproductive and somatic traits. In particular, I make the point that individual differences in resource acquisition may often be more important than divergence in allocation, and that the resulting phenotypic relationships have important consequences for the evolution of female choice. I conclude by pointing to experimental needs and promising avenues for further study.

130.3 MORINAGA, G*; BERGMANN, P J; Clark University; *gmorinaga@clarku.edu*
Biogeography and body shape evolution in parallel radiations in the Australian skink genus, Lerista
Squamates are notable for their morphological diversity, exhibiting a variety of body sizes and shapes. Lizards in particular show a wide array of body plans, ranging from lizard−like bodies, exhibiting a tetrapedal and pentadactyl morphology, to snake−like bodies, exhibiting elongate bodies and lacking external limbs. In lizards, the snake−like body plan has independently evolved at least 25 times. This repeated transition from lizard−like to snake−like bodies makes lizards an excellent system in which to study body plan evolution. We focus on the species rich Australian skink genus, *Lerista*, exhibiting not only lizard−like and snake−like body plans, but also intermediate forms with varying degrees of limb reduction and body elongation. Using a detailed morphometric dataset of 61 species of *Lerista*, we find that most species fall into two main clades that have undergone parallel radiations in the morphospace. In order to address questions of sympatry between the clades and morphologies, we mapped the geographic ranges of 71 species. We hypothesized that the two main clades would be largely allopatric and for allopatry to occur between morphologically similar species due to competitive exclusion. Finally, we tested for co−evolution between relative body size and relative limb lengths and relative limb element lengths. As expected, relative limb lengths co−evolved with relative body length, and all relative limb elements evolved in a correlated manner with one another, indicating that limbs are reduced as the body is elongated. Furthermore, the rate of change of hind limb elements was different between the two clades, suggesting that Lerista have evolved similar morphologies through different ways.

P1.183 MORITZ, G.L.*; ONG, P.S.; PERRY, G.H.; DOMINY, N.J.; Dartmouth College, University of the Philippines, Diliman, Penn State University; *gillian.l.moritz@dartmouth.edu*
The visual and molecular ecology of Tarsius
The color vision of most mammals is based on the presence of two cone−opsin photopigments − the long wavelength sensitive (L−) opsin and the short wavelength sensitive (S−) opsin. While color is barely perceivable at night for humans, there is remarkable diversity in the color vision of nocturnal primates. Some species are colorblind resulting from the functional loss of the S−opsin gene, whereas others maintain two intact opsin genes and thus the capacity for dichromatic color vision. For nocturnal primates, the advantages of making chromatic distinctions at night are unclear. Such variation could be due to a state of evolutionary disequilibrium (i.e., a relatively recent shift to nocturnality from a diurnal ancestor) or it may be adaptive and maintained by natural selection (as evidenced in the dichromatic aye−aye, *Daubentonia madagascariensis*). Tarsiers (genus *Tarsius*) are instructive because their visual system extends to the Eocene. They have relatively enormous eyes, a vestigial fovea, and are devoid of a tapetum lucidum. While the tarsiers of Borneo (*T. bancanus*) express an M−opsin gene, those from the Philippines (*T. syrichta*) and Sulawesi (*T. tarsier*) express an L−opsin gene. To explore the evolutionary significance of opsin functionality in nocturnal primates, we have taken an integrative approach utilizing molecular ecology and visual modeling. We first used a population genetics approach to estimate d_N/d_S ratios for intergenic and S−opsin gene sequences from Philippine tarsiers. Next, we modeled the responses of *T. bancanus* and *T. syrichta* color vision phenotypes to common prey items under nocturnal light levels. Our results suggest that opsins are functional and potentially adaptive in lineages with long−standing nocturnal behavior.

87.5 MOROZ, LL; Univ. of Florida; *moroz@whitney.ufl.edu*
How many times might complex brains have evolved?
The origin of complex centralized brains and elementary cognitive functions are two major evolutionary transitions in the history of our planet. We integrate a large−scale comparative neuronal transcriptome (>200 species) and genomic sequencing data (from several new sequenced genomes including ctenophores, Aplysia, cephalopods and related lophotrochozoans) with modern phylogenomics to reconstruct parallel evolution of neuronal centralization. In contrast to the widely accepted monophyletic scenario (i.e. the presence of a centralized nervous system in urbilateria), our analysis suggests that complex brains may have independently evolved at least 9 to 11 times within Metazoa. Even within Mollusca, the cephalization events might have occurred at least five times. It is now possible to employ single−cell RNA−seq protocols to follow up the evolution of homologous, even ancestral, neuronal lineages at significant speciation distances. Thus, using examples from ctenophores, molluscs and basal deuterostomes, we start to decipher changes in the genomic organization of neurogenic tissues underlying the formation of ganglionic structures or even their fusion into a centralized brain. In summary, the modular organization of neurogenic pathways and memory−forming circuits is a common feature. However, these pathways and circuits have very complex ancestry and, frequently, very different molecular makeup with an independent recruitment of both shared and numerous lineage−specific gene products.

123.6 MORRIS, Z. S.; The University of Texas at Austin; *zsmorris@utexas.edu*
Variation and variability in developmental studies: An analysis of skeletal ontogeny in Monodelphis domestica.
The field of evolutionary developmental biology (evo−devo) has provided significant insight into the evolution of skeletal development. However, most current methods for characterizing and comparing the order of ontogenetic events do not allow intraspecific variation. The lack of data on variation in these methods limits our ability to meaningfully describe and compare ontogenies. One method that does account for and quantify developmental variation and variability is Ontogenetic Sequence Analysis (OSA). My study uses OSA to characterize levels of variation and variability in the ontogeny of the skeleton of the marsupial *Monodelphis domestica*. I evaluated 92 events during skeletal development using 35 specimens of known age (spanning birth to 24 days), to assess the degree to which intraspecific variation may affect the results of developmental studies. I did separate analyses for cleared−and−stained (C&S) specimens and computed tomography (CT), as it was previously shown they reconstruct skeletal maturity differently. The analysis of C&S specimens finds significant levels of sequence variation, including over 800 possible sequences. Analysis of 12 CT scanned specimens found 16 potential sequences; the smaller number a function of sample size. By recovering more than one ossification sequence for *Monodelphis domestica*, my study demonstrates intraspecific ontogenetic sequence variation is a real phenomenon and can be quantified. As a result, evo−devo studies that use only a single sequence are likely to overestimate differences among taxa. Variation is necessary for the timing and order of ontogenetic events to evolve and, therefore, is important for understanding how ontogeny evolves. My results emphasize that methods like OSA provide a key tool for integrating ontogenetic variation into comparative developmental studies.

P2.150 MORRIS, J.S.*; CARRIER, D.R.; University of Utah; *j.s.morris@utah.edu*
Specialization for aggression in sexually dimorphic skeletal morphology in Carnivora
Based on sexual selection theory, male mammals are expected to be more specialized for physical competition than females. Morphological specialization for aggression likely results in several correlated characters. Broad, robust limb bones increase safety factors and provide more surface area for muscle attachment. Large anatomical mechanical advantages about the limb joints increase forces available to strike or manipulate opponents. However, these characters are in conflict with locomotor efficiency because they increase limb mass and inertial forces that must be overcome while cycling the limbs. Thus, a functional trade−off may occur between morphological specialization for economical locomotion and aggression, both of which are ecologically critical activities. In Carnivora, polygyny enforced by male−male competition is the most common mating system. However, variation in social structure (e.g., sociality in Canidae) may lead to differences in the relative importance of aggression. Here we present a large comparative data set on skeletal sexual dimorphism for several morphological characters associated with specialization for aggression. We include data for 27 species from eight families within Carnivora, spanning a large range of body sizes (1 kg to > 200 kg), social systems, and dietary niches. Our results indicate variation in the degree of skeletal sexual dimorphism among carnivores. In several species, males were found to have morphological traits (e.g., larger mechanical advantages about the limb joints, relative to females) consistent with specialization for aggression. In other species, few or no differences were detected. This may be associated with the relative importance of aggression based on mating system and the intensity of male−male competition.

P2.12 MORRISON, R.*; BROUSSARD, J.; McDaniel College, Westminster, MD; *rmorriso@mcdaniel.edu*
Color−change in the leaf−tail gecko, Uroplatus henkeli, in response to checkerboard backgrounds with different square sizes
Leaf−tail geckos from Madagascar are well known for their crypticity. *Uroplatus henkeli* is a large species of leaf−tail gecko that is a phenomenal bark mimic. Interestingly males and females differ in term of their overall pattern, females are banded and males are spotted. Both genders, however, are capable of rapid color change. Background matching was measured in a captive bred male and female *Uroplatus henkeli* by placing individuals on black and white checkerboard patterns with squares of different sizes. Trials were conducted in ten gallon aquaria in a dark room and lizards were photographed following acclimation for two hours. The hue/saturation/value of dark skin (spots or bands) and of light skin regions were measured and analyzed. In both genders it was found that there was a statistically significant difference between the checkerboard square size and the value of both dark skin and light skin. Hue did not change with the size of checkerboard squares, but there were statistically significant differences between the two genders and within the male there is significant difference in hue between dark skin and light skin. As the overall contrast of the background pattern changes, both males and females are able to increase or decrease the difference in the value between dark skin and light skin. On small squares the lightness values of dark and light skin are very different, but they converge on large squares. Square size does not seem to be affecting hue in the same way, but there are gender specific differences in hue.

27.5 MORTIMER, B.*; SIVIOUR, C. R.; HOLLAND, C.; VOLLRATH, F.; University of Oxford, UK, Sheffield University, UK; *beth.mortimer@zoo.ox.ac.uk*
Multipurpose spider silks: the implications of web impact on vibration signalling
Spider silks are multipurpose materials optimised for both mechanical and signalling roles. A prime example is found in the orb web, where the silks have to first absorb prey impact and then transmit its location. To probe the response of silk to impact, we present work which quantifies the mechanical response of single fibres of spider silks across a range of deformation rates, from low−rate tensile testing through to high−rate ballistic impact. The rate−dependence of silk is a consequence of the inelastic (or viscous) material component, which governs the energy absorption during impact. This leads to irreversible changes in silk structure as a consequence of the high stresses involved. Hence, to explore the implications of impact damage on silk signalling, the transverse and longitudinal sound velocities in silk were measured across a range of stresses. We have shown that unlike transverse waves, longitudinal waves are consistent vibration signallers over a range of stresses. This is because longitudinal sound velocities are governed by the elastic material component. In conclusion, the combination of elastic and viscous components of silks enables dual signalling and mechanical functions. We interpret this within a wider framework of energy conservation (signalling) and dissipation roles (impact) and shall discuss the role of evolution in shaping the balance between these conflicting traits.

P1.31 MORTON, M. L.*; PEREYRA, M. E.; Univ. of Texas − Pan American; *pereyrame@utpa.edu*

Nest mortality in two species of passerines at high altitude

Major storms sometimes cause mortality in migratory birds in passage and also during their residency on breeding areas. This has been quantified to some extent, almost always in relation to the actions of a single storm, and usually on a single species. The frequency, type, and outcome of these storms is difficult to predict, challenges that are almost certain to grow with changes in climate. Herein we provide data on two species of summering birds, White−crowned Sparrows (*Zonotrichia leucophrys*)and Dusky Flycatchers (*Empidonax oberholseri*) breeding on the same subalpine meadows in the Sierra Nevada Mountains, and compare nest mortality caused by 16 storms during an 11−year period. Of the three types of storms involved, snow, hail, and rain, snow storms were most damaging to eggs, accounting for 90.3 % of 248 egg deaths in White−crowned Sparrows and 71.7 % of 121 in Dusky Flycatchers. Hail storms caused the majority of nestling deaths being 44.9 % of 138 in sparrows and 78.8 % of 113 in flycatchers. When mortality was calculated as a percentage of eggs killed during each type of storm, the species did not differ, indicating that females of both defended their nests equally well. The same was true of nestling deaths due to snow storms, but their mortality rate was greater from hail storms in flycatchers and much greater from rain storms in sparrows. Survival tended to be greater in nestlings of both species that were older and able to thermoregulate.

32.5 MOSELEY, M. A.*; COX, C. L.; CHIPPINDALE, P. T.; University of Texas−Arlington, University of Virginia; *mmoseley@uta.edu*

Phylogeography of the Four−lined Skinks, Plestiodon tetragrammus, in the Balcones Escarpment region of Texas

Characterizing patterns of biodiversity is important for understanding the mechanisms underlying diversity and has broad applications for conservation (i.e., recognition of distinct lineages or species for conservation) and wildlife management (i.e., identifying areas with high levels of endemism). Understanding the relationships between species is crucial in the characterization of biodiversity. We seek to determine if there is any uncharacterized diversity within the skinks of the *Plestiodon tetragrammus* species group. This group is currently composed of 2 species, *P. tetragrammus* and *P. multivirgatus*. *P. multivirgatus* is distributed in western Texas, New Mexico, and Arizona north to South Dakota, while the two subspecies of *P. tetragrammus*, *P. t. tetragrammus*, found in southern Texas and northern Mexico, and *P. t. brevilineatus*, found throughout central Texas and northern Mexico, are separated by a small hybridization zone in the Balcones Escarpment in south central Texas. We sequenced 3 mitochondrial and 4 nuclear genes and reconstructed evolutionary relationships using Bayesian, maximum likelihood, and parsimony. We found notable genetic variation across the geographic range of the *P. tetragrammus* species group. All analyses found that this species group is monophyletic, and that *P. t. tetragrammus* and *P. t. brevilineatus* are genetically divergent and form distinct evolutionary groups. Preliminary data suggests that the southern population of *P. multivirgatus* may be more closely related to *P. t. brevilineatus* than to *P. t. tetragrammus* suggesting revision of current taxonomy may be needed for accurate representation of the relationships between these taxa, thus giving a more accurate understanding of the biodiversity in Texas.

126.5 MOUNTCASTLE, AM*; ALEXANDER, TM; COMBES, SA; Harvard University, Morgan State University; *mountcastle@fas.harvard.edu*

Don't stop bee−weavin': effects of wing wear on flight maneuverability in bumblebees

The wings of many insects experience cumulative and irreversible damage over the course of their lifespan, and this wear and tear can impose significant costs on flight performance and survivability. Wing wear has been found to reduce vertical acceleration and predation success in dragonflies, alter foraging behavior in bees, and increase mortality in bumblebees and honeybees. Although the causal link between wing wear and increased mortality rates in bees is unknown, wing area loss is thought to increase predation risk by reducing maneuverability. Here we test the extent to which wing wear affects flight maneuverability in the bumblebee, *Bombus impatiens*. We used high−speed videography to record bumblebees flying through an obstacle course of evenly spaced vertical posts oscillating side to side at 1.7 Hz. We simulated wing wear by experimentally clipping the distal trailing edge of the forewing, and recorded maneuverability trials both before and after wing clipping. We digitized flight paths with 3D tracking software, and quantified flight parameters associated with maneuverability, including maximum velocity, acceleration, and turning rate. We compare flight maneuverability before and after wing clipping.

20.3 MUñOZ, M.M.*; LOSOS, J.B.; Harvard University; *mmunoz@oeb.harvard.edu*

Behavior simultaneously drives and impedes evolution: An empirical test using the tropical lizard, Anolis cybotes

Behavior determines how organisms interact with their environment and has long been posited as a pacemaker for evolutionary diversification. The classical view is that novel behaviors expose organisms to new selective pressures, in turn "driving" morphological and physiological evolution. Behavior can also restrain evolutionary change. The "behavioral inhibition" hypothesis suggests that some behaviors, such as thermoregulation, help organisms maintain a constant selective environment, obviating the need to adapt even in the face of changing environments. However, behavioral drive and inhibition are not necessarily mutually exclusive processes − in response to a changing environment, behavioral changes that keep a population in its ancestral niche with regard to one niche axis often will be accomplished by subjecting the population to novel selective pressures on a different niche axis. In this study we test the hypothesis that behavior simultaneously inhibits physiological evolution while impelling morphological evolution in the lizard, *Anolis cybotes*, a species that ranges from sea level to nearly 3000 meters on the Caribbean island of Hispaniola. We demonstrate that behavioral flexibility allows individuals to maintain a constant body temperature along two elevational transects, thus precluding the evolution of differences in thermal physiology (behavioral inhibition). We show that the behavioral change allowing lizards to maintain a constant body temperature is accomplished by altering the part of the environment they occupy, and test whether a shift in structural habitat use in turn impels morphological evolution (behavioral drive). We discuss the implications of our findings in the light of contemporary debates in evolutionary biology.

P3.26 MUDRON, M. R.*; CHANG, E. S.; MYKLES, D. L.; Colorado State University, Fort Collins , UC Davis Bodega Marine Lab, Bodega Bay; *megan.mudron@gmail.com*

Myostatin and mTOR expression in the blackback land crab (Gecarcinus lateralis) Y−organ after molt cycle manipulation

Ecdysteroids produced from the molting gland (Y−organ or YO) induce molting in decapod crustaceans. Reduction in molt−inhibiting hormone (MIH) activates the YO and animals enter premolt. At mid−premolt, YOs transition to the committed state, during which ecdysteroid production increases further. In blackback land crab (*Gecarcinus lateralis*), SB1431542, an inhibitor of Activin receptors, decreases hemolymph ecdysteroid titers in premolt animals and delays the activation of the molt cycle. This may suggest that an Activin−like transforming−growth factor (TGF−^{2}) is produced by the activated YO and drives the transition of the YO to the committed state. Rapamycin (Sirolimus) blocks mechanistic Target of Rapamycin (mTOR) and thus prevents early premolt from occurring. Myostatin (*Gl−Mstn*) is an Activin−like factor that is highly expressed in skeletal muscle. As *Gl−Mstn* is expressed in the YO of intermolt animals, the effects of molting on the *Gl−Mstn* expression in the YO were determined. The expression of mTOR signaling genes (*Gl−mTOR*, *Gl−S6 kinase*, *Gl−Akt*, and *Gl−Rheb*) were also quantified using qPCR. Intermolt animals were eyestalk ablated (ESA) and injected with vehicle (DMSO), rapamycin, or SB1431542 at Day 0. YOs were harvested from intact (intermolt) animals and from animals at 1, 3, 5, 7, and 14 days post−ESA. ESA−dependent increases in expression of mTOR signaling genes and *Gl−elongation factor−2* (*Gl−EF2*) was blocked by SB1431542. *Gl−Mstn* mRNA level peaked at 3 days post−ESA, which is before the transition to the committed state at 7 days post−ESA. Expression of *Gl−EF−2* was increased 7 days post−ESA, indicating an increase in protein synthetic capacity in the YO. Gl−mTOR and other genes will be quantified. Supported by NSF (IOS−1257732).

P3.27 MUELLER, E.*; JENNINGS, D.H.; Southern Illinois University − Edwardsville; *dajenni@siue.edu*

Endocrine mechanisms of evolutionary changes in body size of Anolis lizards

Vertebrate body size is largely regulated by the actions of pituitary growth hormone (GH) and insulin−like growth factors (IGFs) and adult body size is positively correlated with circulating levels of both GH and IGF. A heterologous ELISA was used to determine circulating GH levels in three species of Anoles that vary in body size (*A. sagrei*, *A. carolinensis*, and *A. equestris*). Plasma dilutions used to validate the assay paralleled the standard curve. Plasma GH levels were lowest *A. sagrei*, the smallest species. GH levels were higher in *A. carolinenesis* and *A. equestris*, but did not differ between the two species despite differences in body size. Within each species, plasma GH levels were correlated with snout−vent length in *A. equestris*, but not in *A. sagrei* or *A. carolinensis*. While, our results suggest that changes in circulating GH levels underlie some differences in body size among Anoles, other components of the growth hormone axis (GH receptors, IGF levels, and IGF−binding proteins) are likely mediators of evolutionary changes in body size in these lizards.

54.2 MUIJRES, FT*; MELIS, J; ELZINGA, MJ; DICKINSON, MH; University of Washington, Seattle, Delft University of Technology, the Netherlands; *fmuijres@uw.edu*

Kinematics and aerodynamics of escape responses to looming stimuli in freely flying fruit flies

Flying insects possess a range of stereotypic flight responses that are triggered by particular sensory stimuli. Arguably, one of the most extreme flight responses is the evasive maneuver in response to looming stimuli, which enables an animal to avoid collisions and escape from approaching predators. Here, we study the aerodynamics and body and wing kinematics of visually−elicited evasive maneuvers in freely flying fruit flies. Using an array of high−speed cameras (7,500 frames per second), we tracked body and wing kinematics throughout the behavioral response. The maneuvers were triggered using a circular looming stimulus displayed on the arena walls, which consisted of a cylindrical array of LEDs. The wing kinematics were extracted using an automated tracking routine and were replayed using a dynamically−scaled mechanical model of a fruit fly to study the aerodynamic forces and moments that govern the maneuver. The free−flight experiments show that rapid evasive maneuvers in fruit flies consist of four overlapping components: 1) a fast body roll, followed by 2) a counter−roll, 3) a pitch−up body rotation, and 4) an increase in total force production. As a result, the wing stroke plane, and as a consequence, the average flight force vector are directed away from the looming threat. Our results show that the fly controls roll, pitch, and flight force independently, by varying distinct kinematic features of its wing motion on a wingbeat−to−wingbeat basis.

59.4 MULALY, L.E.*; O'LEARY, F.A.; St. Edward's University, Austin, TX; *lmulaly@stedwards.edu*

Differential impacts of organic and synthetic pesticides on the non−target organism Caenorhabditis elegans and the target organism Termitoidae

Synthetic pesticides are manufactured to mimic organic pesticides but typically persist longer in the environment. Pesticides are absorbed into soil and affect non−target organisms like *C. elegans*, a nematode. In this study, we compared the impact of the organic pesticide pyrethrum to its synthetic counterpart, cypermethrin. We also examined effects of combining each pesticide with an organic synergist, parsley seed oil (PSO), a common agricultural practice. We tested the effects on *C. elegans* and on the target organism, *Termitoidae* (termites). OP50 *E. coli* was prepared with each pesticide treatment (pyrethrum, cypermethrin, pyrethrum+PSO and cypermethrin+PSO each in three ratios, PSO alone) at the highest sub−lethal concentration of pesticide (5 ¼g/mL). After *C. elegans* cultures were exposed, motility and lifespan were assessed. Motility was assessed via a thrashing assay in M9 buffer. Lifespan was determined by age−synchronizing worms, exposing them to pesticide, then transferring them to egg−laying inhibitor plates. No statistically significant differences in lifespan or motility between treatment groups were found. However, PSO had detrimental effects on *C. elegans* development, suggesting high vulnerability early in life. Termites were exposed to the same pesticide treatments and tested for lifespan. An ANOVA determined that all termites exposed to PSO, cypermethrin or a combination had significantly shorter lifespans than control termites. Our data suggests that addition of PSO increased the detrimental impact of cypermethrin and pyrethrum on *C. elegans* and termites. This can be used in environmentally conscious practice to eliminate termites with a biodegradable pesticide treatment, reducing the pesticide's persistence in soil.

P1.195 MULLER, UK; California State University Fresno; *umuller@csufresno.edu*
How to use multiple stepped authentic research projects to build critical thinking and quantitative reasoning skills in biology courses
Modern STEM education has as a goal to increase science and information literacy. Yet many non−majors science courses are still taught as watered−down majors courses, focusing on what STEM majors should know rather than on educating non−STEM majors in how to make sense and use of science. Many major science courses focus on content delivery rather than building skills. I have redesigned a non−majors and several upper−division biology courses (comparative animal physiology, comparative vertebrate morphology) to build students' academic skills (critical thinking, quantitative reasoning, information literacy, communication). The non−majors biology course now uses issue−driven learning − students research authentic, relevant questions to informed citizens, such as the MMR vaccine scandal, health food myths, conservation and resource management issues, to build information and science literacy, and then write information brochures to build communication skills. The vertebrate morphology course teaches functional morphology of locomotion and quantitative reasoning through a succession of stepped mini−projects that cumulate in an authentic research project. Inquiry−based learning can be achieved without increasing instructor workload for grading by using student peer review. To circumvent the pitfalls of student peer review, I developed assignments that develop students' content expertise before they peer review other students, and I developed rubrics that focus peer reviewers on core criteria to assess quality. Furthermore, I use student peer reviews like an editor: peer reviews do not determine the grade of an assignment; instead, looking at the overall tenor of typically 5 to 6 student reviews per assignment helps me to more quickly arrive at a fair grade. I will present example assignments to demonstrate my redesign philosophy.

73.5 MUNK, Y*; BRUNTON, B; HORVITZ, E; DANIEL, TL; University of Washington, Microsoft Research; *yomunk@uw.edu*
High Score! Hawkmoth video games reveal obstacle navigation policy
Navigation within cluttered environments is a complex behavior, in which navigational policy may be influenced by numerous factors including visibility range, flight speed, and light level. We investigated obstacle navigation in the hawkmoth *Manduca sexta* using a closed−loop flight simulator in which subjects navigate within a three−dimensional virtual forest. Each experiment yields a set of trajectories through the virtual forest under varying conditions of flight speed, visibility range, and contrast between obstacles and background. Each trajectory potentially includes hundreds of navigational interactions with virtual obstacles, and we have collected 836 trials over 30 subjects. In analyzing these trajectories, we posit a scoring system that awards points based on how a moth controls its trajectory near obstacles. We then assess the likelihood that the proposed scoring system reflects the intent of the subject by comparing the score obtained by the real trajectory to scores obtained by a distribution of trajectories that are randomized via resampling, establishing a bootstrap statistical test. At low flight speed and moderate visibility range, moths were often attracted to both bright and dark obstacles, flying close to but not necessarily hitting them. At high speed and low visibility range, some moths exhibited avoidance behavior, tending to steer away from obstacles. We identify a policy selecting for different navigation control behaviors dependent on the availability of visual information in *M. sexta* that may represent general visual strategies in animals navigating within cluttered environments. More generally, we describe a methodology for coupling computer−generated virtual environments with parameter search to identify implicit, context−sensitive navigational policies.

S3.1−1 MUNRO, E.M.*; HASHIMOTO, H.; ROBIN, F.R.; SHERRARD, K.M.; University of Chicago; *emunro@uchicago.edu*
Dynamics of Tissue Morphogenesis in Ascidians
A key challenge in developmental biology is to understand how embryonic cells organize force production in space and time and how these forces are resolved into globally stereotyped patterns of cell shape change, rearrangement and tissue deformation. Ascidian embryos provide a unique opportunity to address this challenge; they elaborate all of the essential elements of the chordate body plan, but they do so in a few hours, with a few hundred large and optically clear cells, against the backdrop of highly stereotyped early cleavages and cell fate determination. In this talk, I will highlight our recent attempts to understand mechanisms that govern ascidian neurulation. The ascidian neural tube forms through neuroectoderm (Ne) invagination, followed by epidermal "zippering", in which the neural folds and adjacent epidermis (Epi) meet at the midline, then exchange junctions in a posterior−anterior progression to separate the neural tube from the overlying epidermis. Using quantitative live imaging, we have identified a moving zone of actomyosin−dependent contractile activity just ahead of the zipper, in which individual Ne/Epi junctions sequentially undergo rapid shortening, drawing the zipper forward and drawing the edges of the neural plate into contact at the midline. Newly met epidermal cells remain associated with the zipper during Ne/Epi junctional exchange, elongate as the zipper moves anteriorly, then release from the zipper and relax towards more isodiametric shapes. Combining experimental manipulations with computer modeling, we have shown that a local increase in contractile tension within this zone provides the essential driving force, while junctional release and cell shape relaxation behind the zipper creates an essential mechanical asymmetry that leads to unidirectional zipper progression.

P3.142 MUNTEANU, VD*; STAYTON, CT; Bucknell University; *vdm003@bucknell.edu*
The effect of turtle locomotor style on plastron shape and strength
The shells of aquatic and terrestrial turtles are well known to differ in shape. The most well−studied differences involve features of the carapace: terrestrial turtles tend to have tall, domed carapaces, while the carapaces of aquatic turtles are flatter. These differences in shape are known to have functional implications − the more domed carapaces of terrestrial taxa develop lower stresses for a given load than those of aquatic taxa. However, given the differences in locomotor styles, and the consequent differences in typical limb movements between aquatic and terrestrial taxa, differences in the shapes of the plastron are expected as well. These differences in plastron shape are likely to have important functional consequences. We investigated differences in the morphology and mechanical performance between the plastrons of aquatic and terrestrial emydid turtles. Given the differences in limb orientation and motion required by terrestrial locomotion relative to aquatic locomotion, we hypothesized that terrestrial turtle plastrons will be narrower than those of aquatic turtle plastrons and will have a larger bridge region. Given this, we also predicted that the plastrons of aquatic turtles will be stronger than the plastra of terrestrial turtles, but that the bridges of aquatic turtles will be weaker. We used geometric morphometrics methods to test our morphological hypotheses and finite element analysis (FEA) to test our functional hypotheses. We found support for our morphological hypotheses. However, we found that the plastra and bridges of terrestrial turtles were stronger, on average, than those of aquatic turtles. These results imply that differences in locomotor style do indeed affect plastron shape in aquatic and terrestrial species, but that there is not necessarily a trade−off between plastron strength and efficiency of terrestrial locomotion.

88.1 MURPHY, E.A.K.*; REIDENBACH, M.A.; Univ. of Virginia; *eam6vf@virginia.edu*

Effects of temperature on ventilation patterns in polychaete burrows

Burrowing organisms living in temperate intertidal zones are subject to extreme temperature fluctuations on daily to seasonal timescales. Many of these organisms build permanent or semi−permanent burrows that they irrigate with overlying water. This activity expands the sediment−water interface, enhancing exchange of solutes between porewater and surface water, and altering sediment chemistry. We investigated 1) the temperature variations experienced by organisms at three depths between 3 and 25 cm in intertidal muddy sediment on Virginia's Delmarva peninsula and 2) the effects of temperature variations on ventilation patterns in irrigated burrows. HOBO temperature loggers were buried within intertidal mudflats to examine temperatures experienced by burrowing organisms at different depths throughout multiple tidal cycles. To examine how temperature affects the ventilation of irrigated burrows we used *Neanthes succinea*, a common polychaete, as a model organism. This species builds U−shaped burrows and irrigates the burrows by undulating its body. A planar optode was used within a mesocosm composed of natural sediment to measure oxygen levels in burrows at three temperatures between 6 and 36 ° C that correspond to the range of temperatures experienced seasonally. We found that oxygen levels in natural burrows follow a distinct pattern with higher temperatures corresponding to increased frequency of ventilation and lower oxygen levels in the burrow and lower temperatures corresponding to decreased frequency of ventilation and increased oxygen levels.

123.8 MUSSER, JM*; WAGNER, GP; PRUM, RO; Yale University; *jacob.musser@yale.edu*

Investigating the Homology of Feathers and Scales using High−throughput Genomics

Feathers are an early avian innovation that facilitated the evolution of flight, greater thermoregulation, and other facets of avian life. However, the molecular basis for the evolution of feathers is poorly understood, and the homology of feathers to other skin derivatives, especially scales, remains contentious. Here, we investigate feather novelty and homology by comparing transcriptomes from different stages of developing feathers, different scales, and claws. Transcriptomes were assayed at different developmental stages and in multiple species, including two distantly related birds, Chicken (Gallus gallus) and Emu (Dromaius novaehollandiae), and American Alligator (Alligator mississipiensis). We found that in early development feathers and scutate scales, an asymmetric avian scale, share similar gene expression compared to other scales and claws. However, as development progresses gene expression in feathers becomes distinct, suggesting later stages of feather development are novel. This close relationship between feathers and scutate scales in early development, and subsequent unique expression in later feather development is supported independently by transcriptomes from both epidermis and dermis, as well as across multiple avian species. Further, to complement our transcriptome data, we used immunohistochemistry to compare spatial patterns of expression of the transcription cofactor &beta−catenin, the earliest known molecule expressed in feathers. We found that &beta−catenin is expressed in similar spatial patterns in early developing feathers and scutate scales. These complementary results suggest feathers share similar molecular pathways to scutate scales in early development, and that feathers may have evolved via elaboration of an asymmetric scutate type scale.

36.6 MUSTONEN, MS; HAIMI, J; KNOTT, KE*; University of Jyvaskyla; *emily.knott@jyu.fi*

Metallothionein gene expression differs in populations with different exposure history

Metal pollutants in soils can harm organisms and decrease species diversity. Species can cope with metal contamination with the help of metallothioneins, small metal−binding proteins that are involved in homeostasis and detoxification of metals. We studied the expression of metallothionein with qPCR in a small, epigeic earthworm, *Dendrobaena octaedra*, collected from two sites differing in metal exposure: Harjavalta, contaminated by a local Cu−Ni smelter, and Jyväskylä, an uncontaminated site. Worms from both sites were exposed to different concentrations of copper (control, 50, 100 or 200 mg/kg) or zinc (control, 75,150 or 300 mg/kg) for 7, 14 or 28 days to see if there is a time related dose response in gene expression. Population comparison showed that earthworms from the two populations differed in metallothionein expression ($F=83.616$, $df=1$, $P< 0.001$), being higher in earthworms from the contaminated site. There was a positive correlation between metallothionein expression and Cu, Zn and Cd concentration in earthworms from Jyväskylä, but not in worms from Harjavalta, suggesting that higher gene expression in worms from the contaminated site may aid regulation of metal body burdens. In the exposure experiment, a dose response to zinc was found ($F=7.112$, $df=3$,$P< 0.001$) but there was no response to copper ($F= 0.849$, $df=3$, $p=0.472$), suggesting that this isoform of metallothionein might not be strongly induced by copper, but moreso by zinc or some other metal that was not included in the experiment. Exposure time also affected expression, but only for earthworms from Jyväskylä (Cu: $F= 17.601$, $df=2$, $P< 0.001$, Zn: $F=9.437$, $df=2$, $P< 0.001$), suggesting that there is a delay in the metallothionein response of earthworms in this population. Adaptation of *D. octaedra* to metal contamination can explain its persistence in contaminated forest soils.

80.3 NAIR, A. M.*; MCHENRY, M. J.; Univ. of California, Irvine; *amnair@uci.edu*

The fast start in larval zebrafish creates 3D maneuvers

The fish fast start is a classic escape response where the body curls into a "C" shape and then rapidly unfurls to accelerate the body. Although this motion is generally described as planar, our recent experiments have observed that larval zebrafish (*Danio rerio*, 5−7 dpf) evade predators by executing the fast start in three dimensions. With interests in the motor control and strategic implications of this motion, we measured detailed kinematics of the fast start of larval zebrafish in 3D. We determined the euler angles of the head (roll, pitch and yaw) and the tail shape (curvature, torsion, and twist) throughout the whole escape response. We observed two categories of escape responses: lateral−directed and ventral−directed. During a ventral−directed response, larvae positioned their head downwards while curling the body (i.e. stage 1). In contrast, zebrafish larvae did not alter head elevation until after the body had begun to unfurl (i.e. stage 2) when performing a lateral−directed fast start. Moreover, ventral−directed maneuvers had a greater change in angular elevation of the head and a greater twisting and pitching of the tail compared to lateral−directed responses. Therefore, larval zebrafish exhibit contrasting tail kinematics according to the elevation of the motion. This ability may enhance survival and appears to require a more sophisticated motor control system than previously appreciated.

60.5 NAKAMOTO, A.*; HESTER, S.; BLAINE, W.; IKPATT, J.; KHAHIL, S.; MATEI, M.; PACE, R.M.; TEWKSBURY, A.; NAGY, L.; WILLIAMS, T.; Univ. of Arizona, Trinity College , Trinity College ; *monaka@email.arizona.edu*

Cellular mechanisms underlying posterior segmentation in Tribolium

The perceived view of *Tribolium* segmentation is that it proceeds from a posterior growth zone, regulated by interactions of WNT−CAD and an ODD oscillator. While such oscillators are thought to add segments in a clock−like manner, we measured the actual timing of segment addition throughout germband elongation. We use a lineage tracer to fate map small clusters of blastoderm cells. We find a direct relationship between location of a clone along the A/P egg axis and its fate in the embryo. We observe similar low rates of division between anterior and posterior blastoderm clones during axial elongation. The behavior of the clones is consistent with a model of cell rearrangement, rather than posterior growth, driving sequential segmentation in *Tribolium*. We develop a computational model that confirms that a realistic rate of elongation can be achieved in the absence of cell division through cells that have random, generic motility plus some directed cell movement. Embryonic injections of eveRNAi demonstrate that in the absence of Eve cells divide normally, but fail to initiate wildtype cell movements.

P1.89 NAMIGAI, E.K.O.*; SHIMELD, S.M.; University of Oxford; *erica.namigai@zoo.ox.ac.uk*

The establishment of left−right asymmetry in spiralian development

The establishment of body axes is a fundamental process of metazoan development. Despite the wealth of studies on the anterior−posterior and dorsal−ventral axes, the left−right (LR) axis remains poorly understood. I am studying the mechanisms underlying LR asymmetry in the Lophotrochozoa using *Pomatoceros lamarckii*, a serpulid annelid, as a model. To this end, we have sequenced the *P. lamarckii* genome, giving us a representative view of the major TGF−beta superfamily components. Key TGF−beta members and aspects of cellular architecture, such as the dynamics of early spiral cleavage, are currently being analyzed, in addition to the role of ion channels in early development. This research answers key questions concerning body axis establishment during spiralian development, and is valuable for understanding the evolution of LR asymmetry within the Lophotrochozoa.

86.7 NAVA, A.*; NISHIGUCHI, M.K.; New Mexico State University; *nish@nmsu.edu*

Sublte genetic changes in the two−component regulatory system etk effects anti−predatory behavior in the symbiotic bacterium, Vibrio fischeri

Biofilms are comprised of vast array of exopolysaccharides, channels, and bacteria that provide a stable environment for the consortium of bacteria to accommodate abiotic stresses. Formation of biofilms can be controlled by both biotic and abiotic stress, and involves different regulatory genes that sense as well as respond to such fluctuations. One strong selection pressure that effects biofilm formation is grazing by predatory protozoans. Biofilms have evolved certain mechanisms to prevent such destructive grazing from the strong selective pressure placed by protists. Previous research has demonstrated that different feeding modes of protists have driven the selection of these mechanisms. Biofilms can also change their morphology in response to the different types of predation, or produce noxious chemicals to deter or destroy their predators. We investigated the two−component regulatory locus, *etk* in the beneficial mutualist *Vibrio fischeri*, to determine if this locus is responsible for the anti−predatory behavior observed among strains of this bacterium. The *etk* locus is a protein−tyrosine kinase chain length regulator for capsular polysaccharide biosynthesis. Single nucleotide polymorphisms in the loci of various strains of *V. fischeri* enable these symbionts to resist predation by various protists or competitive bacteria by changing the morphological structure of the biofilm. Genetic diversity within the *etk* locus of a single species of *V. fischeri* demonstrates the large evolutionary and ecological benefits derived as a result of small subtle changes in genotype.

44.1 NAVARA, KJ; Univ. of Georgia; *knavara@uga.edu*

Gestational weight gain influences sex ratios at birth in humans

Previous studies in birds and non−human mammals suggest that females bias the sex ratios of offspring in response to resource limitations. In addition, a previous study in humans indicated that women with high levels of energy intake prior to conception produced more boys, and the numbers of boys produced by humans appears to drop in times of famine. It is unclear, however, whether these adjustments happen prior to or during gestation, as a primary or secondary adjustment of sex ratio. By analyzing sex ratios of over 85 million US births over 21 years, we tested whether the human sex ratio at birth was related to gestational weight gain and the development of gestational diabetes. We predicted that women who gain more weight and/or develop diabetes during gestation would produce more boys, and that, if the adjustment was happening during gestation, the sex ratios of fetal deaths would be more female−biased in women who gained more weight during gestation. Indeed, there was a near−perfect positive correlation between the amount of weight women gained during pregnancy and the percentage of boys produced ($p < 0.0001$), and women who developed gestational diabetes were more likely to produce boys ($p < 0.0001$). In addition, there was a negative correlation between the amount of weight women gained and the percentage of male fetal deaths, but only between 20−23 weeks of gestation ($p = 0.02$). These results suggest that from 20−23 weeks of gestation is a critical time during which weight gain can influence the survival of male or female offspring, and ultimately affect the sex ratio at birth.

3.7 NAVARRO, A*; FRAKER, T.L.; DEATON HAYNES, P.D.; SCOBELL, S.K.; St. Edward's University, Austin, TX, Brooklyn College, Brooklyn, NY; *anavarr3@stedwards.edu*

Effects of AVT manipulation on Syngnathus scovelli: a sex role reversed species

Studying sex role reversed species (i.e. those displaying increased male parental investment, female competition for mates, and strong sexual selection pressures on females) provides an opportunity to test the assumptions of sexual selection theory and enhance our understanding of the neurophysiology mediating behavioral sex differences. Syngnathids (seahorses, pipefish, and seadragons) are a useful group for studying neural systems underlying sex−typical behaviors, as this Family displays both conventional and sex role reversed behaviors. The neuropeptide arginine vasotocin (AVT, the homologue to the mammalian gene arginine vasopressin, AVP) facilitates social behavior across all vertebrate taxa (i.e. birds, amphibians, rodents, mammals). In many male vertebrates AVT/AVP mediates aggressive behaviors and in certain species, can operate independent from gonadal hormones (e.g., testosterone). In female sex changing fish, AVT can activate aggressive male−typical behaviors. Yet there is paucity of research assessing AVT's effect on aggression in sex role reversed species. Our goal is to understand the proximate role AVT plays in the mediation of intrasexual aggression in female Gulf pipefish, a highly polyandrous, sex role reversed species. Test females interacted in a baseline behavior test for 30 minutes with a stimulus female prior to receiving either an AVT, Manning compound (an AVT/AVP receptor antagonist), saline, or sham injection. Following a 60 minute recovery period, the pair interacted for another 30 minutes in a post−injection trial. Pilot data supported our predictions that AVT would increase aggressive behavior and Manning compound would decrease aggressive behavior in test females. We are currently analyzing our behavioral and morphological data (n=96).

P3.118 NEEDHAM, CN*; SALERNO, CR; BERKE, SK; Siena College; *cn09need@siena.edu*

Algal showdown: invasive Gracilaria vermiculophylla vs. native species in Virginia's coastal bays

Invasive species have the potential to disrupt food webs if they displace resources that native species prefer. In the coastal bays of Virginia, the red alga *G. vermiculophylla*is a problematic invader that represents more than 90% of all macroalgal biomass in protected intertidal habitats. If *G. vermiculophylla*is a lower quality resource than native algae, then regional food webs may be affected. We assessed grazer preferences for *G. vermiculophylla*versus two native algae − the congeneric red alga *G. tikvahiae* , and the green alga *Ulva* lactuca. Grazers included two common amphipod species, *Ampithoe rubricata* and *Gammarus mucronatus*, the Eastern mud snail *Nassarius obsoletu* s, and the onuphid polychaete *Diopatra cupre* a. All four species preferred the native *Ulva* to either *Gracilaria*, and did not substantially feed on either the native or the invasive *Gracilaria* species in 3−way choice experiments. In feeding assays using freeze−dried algae mixed with agar, *D. cuprea* readily consumed all three species in equal amounts, suggesting that the preferences are rooted in the red algae's physical properties rather than chemical defenses. For *D. cuprea*, we also assessed growth and regeneration over a one−month period in which worms were maintained on a diet of G. vermiculophylla, *G. tikvahiae* , or *Ulva* alone, or a mix of all 3 supplemented with shrimp meat. While worms given meat grew and regenerated the most, we found no differences among the algae, suggesting that *G. vermiculophylla*may be an acceptable food resource in the absence of preferred species. Future work will assess the relative rates at which grazers consume the invasive vs. native algae, and the extent to which small epifaunal invertebrates use invasive vs. native species as habitat.

18.4 NEEMAN, N*; ESPINOZA, M; FARRUGIA, TJ; LOWE, CG; SOBEL, MJ; O'CONNOR, MP; Drexel University, California State University, Long Beach, Temple University; *nn72@drexel.edu*

Using a Hidden Markov Model to find foraging areas for the gray smooth−hound shark (Mustelus californicus) in a Full Tidal Basin

Analyzing movement pathways can allow unobservable, underlying, discrete behavioral states to be inferred from tracking data. This can be used to understand how animals use their habitats, for example where they tend to forage vs. what areas they use as transit corridors. This study analyzes acoustic telemetry data for the benthic, coastal predator *Mustelus californicus* (gray smooth−hound shark) to determine if and where they forage within the Full Tidal Basin of Bolsa Chica, Huntington Beach, California and whether or not this varies by individual shark. Preliminary analysis of the data for all the sharks showed that their speeds are a mixture of two log−normal distributions (log−mean −3.8 and −1.6) and that turning angles vary with speed such that at lower speeds the turning angles are uniformly distributed and at higher speeds the turning angles are a mixture of two normal distributions (centered around 0 and 180 degrees). Normally, analysis requires interpolating so the data is at regular time intervals. However, since there is abundant data and since the turn angles close to 180 degrees might be indicative of behavioral state, this analysis used the data as irregular time intervals and used a Hidden Markov model evaluated using particle filters to determine the behavioral state at each location. Preliminary results show that individual sharks have clustered foraging sites, more analysis is needed to determine how different these clustered sites are between individuals.

MOORE.1 NEHM, R.H.; Stony Brook University, New York

John A. Moore Lecture − The Contextual Nature of Evolutionary Reasoning: Implications For Biology Teaching, Learning, and Assessment

Recent studies of evolutionary reasoning across age groups (elementary, high school students), nations (China, Germany, Indonesia, and the USA), and expertise levels (undergraduates, practicing scientists) have revealed new insights about how humans think about evolutionary change. This talk will summarize these empirical findings, and discuss their implications for biology teaching, learning, and assessment.

Ross H. Nehm is Associate Professor in the Department of Ecology & Evolution, and a member of the Ph.D. Program in Science Education, at Stony Brook University in New York. His recent work has focused on measurement of evolutionary understanding and study of the growth of evolutionary thought. His evolution education research was recently highlighted in the National Research Council publication Thinking Evolutionarily (National Academy Press, 2012).

125.3 NEMETH, Z*; SMEETS, M; RAMENOFSKY, M; Univ. of California, Davis, Rheinische Friedrich−Wilhelms−University; *znemeth@ucdavis.edu*

Do migrant and resident White−crowned Sparrows respond differently to changes in their environment?

Organisms are increasingly exposed to rapid changes in the environment, yet it remains difficult to predict their responses to such changes. Migratory birds are considered to be ecologically less flexible than resident species thus it may be hypothesized they are more vulnerable to altered conditions. If so, we predict that migrants may be less able to cope with challenges in the environment than resident congeners. To test this prediction, migratory and resident subspecies of the White−crowned Sparrow (*Zonotrichia leucophrys gambelii*) and (*Z. l. nuttalli*) were examined in cognitive, behavioral and physiological tests and the following variables were measured: (1) risk tolerance (i.e. flight initiation distance); (2) problem−solving ability; (3) object neophobia; (4) spatial exploratory tendency; and (5) adrenocortical stress response. All tests, except the exploratory test, were conducted in the non−breeding season. In support of the prediction, migrants were found to be more risk−averse and less innovative in accomplishing a feeding task but did not differ in their response to novel objects, novel space or capture and restraint stress. These results suggest that migrants may be more constrained in their ability to cope with human disturbance and exploit emerging novel resources.

P1.186 NESLUND, M/C*; BAKER, T/C; SHIELDS, V/D/C; Towson University, The Pennsylvania State University; *mneslu1@students.towson.edu*

Electroantennogram Responses of Acheta domesticus to Plant−Associated Volatiles

Insects use their antennae to locate food sources, mates, and oviposition sites. The antennae are the main olfactory sensory organs or sensilla by which odorants pass through small pores in the cuticle where they interact with the underlying dendrites, relaying information to the brain of the insect. *Acheta domesticus* bear sensilla contained on their long easily accessible antennae that have been identified as possessing an olfactory function via electron microscopic studies, allowing this species to be used as an excellent model to study olfaction. In addition, information is sparse regarding the olfactory system of crickets. In this study, we used an electroantennographic detection technique (EAG) to determine which behaviorally relevant plant−associated volatiles, selected from a wide array of chemical classes, were detected by olfactory receptor neurons within the olfactory sensilla on the antennae. We found some volatiles to elicit strong EAG responses (e.g., aromatic esters, green leaf volatiles), while others evoked medium to weak responses. This study was carried out in conjunction with behavioral bioassays using a y−tube olfactometer. The results of this research will hopefully advance our understanding of insect olfaction in this species.

114.4 NEUMAN−LEE, LA*; SMITH, GD; FRENCH, SS; Utah State Univ.; *lorin215@gmail.com*

Interactive effects of food restriction and restraint stress on stress reactivity, immune function, and energy metabolite use and storage in snakes

Snakes are a unique in the animal kingdom due to their ability to withstand long periods of food deprivation with few deleterious consequences. In many organisms food deprivation can result in the activation of the hypothalamic−pituitary−adrenal axis. However, in animals that do not require food at regular intervals, such as snakes, this activation may not be as pronounced or necessary. It is also unclear how energy utilization decisions vary with individual stress and energy states. In the current study, we sought to determine if food deprivation, stress state, or interactions among the two resulted in altered stress reactivity, immunity, and energy metabolite use and storage in the wandering gartersnake (*Thamnophis elegans*). We assigned snakes into one of four treatment groups: maintenance diet/no stress, maintenance diet/stress, food deprivation/no stress, and food deprivation/stress. For six weeks, snakes were either given 10% of their body weight in food or no food at all. For the next 12 days, snakes were either left in isolation (no restraint) or removed from enclosures and placed in an opaque bag (restraint) for half an hour daily. At the end of the experiment, we conducted a stress reactivity challenge by taking a baseline blood sample, restraining the snake for 30 minutes in an opaque bag, and taking a final stress−induced blood sample. We analyzed the plasma for the glucocorticoid corticosterone, innate bactericidal ability, protein, total triglyceride, true triglyceride, and free glyceride. Our results show that food restriction and restraint both acted in similar manners on the stress reactivity, immune function, and nutrient processing. However, when exposed to both stressors, the effects were far more pronounced.

P1.210 NEUMEYER, C.H.*; FARMER, C.G.; Univ. of Utah, Salt Lake City; *courtney.neumeyer@utah.edu*

Computing body mass from skeletons using photogrammetric models

Body mass underpins numerous key life history traits. Therefore, it is an important characteristic to deduce in order to understand the biology of both extinct and extant organisms. One method used to find body mass of extinct animals is to compute body volumes from reconstructed skeletons and multiply this volume by a density based on extant animals. We aimed to test the validity of using estimates of body volume to compute mass. We weighed a specimen of a juvenile American alligator (*Alligator mississippiensis*) using a conventional top loading scale. We then removed and weighed the skin, muscle, and viscera. Using VisualSFM, we created a photogrammetric (3D) model of the remaining skeleton. Then we processed the model using CloudCompare, MeshLab, and MatLab. We multiplied volumes of segments of the model by 900 kg ml^{-3} to obtain masses. The mass given by the top loading scale was 1.4 kg and the computed mass was 1.5 kg. We are expanding the study to include more individuals and more species but, these preliminary data suggest the modeling methodologies can accurately estimate body mass. This work was supported by NSF−IOS−1055080 to CGF.

5.2 NEUTENS, C.*; DIERICK, M.; VAN HOOREBEKE, L.; ADRIAENS, D.; Ghent University, Ghent, Belgium; *c.neutens@ugent.be*

From swimming to grasping: evolutionary morphology of the prehensile tail in syngnathid fishes

Seahorses and pipehorses both possess a prehensile tail, a unique characteristic among teleost fishes, allowing them to grasp and hold onto substrates, like sea grasses. Recent phylogenetic studies suggest that the prehensile tail in syngnathid fishes evolved more than once and also suggest the existence of intermediate forms in the lineage giving rise to the seahorses. The tail of the pipefishes − which are considered to represent the ancestral state − is characterized by a vertebral column that is surrounded with solid dermal plates − four per vertebra − covering the whole surface of the tail and making it a rigid structure. In seahorses however, we observed a reduction of certain parts of de plates, with their caudal spine relatively longer and so increasing tail flexibility. We tested the hypothesis that there is a relationship between the structural organization of these dermal plates and the flexibility of the tail. We compared the tail skeletal morphology of both seahorses and pipefishes with (1) the skeletal system of two species belonging to the lineage giving rise to the seahorses, i.e. the bastard seahorse (*Acentronura gracilissima*) and the ribboned pipehorse (*Haliichthys taeniophorus*), expecting to find an intermediate morphology, (2) the tail morphology of three pipehorse species that are nested within the pipefish lineages, expecting to find different convergent strategies to obtain a prehensile tail and (3) a seadragon species with a non−prehensile tail, but lacking a tail fin. To test these hypotheses, μCT−scanning was combined with virtual 3D−reconstructions and bending experiments with cleared and stained specimens.

P3.186 NEWCOMB, J.M.*; WATSON, III, W.H.; New England College, University of New Hampshire; *jnewcomb@nec.edu*

Small cardioactive peptide immunoreactivity in the nudibranch Melibe leonina

Small cardioactive peptide (SCP) is a neurotransmitter that influences numerous biological functions in molluscs, including heart activity and feeding. The purpose of this study was to localize SCP−immunoreactive neurons in the brain and periphery of the nudibranch *Melibe leonina*. Using monoclonal antibodies directed against SCPB, we were able to identify roughly a dozen bilaterally symmetrical neurons throughout the major ganglia of the brain. The most prominent were a bilateral pair of neurons located in the buccal ganglia. These buccal neurons gave rise to extensive processes in all of the buccal nerves, some of which appeared to innervate the esophagus. SCP immunoreactivity was also present in a number of other nerves emanating from the brain. These results indicate that SCPB is likely to play an important role in neural networks controlling the physiology and behavior of *Melibe*, particularly those involved in aspects of feeding and digestion.

68.3 NEWCOMB, LA*; CARRINGTON, E; GEORGE, MN; O'DONNELL, MJ; University of Washington, California Ocean Science Trust; *newcombl@uw.edu*

Short−term exposure to elevated temperature and low pH alters mussel attachment strength

Rising ocean temperature and decreasing ocean pH may impose physiological stress on organisms by affecting the material properties of structures that allow organisms to survive in a given environment. A mussel's ability to form strong byssal threads to attach themselves to substrate is crucial for their survival in a hydrodynamic environment. The combined effects of ocean warming and acidification (decrease in pH), may decrease mussel attachment strength and thus their ability to survive. Threads are comprised of three functionally distinct regions acting in series, therefore the ability of multiple stressors to work in tandem with each other is dependent upon the region they affect. Our previous work demonstrated elevated temperature weakens all thread regions while low pH only affects the adhesive plaques. We tested the hypothesis that at high temperatures, temperature is responsible for thread weakening with minimal effects of pH, and at cooler temperatures, low pH conditions will weaken threads. Field collected mussels (*Mytilus trossulus*) produced threads in temperature and pH controlled aquaria for three days. Temperature and pH did not have additive effects on byssal thread strength, rather, depending on the given temperature and pH, one of the stressors dominated. Temperature had a greater effect than pH on byssal thread strength under the conditions measured; mussels produced 2.7 times fewer and 2.7 times weaker threads at 25C in comparison to 10C. Low pH led to a slight increase in plaque strength in the lower temperature treatments. Short−term exposure to elevated temperature and low pH is enough to cause changes in byssal thread material properties suggesting mussel attachment may be impacted by future predictions of ocean change.

112.1 NEWMAN, S.J.*; BERNS, H.M.; ZENTKOVITCH, M.M; JAYNE, B.C.; Univ. of Cincinnati; *newmansv@mail.uc.edu*

Incline, peg height, peg shape and body shape have interactive effects on the arboreal locomotion of snakes

The height and shape of ledge−like structures in the bark of trees vary substantially. Several species of arboreal snakes have convergently evolved the ability to make a ventrolateral keel, which seems well suited for catching on ledge−like structures. However, the effects of these aspects of environmental structure and morphology on arboreal locomotion are poorly understood. Hence, we used cylindrical surfaces with different inclines (N=5) and heights (N=5) and shapes (N=2) of pegs to test how certain attributes of bark texture affect the locomotion of snakes. Of the three species in our study, both corn snakes and brown tree snakes formed a conspicuous ventrolateral keel, but boa constrictors did not. Unlike the other two species, brown tree snakes performed lateral undulation on pegs that were only 1 mm high on all inclines ranging from horizontal to vertical as well as up a 60 deg slope on the underside of a cylinder that had 2 mm high, wedge−shaped pegs. Brown tree snakes were faster and used lateral undulation on more surfaces than the other two species. Corn snakes often performed lateral undulation when pegs were 2 mm but not 1mm high, and steep surfaces with short pegs where often impassable for this species. Boa constrictors used concertina locomotion more often than the other study species, and they usually did not perform lateral undulation until the height of pegs exceeded 2 mm. Some tradeoffs between proficient concertina and undulatory locomotion occurred between corn snakes and the stouter boa constrictors. By contrast, every aspect of the arboreal locomotor performance that has been documented for brown tree snakes appears to equal or exceed those of the other two more muscular study species, which also regularly climb trees.

S8.1−3 NEWMAN, Amy EM; University of Guelph;
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The influence of the early−life environment on adult stress physiology and fitness in the wild

Early−life conditions can have profound and lasting effects on physiology and behaviour throughout an individual's lifetime. For example, in captive songbirds, nutritional restriction or corticosterone treatment during early−life has been related to changes in hypothalamic−pituitary−adrenal (HPA) axis function, brain development and behaviour during adulthood. While exposure to pre− or post−natal stress often carries negative connotations, eco−physiologists are making progress towards understanding how the early−life environment programs offspring physiology and behaviour to match the anticipated environment and how phenotypic plasticity enables individuals to track fitness optima. However, how the effects of the early−life environment, specifically stress exposure, are manifested in the wild is not well understood. Using two long−term, marked, wild populations with high natal philopatry: Savannah sparrows (*Passerculus sandwichensis*) on Kent Island in the Bay of Fundy, New Brunswick and Red squirrels (*Tamiasciurus hudsonicus*) in Kluane, Yukon, I examine the ecological and physiological outcomes associated with early−life stress. Conducting large−scale field experiments in both of these wild systems, I describe the relationship between early−life conditions, adult stress physiology, survival and annual reproductive success.

S9.1−3 NEWSOME, Seth D.*; WOLF, Nathan; FOGEL, Marilyn L.; University of New Mexico, University of Alaska−Anchorage, University of California−Merced; *newsome@unm.edu*

Bulk tissue and amino acid $\delta^{13}C$ analysis shows that mice can use dietary lipids to build proteinaceous tissues

Understanding the mechanisms that govern the incorporation and routing of macronutrients from dietary sources into consumer tissues is a fundamental question in animal eco−physiology. Not only do these mechanisms play a potential role in influencing the selection and use of dietary items by consumers, but, in addition, these processes also determine the efficacy of techniques such as stable isotope analysis for studying animal ecology. By feeding growing mice (*Mus musculus*) one of four diet treatments in which the total dietary content of C_4−based lipids and C_3−based proteins varied inversely between 5% and 40%, we were able to examine the relationship between dietary proteins and lipids and mouse hair, blood, muscle, and liver. The difference in $\delta^{13}C$ between mouse tissues and dietary protein, or trophic discrimination factor, varied systematically among tissues and ranged from 3.1±0.10 to 4.5±0.60 (mean±SD) for low fat diets and 5.4±0.40 to 10.5±7.30 for high fat diets. In contrast, the difference in $\delta^{13}C$ between mouse tissues and bulk diet that had not been lipid extracted prior to isotope analysis ranged from 0.1±1.50 to 2.3±0.60 for all diet treatments. This pattern suggests flexibility in the routing of dietary macromolecules to consumer tissues based on dietary availability. We also analyzed the $\delta^{13}C$ composition of individual amino acids in mice muscle to determine the ultimate source of carbon in both essential and non−essential amino acids. Amino acid analysis shows that dietary lipid carbon is being used to synthesize non−essential amino acids. The $\delta^{13}C$ of essential amino acids did not change among dietary treatments showing that they are routed directly from dietary protein.

124.6 NEWTON, C*; BRACKEN, MES; THORNBER, CS; MCCONVILLE, M; RODRIGUE, K; Northeastern University, University of Rhode Island, University of Rhode Island;
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Seaweed invader spans multiple biogeographic provinces in the western North Atlantic Ocean

The invasion of the western North Atlantic Ocean by the red alga, Heterosiphonia japonica has provided a unique opportunity to study invasion dynamics across a biogeographical barrier. Native to the western North Pacific Ocean, the initial invaded range of this invader in the western Atlantic was restricted to Rhode Island, USA in 2007 and 2009. However, through subsequent subtidal community surveys, we document the presence of Heterosiphonia in coastal waters from Maine to New York, USA, a distance of more than 700 km. This geographical distribution spans a well−known biogeographical barrier at Cape Cod, Massachusetts. Despite significant differences in subtidal community structure between the two biogeographic provinces, Heterosiphonia was found at all but two sites surveyed north and south of Cape Cod, suggesting that this invader is capable of rapid expansion over broad geographical ranges. Across all sites surveyed, Heterosiphonia comprised 14% of the subtidal benthic community. However, average abundances of nearly 80% were found at some locations. Our surveys suggest that the high abundance of Heterosiphonia has already led to marked changes in subtidal community structure as we found significantly lower species richness in recipient communities with higher Heterosiphonia abundances. Heterosiphonia has also been impacting local beaches and was found as intertidal wrack in abundances of up to 65% of the biomass washed up along beaches surveyed. Based on temperature and salinity tolerances from European populations, we believe Heterosiphonia has the potential to invade and alter subtidal communities from Newfoundland to Florida in the western North Atlantic Ocean.

P1.17 NGUYEN, J.M.*; WEITEKAMP, C.A.; HOFMANN, H.A.; Univ. of Texas, Austin ; *mai.duyen.jwin@gmail.com*

Dopaminergic Regulation of Social Competence in a Cichlid Fish

Social competence (the ability to evaluate and respond to a wide variety of social cues) allows individuals to optimize their behavior based on the available social information. Although the fitness consequences are understood, little is known about the neural and molecular basis of social competence. Previous studies have shown that the dopamine system plays a central role in the context−dependent modulation of social behavior and in encoding salience and rewarding properties of social stimuli. We use the African cichlid fish, *Astatotilapia burtoni*, a model system in social neuroscience, to examine how dopamine D2 receptor pathways regulate decision−making across different social contexts. After repeated exposure to either a territorial male, a gravid female, or a non−gravid female, a large conspecific intruder is added to the tank of a focal territorial male. In each context, the focal male was treated with either D2 agonist, D2 antagonist, or saline. We found that social context has a significant effect on aggressive displays to the intruder, where focal males habituated to another male or to a gravid female displayed high levels of aggression compared to males habituated to a non−gravid female. In the context of a familiar male, D2 agonist treatment caused aggressive displays to be redirected from the intruder to the familiar male whereas the D2 antagonist had no significant effect. In the context of a gravid female, D2 antagonist treatment inhibited aggressive displays to the intruder while the D2 agonist had no effect. These results show that D2 signaling has opposing effects across social contexts and provide insight into our understanding of the role of dopamine in regulating social competence.

P1.46 NGUYEN, T.T*; HENDERSON, S.Y; BURNAFORD, J.L; University of Washington Friday Harbor Laboratories, Cerritos College, California State University, Fullerton; *vynguyen313@csu.fullerton.edu*

Effects of low tide conditions on the photosynthetic health of the kelp Saccharina sessilis

Intertidal seaweeds experience different environmental conditions during high and low tides, and stressful low−tide conditions may directly impact photosynthesis. We used laboratory manipulations to examine the effects of light and desiccation on the health of the canopy−forming low−intertidal kelp *Saccharina sessilis*. We predicted that high light and desiccation would cause health to decline over a single low tide. We simulated a 2 hour low−tide exposure with one no−emersion treatment (low light, no desiccation), and 4 emersion treatments: low stress (low light, low desiccation), high light (high light, ambient desiccation), high light + desiccation (high light, constant wind), and high light + hydration (high light, saltwater spray every 5 minutes). We measured photosynthetic potential as dark−adapted Maximum Quantum Yield (MQY) using pulse−amplitude−modulated (PAM) fluorometry, assessed tissue damage by quantifying the proportion of discolored blade area, and evaluated biomass loss by quantifying wet mass. We made measurements for three consecutive days following low−tide exposure to assess damage and recovery. High light severely reduced kelp health during low tide, but hydrated blades showed a strong ability to recover from this damage while desiccated blades did not recover. Blades which did not recover lost biomass: thus damage from even a single low tide exposure can have lasting consequences for the individual and the community as it affects the provision of shade for other organisms. Understanding how intertidal organisms respond to multiple simultaneous stressors is important in predicting the response of these communities to a changing climate.

P2.90 NICHOLAS, S.A.*; DAVIS, J.E.; Radford University, Virginia; *sanicholas@radford.edu*

Hormonal interactions between Royal Jelly and a juvenile hormone analog on Manduca sexta development.

Royal jelly is a secretion that, when consumed by honeybees (*Apis mellifera*), leads to the development of queens. Recent evidence suggests that hormones found within royal jelly, such as the protein royalactin, may alter the physiology of invertebrates other than just honey bees. In previous studies, both *Drosophila melanogaster* (Kamakura, 2011) and *Gromphorrdinia portantosa* have exhibited substantial physiological changes in development when treated with royal jelly. Research in our laboratory suggests that royal jelly interacts with juvenile hormone, or at least at points within the same hormonal axis. We studied the effects royal jelly and methoprene, a juvenile hormone analog, on *Manduca sexta*. Although the results of the project are only suggestive, due to high mortality rate, we have reason to believe that royal jelly and specifically the functional hormones within royal jelly, does indeed modulate the development of *Manduca sexta*. By determining the effects royal jelly has on *Manduca sexta* and other invertebrates we will expand our understanding of the mechanisms and evolution of arthropodal hormonal systems.

15.5 NIEDERMEYER, P/M*; SHIH, C; HALLEY, M/A; OSBORN, J/L; SCHMITZ, L; Pitzer College; *niedermeyer1023@gmail.com*

The effect of evolutionary transitions to diurnality on scleral ring and orbit morphology in birds

Diel activity pattern is considered one of the major axes of the morphological and functional diversity of vertebrate eyes. When examined in a broad comparative framework, the eye shape of diurnal, cathemeral, and nocturnal vertebrates corresponds well to predictions from physiological optics, with nocturnal species having the best ability to see in dim−light conditions. However, it has been suggested that evolutionary transitions to diurnality do not prompt a morphological response that correlates with lower light sensitivity, possibly reflecting decreased strength of selection. We investigated the effect of transitions to diurnality on skeletal visual morphology in birds, focusing on Strigiformes (48 species) and Caprimulgiformes (59 species, including Apodiformes). We collected linear measurements of scleral ring and orbit morphology that are closely correlated with visual light sensitivity: orbit length, a proxy for eye size; the optical ratio, an indicator of ocular image formation; and the optic nerve foramen index, considered a measure for retinal summation. We performed all analyses in a detailed phylogenetic framework, accounting for uncertainty in reconstructions by repeating the analyses over a sample of 1000 trees. While orbit length and the optic nerve foramen index show only little variation, the optical ratio is decreased in diurnal species, indicating lower light sensitivity. Our results show that evolutionary transitions to diurnality in birds are associated with changes in skeletal visual morphology, at least in parts of this functional system. It is possible that uncoupled evolution of visual performance features is a potential source of morphological diversity.

P3.56 NIELSEN, ME*; PAPAJ, DR; University of Arizona; *nielsenm@email.arizona.edu*

Interactions between two cooling mechanisms, color change and behavioral thermoregulation, in Battus philenor caterpillars

When organisms respond to an environmental change via phenotypic plasticity, they can often change several different traits, and the changes in these different traits may interact with each other and affect each other's expression and function. In *Battus philenor* (pipevine swallowtail) caterpillars, a change in environmental temperature can be responded to with behavioral thermoregulation, including leaving its host plant, or color change between a black and a red form. Using field enclosures, I have tested how a caterpillar's color affects its thermoregulatory behavior and vice versa and also how they jointly determine the caterpillar's temperature and fitness.

S6.3−1 NIJHOUT, H.F.*; REED, M.C.; Duke University; *hfn@duke.edu*

Homeostasis and dynamic stability of the phenotype: Implications for understanding the nature and evolution of robustness and plasticity

Metabolic networks have evolved diverse and unusual homeostatic mechanisms that stabilize critical reactions against genetic and environmental variation. These mechanisms achieve stability dynamically, by continually altering some reaction rates in order to keep critical reactions stable. Thus phenotypic stability occurs far from the steady−state of the system. Robustness exists in only restricted regions of genotype space, and we show that natural standing genetic variation in human populations is concentrated in these regions. Thus homeostatic mechanisms allow the accumulation of small−effect and largely cryptic genetic variation that has a low correlation with the phenotype. The region of genotype space where the phenotype is stable is not a property of the topology of the network but is a function of both genotype and environment. Therefore, genetic perturbations and/or environmental shifts that disrupt the homeostatic regime can increase phenotypic variation and the correlation between standing genetic variation and phenotypic variation. We illustrate these various effects by means of well−validated mathematical models for one−carbon, dopamine, and serotonin metabolism. Robustness and stability are never perfect and, because they are maintained dynamically, can be readily perturbed. Falling off the tightrope between stability and change is easy and, through the release of genetic variation, may be an important enabler of rapid phenotypic evolution. Although we use examples from metabolic systems, where quantification of mechanism is particularly accessible, we note that the same principles obtain in other homeostatic systems in physiology and development.

P3.47 NIKRAD, J*; TWEETEN, K; St. Catherine University, St. Paul, MN; *katweeten@stkate.edu*

Starvation−induced Changes in the Morphology and Physiology of Lumbriculus variegatus

Tissue degrowth occurs in some organisms when overwintering in natural habitats or subjected to food withdrawal in the laboratory. We monitored degrowth in the freshwater annelid, *Lumbriculus variegatus*, an oligochaete that can withstand up to six months of starvation. Significant reductions in biomass were observed in starved compared to fed worms. By the time starved worms began to die, their biomass had decreased by 83%. Degrowth resulted in substantial reduction in worm length and segment size without extensive decrease in segment number. Starved worms showed fewer cells than fed worms with little difference in cell size. Starved cultures asexually reproduced only during the first 12 weeks of starvation, doubling the population. During the same time period, fed cultures increased 7−fold in number. When cut to induce regeneration, starved worms formed new heads and generated new posterior segments. Although the number of new segments formed was less than that in fed worms, extensively starved worms continued to allocate energy towards regeneration and segment formation. Membrane−inlet mass spectrometry measurement of oxygen uptake and carbon dioxide release showed reductions in metabolic rate that were directly related to length of starvation. Throughout the starvation process, *L. variegatus* used mixed metabolism with gradual depletion of both lipid and glycogen. When fed after six months of starvation, worms doubled biomass within two weeks and began to reproduce asexually within four weeks. Our results indicate that the starvation response in *L. variegatus* is complex, involving morphological and physiological changes associated with energy−saving mechanisms. The ability of *L. variegatus* to survive and quickly recover from long−term starvation suggests that this annelid provides a useful system in which to study responses to caloric restriction.

39.3 NISHIKAWA, KC*; MONROY, JA; PACE, CM; Northern Arizona University, Denison University; *Kiisa.Nishikawa@nau.edu*

Understanding how motor commands and applied forces interact to determine muscle force output.

The goal of predicting how muscle forces change during natural movements remains elusive. Muscle models perform poorly at predicting muscle force during stretch or shortening, as well as in doublet potentiation and work−loop experiments. Yet these properties have crucial implications for understanding motor control. Our goal is to explore the ability of the winding filament hypothesis to inform our understanding of muscle force output. We used the muscular dystrophy with myositis (mdm) mouse, with a 779 bp deletion in the N2A region of the titin gene, to test the hypothesis that titin contributes to active force in doublet potentiation and work loop experiments. We performed doublet potentiation, isovelocity stretch and shortening, and work−loop experiments in soleus muscles from wild type and mdm mice. Doublet potentiation was 20% lower in mdm than in wild type soleus. Active force enhancement was lower and passive force enhancement was higher in mdm than in wild type soleus. In work loop experiments, force increases steeply upon activation during stretch and a single added stimulus greatly increases force during active stretch in wild type soleus. The additional force persists throughout the entire cycle, and disappears only upon return to the starting length. The doublet stimulus increases muscle work per cycle by 50%. Soleus muscles from mdm mice showed little increase in force upon activation during stretch, and the work per cycle was the same with and without the doublet. These results suggest that titin contributes to dynamic force output of active muscle, and demonstrate that the mdm mouse is an important model system for understanding how motor commands and applied forces interact to determine muscle force output.

67.4 NOTO, C.R.; University of Wisconsin−Parkside, Kenosha; *noto@uwp.edu*

Implications of Morphological Variation in the Manual Unguals of Theropod Dinosaurs

Among living tetrapods, research shows a strong correlation between claw shape and such factors as locomotor mode or predatory behavior. Using a similar approach to dinosaur unguals we may expect that differences in claw shape will follow ecological and/or evolutionary patterns. Theropod manual unguals vary greatly in overall morphology (size, length, curvature), yet their shape has not been studied in detail. A geometric morphometric analysis was applied to images of 200 claws, representing over 80 theropod taxa, including early birds. Results of principal components analysis (PCA) show that most shape variation occurs in two areas: the degree of nail curvature and nail size relative to the ungual body. Statistical analysis between theropod clades shows coelurosaurs fill a much larger proportion of shape space than non−coelurosaurs suggesting greater ecological diversification. The claws of non−coelurosaurs appear exclusively predatory in function, likely being used as giant hooks or gaffes to hold prey. Within different coelurosaur clades, the evolution of ecological specializations is recorded in changing claw shape as one moves toward derived members of a group, for example the evolution of elongated, straight claws in herbivorous ornithomimids. The claw shape of some small paravians (including birds) falls outside other groups and may represent a specialization for climbing. This novel approach allows one to explore ecological differences between theropod species and higher taxa, including food preference and predatory behavior, though correlating specific behaviors with claw shapes may be premature at this time. Furthermore, these results may aid in understanding the evolution of the theropod manus, its functional changes, and yield important character data useful for cladistic analyses.

P3.148 NOTO, C.R.*; ZANNO, L.E.; WITYNSKI, D.; MEYER, K.; University of Wisconsin−Parkside, Kenosha, North Carolina Museum of Natural Sciences, N.C. State Univ., Raleigh, University of Wisconsin−Parkside, University of Wisconsin−Parkside; *noto@uwp.edu*

Quantifying the Relationship Between Curvature and Sheath Length in Bird Claws

Many studies have related the claw geometry of birds (size, curvature, etc.) to ecology with varying success. However, to date, ecomorphological correlations have considered the morphology of the whole claw, without attention to the bone core component. Tetrapod unguals (claws) are composite structures formed from an internal bone core and superficial keratinous sheath. It is assumed that the distal extension of the keratinous sheath beyond the bone core remains constant across claw morphologies, yet this has not been measured empirically. Here we present results from a dataset consisting of 200+ specimens from 150 taxa representing most major bird orders. Claw images were captured in lateral view using a custom−built, high resolution, digital X−ray unit. Bone core radius (core length), whole claw radius (claw length), and bone core angle (core angle) were measured using the software ImageJ. The proportion of the claw length made up by the core length was calculated to remove the effect of size. Results indicate that the contribution of the sheath to total claw length varies with the bone core curvature. As the core angle decreases (becomes more trenchant), the proportion of the total claw length made up by the keratinous sheath decreases. This relationship spans all bird orders tested, yet varies in strength across clades. We suggest that this relationship has both biomechanical and phylogenetic components warranting further study. Characterizing core/sheath relationships in birds is an important tool for identifying ecomorphological relationships in extinct theropod dinosaurs and a first step toward extending these patterns to tetrapods in deep time.

43.3 NOWINOWSKI, I*; BALABAN, J; WILGA, C; University of Rhode Island, University of Rhode Island ; *inowinowski@my.uri.edu*

Shape Changes in Hyoid Arch Elements in Four Shark Species

Hyoid depression aids in oropharyngeal expansion and is crucial for suction generation in sharks. The hyoid arch is medial to the jaws and is made up of paired hyomandibular cartilages (HY) dorsally, paired ceratohyal cartilages (CH) ventral to the HY, and a single, medial basihyal cartilage (BH) that interconnects the two sides. The coracohyoideus muscle pulls the BH down and back, which in turn swings the CH down and back, creating substantial bending forces in the CH. Suction feeders are expected to have robust hyoid elements to withstand suction forces. Bite feeders are expected to have relatively more gracile elements, since strong, rapid jaw adduction is more critical to prey capture. Shape differences in BH, CH, and HY elements were studied in bamboo (suction feeders and crush processors), sandbar (bite feeders and bite processors), smoothhound (bite capturers and crush processors), and dogfish (intermediate feeders and bite processors) sharks using 2D geometric morphometrics. Two to four landmarks were digitized on the lower and upper cranial articulation and 46 to 58 equidistant semi−landmarks were digitized along the outline. Covariance matrices, procrustes coordinates, principal component analyses, and discriminant analyses distinguish the shapes of elements and determine changes among species. The CH and BH are similar in the two species with similar capture style (robust in suction, slender in bite), while the HY is similar among the species with similar processing style (extra processes on bite compared to crush).

P3.182 NUGENT, BM*; STIVER, KA; ALONZO, SH; HOFMANN, HA; Yale University, Southern Connecticut State University, University of Texas at Austin; *bridget.nugent@yale.edu*

Transcriptomics and behavioral endocrinology of alternative reproductive tactics

Understanding the proximate mechanisms that give rise to variation within and across species is critical to understanding the origins of biodiversity. The male ocellated wrasse (Symphodus ocellatus) is an ideal model system to study the underpinnings of diversity because it displays multiple reproductive tactics in the wild. Three distinct phenotypes are observed in the male ocellated wrasse. Large, colorful nesting males build and defend nests and provide paternal care. Small, parasitic sneaker males covertly slip into the lairs of nesting males to spawn, but take no part in paternal rearing. Satellite males are intermediate in size, assist the nesting males in nest defense, and sneak matings. The reproductive tactics of the ocellated wrasse have been extensively studied in the field, yet the biological underpinnings of their marked physical and behavioral differences remain unknown. Circulating hormone levels differ between male morphs and likely create differences in gene expression among males, underlying their disparities in physiology and behavior. We used RNA−seq to generate brain transcriptomes for nesting males, satellites, sneakers, and females. We quantified gene expression differences between each phenotype and predicted that this approach would provide us with candidate genes involved in the expression of alternative phenotypes in this species. Next, we quantified candidate gene expression in the specific regions of the ocellated wrasse brain putatively associated with reproductive behaviors and paternal care. Ongoing and future work will investigate the influence of hormone manipulations on candidate gene expression and behavior in the wild ocellated wrasse.

76.4 NULL, RW*; KRUP, AL; SINHA, M; PATEL, NH; Univ. of California, Berkeley, Univ. of California, San Francisco; *ryan.null@berkeley.edu*

An Integrative Approach to Dissecting the Nanoscopic Morphogenesis of Structural Color in Butterflies

The adaptive evolution of animal coloration is influenced at both micro and macroevolutionary levels by sexual selection and predation resulting in many well−known phenomena such as sexual dimorphism, crypsis, aposematism, and mimicry. Coloration itself is best understood as the product of pigmentation of the mesoderm and ectoderm of an organism. However, there is a second means of coloration, structural coloration, which is created by repeating "structural" elements on the order of 100nm that manipulate the physical properties of light. Despite being found in all bilaterian phyla, the developmental mechanisms producing these structures are poorly understood. The cellular nanostructures used by butterflies to make color on their wings have been shown to be of diverse organization despite arising on homologous cell types. We are using several species of butterfly to investigate the underlying cell biology of how structural color is built and evolves. Our work to date on the cytoskeleton in *Papilio palinurus* has demonstrated a radical reorganization of cortical actin immediately preceding the formation of the species' color−producing structure. We are further dissecting the developmental mechanisms leading to the creation of structural coloration using an ex vivo system that we believe will allow us to experimentally manipulate these butterfly systems.

26.3 NYAKATURA, J.A.*; ALLEN, V.R.;
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Sprawling locomotion: how similar are kinematics and dynamics in a sample of five phylogenetically, ecologically and morphologically diverse tetrapods?

Sprawling locomotion is utilized by a wide range of extinct and extant non−erect species. Moreover, this locomotor mode likely is basal to crown group tetrapods and thus fundamental for the understanding of terrestriality in tetrapod evolution. Sprawling locomotion is characterized by complex three dimensional movements of the limbs, including important long−axis−rotation of the humeri and femora. This made quantitative comparisons notoriously difficult in the past. To identify common principles in the locomotor mechanics of tetrapods, we currently study the locomotor mechanics of the fore− and hindlimbs in four phylogenetically, ecologically and morphologically different species: metamorphosed axolotls (*Ambystoma mexicanum*), ribbed newts (*Pleurodeles waltl*), blue−tongued skinks (*Tiliqua scincoides*), green iguanas (*Iguana iguana*), and spectacled caimans (*Caiman crocodylus*). We use x−ray reconstruction of moving morphology (XROMM) and simultaneous ground reaction force measurements of individual limbs to study the kinematics and dynamics of these species' sprawling locomotion. Differences in relative limb segment proportions of our sample inevitably lead to kinematic differences. We are interested in how the kinematic differences are reflected in the contributions of individual limb joints to progression. This knowledge could be used to constrain paleontological inference of locomotor characteristics in early crown group tetrapods.

P3.137 NYAKATURA, J.A.*; ANDRADA, E.;
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Biomechanic effects of the coordination of head bobbing and footfalls during locomotion in quail

Head bobbing of birds is considered a primarily opto−motoric phenomenon that improves vision. It comprises of a hold and a thrust phase and has been shown to be coordinated with footfalls during locomotion of many birds, including quail. During terrestrial locomotion the body's center of mass (CoM_{body}) of birds is subjected to rhythmic changes of its potential and kinetic energy. CoM_{body} energy patterns characteristically change with gait and allow broadly discriminating between walking and running. Without compensation, any vertical oscillations of the trunk potentially conflict demands of vision (i.e., ocular stability). We tested the hypothesis that timing of head bobbing is a means to mitigate the conflicting demands of vision and locomotion using x−ray motion analysis and simulation of quail locomotion. We found significant differences in the timing of head bobbing between gaits that corroborate our hypothesis. Forward thrust of the head (eyes) sets in later in trials with walking (vaulting) mechanics than in trials with running (bouncing) mechanics in concert with expectations based on vertical fluctuations of the body's potential energy in vaulting and bouncing models. By simulating altered timing of head−body−coordination we further show that the timing limits the vertical displacement of the head and has a compensating effect on the potential energy fluctuation of CoM_{body}. The first is clearly advantageous for vision, the latter is potentially indicative of an energy saving mechanism during constrained locomotion with necessary head bobbing.

P1.199 O'BRIEN, H.D.; Ohio University; *haley.d.obrien@gmail.com*
Macroevolutionary Impact of Hypothesized Artiodactyl Key Innovations

Many fruitful macroevolutionary studies focus on extreme differential survivorship of phenotypically similar clades, such as the ungulate orders Artiodactyla and Perissodactyla. Although similar in phenotype, life history, and historic diversity, there are 14−fold more artiodactyl taxa. This pattern of extant diversity coupled with a rich fossil record renders ungulates an intriguing model to investigate mammalian evolutionary trends. Here, novel phylogenetic comparative methods and fossil−based evidence are used to examine whether hypothesized artiodactyl key innovations (foregut fermentation [FF] and thermoregulatory cranial vasculature [TCV]) have influenced ungulate diversification and extinction rates. First, diversification and extinction rates were calculated from a time−calibrated mitochondrial phylogeny of Euungulata. Three peaks in diversification were identified: the middle Eocene, the early Miocene, and across the Pliocene and Pleistocene, when the majority of modern taxa arise. Next, presence/absence of FF and TCV were mapped onto the phylogeny, and binary−state speciation and extinction analyses were used to calculate trait dependent diversification rates. Among extant taxa, these rates are not significantly different for each proposed key innovation likely due to significant trait distribution overlap among living ungulates. Therefore, these traits were sought in fossil specimens, using osteological correlates for TCV and dental proxies for FF. Data from fossils reveals that few extinct ungulate clades overlap in distribution of TCV and FF, and that the origins of these specialized features coincide temporally with peaks in diversification rates. Incorporation of diversification patterns among extinct taxa supports the hypothesis that unique digestive and thermoregulatory physiologies are contributing to the generation of modern ungulate diversity.

P1.77 O'CONNELL, K.J.*; DEAROLF, J.L.; RICHMOND, J.P.;
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Effect of prenatal steroids on the citrate synthase activity of the guinea pig external abdominal oblique

Glucocorticoids, a class of steroid hormones, are often used to stimulate lung development and combat mortality in the infants of women at risk of premature birth. Studies have shown improvement in the lung function of premature infants following gestational exposure to betamethasone, a glucocorticoid. However, the effects of glucocorticoids on the development of ventilatory muscles are not widely known. Studies in our laboratory demonstrated an increase in oxidative enzyme activity in fetal guinea pig scalenus muscles exposed to prenatal steroids compared to scalenus muscles not exposed to the steroid. Thus, we hypothesize that external abdominal oblique (EAO) muscles exposed to betamethasone during gestation will show greater oxidative enzyme activity than EAO muscles not exposed to the prenatal steroid. The activity of citrate synthase (CS), an enzyme involved in aerobic metabolism, will be measured by running enzyme kinetic assays on EAO muscles of guinea pig fetuses exposed to betamethasone or sterile water twice a week at 65%, 75%, and 85% gestation. The CS enzyme kinetic assay will be conducted on control and treated EAO muscles under the following conditions: 50 mM imidazole, 0.25 mM DTNB, 0.4 mM acetyl−CoA, and 0.5 mM oxaloacetate, pH 7.5 at 37°C. Data will be analyzed to determine if glucocorticoid exposure significantly increases CS activity in the EAO muscles of treated fetuses compared to those exposed only to sterile water. If the hypothesis is supported, babies exposed to prenatal steroids may have breathing muscles with significantly higher oxidative capacity and therefore, greater fatigue resistance than the muscles of babies not exposed to the steroid.

28.1 O'CONNOR, CM*; MARSH−ROLLO, S; CORTZ GHIO, S; HICK, K; TAN, J; WONG, MYL; REDDON, AR; AUBIN−HORTH, N; BALSHINE, S; McMaster University, Universite Laval, University of Wollongong, Universite Laval; *coconn@mcmaster.ca*

Two closely related cichlids with divergent social systems differ in socially relevant behaviours and molecular pathways

It is widely assumed that complex social behaviours arise from modifications to simpler behaviours and via small changes to the underlying molecular pathways. However, few empirical studies have explored variation between species in simple dimensions of social behaviour in conjunction with proximate mechanisms. Here, we make use of the diversity of social systems that have arisen through the radiation of African cichlid fishes to compare socially relevant behaviours and related molecular pathways between closely related cichlids with similar mating behaviour and ecological niches but divergent social systems. We found individuals of the group−living species displayed higher social motivation and more sophisticated conflict resolution strategies than individuals of the non−grouping species. Furthermore, individuals of the group−living species had higher brain gene expression of the neuropeptides isotocin and vasotocin (the teleost fish homologues of oxytocin and vasopressin, respectively) and their receptors than did the non−grouping species. These results suggest that simple behaviours related to social motivation and conflict resolution are an important component of an overall group−living social system. Furthermore, we provide support for the notion that isotocin and vasotocin play a role in modulating social behaviour in cichlid fishes. Together, the combination of laboratory and field−based, behavioural and molecular results contribute to our understanding of how social systems evolve at the level of both simple behaviours and the underlying molecular mechanisms.

43.2 O'KEEFE, F. R. ; Marshall University; *okeefef@marshall.edu*

Ecological Determinants of Clinal Morphological Variation in the Cranium of the North American Gray Wolf

The gray wolf, *Canis lupus*, exhibits both genetic and morphologic clinal variation across North America. While shape variation in wolf populations has been documented, no study has been made to exhaustively quantify it, or attempted to formally correlate morphology with environmental variables. This study utilizes a large historical database of gray wolf skulls to analyze shape, and attempts to correlate it with wolf ecology. The data set comprised 15 linear measurements from 289 gray wolf crania, distributed from Alaska to Mexico. Also, associated locality data was used to compile temperature and precipitation information for each occurrence. A variety of statistical tests were employed; size and shape were examined through a principal component analysis and a calculation of allometry vectors. Multiple regression analysis (both global and stepwise) was then used to test the resulting principal components against various biotic and abiotic factors. In addition, the effects of sexual dimorphism and sub−species taxonomy on morphology were explored through one−way ANOVA and canonical variates analysis, respectively. Several patterns were revealed, including size increase with latitude in accord with Bergmann's rule. Static allometry is significant, the fundamental pattern being a decrease in the robusticity of the basicranium relative to the viscerocranium. Sexual dimorphism, allometry, and a correlation with precipitation are other key elements showing connections to morphology. Examination of these patterns allows conclusions about the direct and indirect ways that temperature and precipitation drive clinal variation in gray wolves.

P2.23 O'REILLY, K.M.*; ZHANG, J.; DENNIS, T.E.; Univ. of Portland, Oregon, Univ. of Auckland, New Zealand; *oreilly@up.edu*

Characterizing Behavior States of Little Penguins in Wellington Harbour, New Zealand

Little Penguins (*Eudyptula minor*) are well known throughout New Zealand and southern Australia for their habit of returning to nesting colonies in nightly penguin parades. What is less well known is how they behave before returning to land. Using small, lightweight GPS tracking devices and temperature−depth recorders (TDR), we identified three behavioral states in a sample of eight Little Penguins during the guard stage of nesting at Matiu/Somes Island in Wellington Harbour, New Zealand. Immediately after leaving the colony, penguins rested on the water, drifting slowly with fairly straight tracks. Commuting commenced around 5:30am with fast, straight trajectories. Finally, feeding was identified by sharp turning angles, slow speeds, and the loss of GPS signals, indicating diving behavior when coupled with recordings from TDR. Behavioral Change Point Analysis and K−means Clustering were effective methods to analyze data from tracking devices attached to Little Penguins, providing insight to their off−colony activities.

31.3 OAKLEY, TH*; LEUNG, N; TORRES, E; Univ. of California, Santa Barbara; *oakley@lifesci.ucsb.edu*

Origin of luciferase genes in cypridinid ostracods (Crustacea) by gene duplication

How new traits originate is a central question in evolutionary biology, but the molecular changes that lead to evolutionary novelty are often difficult to determine. We aim to identify the molecular changes that gave rise to bioluminescence in cypridinid ostracods, which use bioluminescence for anti−predator displays and mating signals. Cypridinid bioluminescence occurs when luciferase proteins are secreted from the "upper lip", a glandular structure above the mouth also involved in digestion. To date, only two luciferases are described from cypridinid ostracods, even though bioluminescence is present in approximately 100 species in the family. We obtained sequences similar to known luciferases from Illumina transcriptomes of multiple luminescent and non−luminescent cypridinid species. We also found genes similar to luciferase that lack secretion signals and therefore could not function in the behavior. We confirmed luciferase function of a multiple genes by expressing the proteins in cell culture and performing light reaction assays. We hypothesize that cypridinid luciferase originated by duplication of vWF−D−domain containing digestive proteins secreted from the upper lip of non−luminescent ostracods. We characterized the efficiency of light reactions for three different paralogs that we call luciferase 1, luciferase 2 and protoluciferase. We see a step wise increase in enzyme efficiency from no activity in protoluciferase to highest activity in luciferase 1. Most of the protein is under purifying selection, but two sites show a pattern consistent with diversifying selection. We also report differences in enzyme kinetics in the luciferase proteins of species that differ in bioluminescence behavior. We pose the hypothesis that enzyme kinetics could be related to bioluminescence behavior.

P1.175 OKHOVAT, M.*; BERRIO, A.; OPHIR, A.G.; LYSAK, N.; PHELPS, S.M.; Univ. of Texas at Austin, Austin, Cornell Univ., Ithaca, Univ. of Florida at Gainesville, Gainesville; *mariam.okhovat@mail.utexas.edu*

Balancing selection promotes epigenetic variation in prairie vole spatial memory circuit

Evolutionary theory suggests balancing selection should shape the genetic underpinnings of many social behaviors, but few examples exist. Prairie voles are socially monogamous rodents that exhibit a significant degree of extra−pair paternity. Aspects of male mating tactic are regulated by the neuronal expression of vasopressin 1a receptors (V1aR). The retrosplenial cortex (RSC) has been implicated in spatial memory and exhibits highly variable V1aR abundance. Among male prairie voles, RSC−V1aR predicts differences in space use and sexual fidelity. Males with high RSC−V1aR form exclusive home−ranges and mate exclusively within a pair, while those with low RSC−V1aR intrude often and engage in extra−pair fertilizations. To characterize the genetic correlates of this neuronal and behavioral variation, we sequenced ~1kb of coding sequence and ~7kb of non−coding sequence from 40 lab−reared and 30 wild−caught prairie voles. We found two intron SNPs and one 5' SNP that strongly predicted RSC expression in both populations ($P<0.001$). Interestingly, the high−expressing allele was associated with fewer CpG sites, and lab−reared animals exhibited a significantly stronger influence of genotype than did wild−caught animals ($P<0.002$). Among wild−caught animals, intron CpG methylation was negatively correlated with RSC−V1aR ($P<0.0001$). An HKA test shows an excess of polymorphism around the intron SNPs ($P<0.01$), a pattern consistent with balancing selection at these sites. Together our data suggest that trade−offs between intra−pair and extra−pair paternity drive balancing selection on the epigenetic regulation of *avpr1a* in a spatial memory circuit.

P3.108 OKOSODO, C.; EDWARDS, T.*; Louisiana Tech University, Ruston LA; *cok002@latech.edu*

Effects of Nitrate on Schistosomiasis Snail Hosts

Nitrate levels are constantly increasing in aquatic ecosystems due to fertilizer and sewage runoff. The resulting excess environmental nitrate promotes primary production, including algae blooms, and can directly impact animals through endocrine disruption. This study was done to test the effects of nitrate on growth and reproduction of freshwater snails *(Biomphalaria glabrata)* that are intermediate hosts to parasitic worms that cause schistosomiasis. About 200 million people worldwide are infected, making schistosomiasis second only to malaria in its devastating effects on people. The snail hosts and parasites are often more common in water polluted by nitrate. Increased snail densities may simply be due to increased plant and algal food availability promoted by high aquatic nitrogen. However, here we test an alternative hypothesis that nitrate promotes snail growth and reproduction directly through interactions with their physiology. Snails were exposed to environmentally relevant doses of nitrate (0, 5, 10, 15, 30, and 50 mg/L NO_3−N). We monitored snail growth; fecundity; time to first, second, and third egg clutches; mortality; and egg viability. Results from this study will expand our understanding of ecological connections between schistosomiasis prevalence and nitrogen pollution.

8.5 OLSEN, AM*; WESTNEAT, MW; Univ of Chicago, Field Museum of Natural History; *aolsen@uchicago.edu*

Variation on an Old Articulation: Diverse material properties of a key joint underlying avian cranial kinesis

Bird beaks are known for their fantastic variation in shape and diversity of functions, including feeding, preening and vocalizing. But birds are additionally diverse in how they move their beaks. It has been demonstrated that several bird species, from sparrows to mallards, can move not only their lower beak but their upper beak as well. In most birds, movement of the upper beak depends on a flexible joint between the frontal and nasal bones, called the nasofrontal joint. While there have been many studies of beak shape diversity, there has not been a single comparative study of the material properties of the nasofrontal joint across birds. We have developed a new method to cheaply and accurately measure joint torsional resistance in biological specimens. Applying this method, we measured the torsional resistance of the nasofrontal joint to upper beak protraction (raising of the upper beak) in fresh−frozen specimens representing several bird orders. We present the first evidence that this key joint has diverse material properties across birds. This dataset provides an opportunity to test whether the material properties of the nasofrontal joint are related to beak function and a first chance to test hypotheses on the potential function or functions of cranial kinesis in birds.

PLEN.1 Olson, R; www.randyolson.com

Storytelling skills: Now mandatory for a career in science

Randy Olson is a scientist−turned filmmaker, who earned his Ph.D. with former SICB President Ken Sebens. Randy was a Professor of Marine Biology at the Univerersity of New Hampshire until he became an independent filmmaker. Randy is the creator of Flock of Dodos, a documentary film focused on controversies associated with teaching evolution in schools, and Sizzle: A Global Warming Comedy, both award−winning films. He is also the author of Don't Be Such a Scientist: Talking Substance in an Age of Style, which presents a model for effective communication of technical information to a broad audience. http://www.randyolsonproductions.com/

52.2 ORR, T.J.*; BRENNAN, P.L.R.; UMass Amherst; *tjorr@cns.umass.edu*

Genital evolution in bats− a study of glans elaboration

Genitalia are extraordinarily diverse and likely evolve via several processes, primarily sexual selection. The mechanisms include male−male competition (sperm competition), selection for female stimulation (cryptic female choice) or sexually antagonistic coevolution (conflict between the sexes for control of fertilization). How these processes shape genital evolution when mating system and reproductive physiology vary independently is unclear. Bats present a diverse, generally well−studied speciose group within which to investigate how male genital elaborations might vary in the context not only of sexual selection but also physiology and phylogeny. Amid the assorted ecologies and mating systems of bats are three types of reproductive delays including; delayed fertilization, implantation and development. Delayed fertilization (DF) occurs when females store sperm for extended periods before ovulating. By increasing the time over which fertilization occurs, species with DF may experience increased sperm competition and females may store and select among sperm from multiple mates. Previous studies concluded that baculum morphology is not associated with level of promiscuity, thus we investigated glans elaboration. We expected taxa with DF to have more elaborations to allow locking, sperm removal, sperm transfer or female stimulation. Using Scanning Electron Microscopy we examined the glans penis surface of multiple bat species to determine if the presence of penile spines relates to DF, mating system and/or phylogenetic relationships. Although there are significant phylogenetic relationships in the presence and type of penile spines (e.g., Phyllostomid bats lack spines, Mollossid bats usually have spines) the relationship is complicated by both physiological mode and other biological attributes. We discuss these complications and present the results of this study integrating behavior and physiology to evaluate genital evolution.

S10.3−2 ORTEGA−JIMENEZ, VM*; DUDLEY, R; Univ. of California, Berkeley; *vortega@berkeley.edu*

HUMMINGBIRD FLIGHT AND SHAKING IN RAIN

Raindrop impact and body wetting potentially pose challenges for all animals flying in a downpour. Hummingbirds are of special interest in this regard because, in spite of their small size, they can be seen foraging even in extreme rainfall. Using an experimental rain apparatus, we found that hovering Anna's Hummingbirds (*Calypte anna*) exposed to light−to−moderate rain (i.e, 70−180 mm/hr) showed only small marginal effects on flight kinematics. By contrast, birds under heavy precipitation (i.e., 270 mm/hr) oriented their bodies more horizontally and increased wingbeat frequency while reducing stroke amplitude. No loss of flight control was evident, but mechanical power expenditure during flight was estimated to increase by about 9%. Hummingbirds also intermittently performed rapid head and body shaking to expel water from their plumage while perching and, surprisingly, even during flight. Speeds and accelerations of the trunk and tail were similar between aerial and perched shaking, but values for head motions when perched were twice as high as those during aerial shakes. Angular displacement during shakes reached values >180° for the head, >45° for the body trunk, and >90° for the tail and the wings. Feather flexibility plays an important role in increasing drop ejection during shaking, and in absorbing the impact forces associated with individual raindrops.

122.6 OSBORN, M.L.*; GE, J.; MELANCON, K.P.; RAU, A.R.P.; HOMBERGER, D.G.; Louisiana State University, Baton Rouge; currently University of Georgia, Athens, Louisiana State University, Baton Rouge, Louisiana State University Health Sciences Center, New Orleans; *michelleosborn@msn.com*

Bad Posture and its Effects on the Neck and Shoulder Suspension Apparatus of Humans: A 3D Biomechanical Analysis

Bad posture and misalignment of the neck in humans cause clinical issues that significantly affect the quality of life of individuals. An understanding of the physical configuration and biomechanics of the neck and its associated parts in various postures is fundamental for successful treatments. We have re−conceptualized the human head, neck and shoulders as an integrated functional complex (i.e., the shoulder suspension apparatus) and have hypothesized that habitual bad postures (e.g., forward−head posture) lead to changes in the balance of forces acting on this apparatus. We reconstructed the data of an x−ray CT scan of an individual to create 3D models of the shoulder suspension apparatus in a "good" healthy posture and in a "poor" forward−head posture. We analyzed these models with the free−body diagram force analysis in 3D. In a good posture, the head and neck are stabilized by the core muscles, the nuchal ligament is relaxed, and the shoulders are suspended from the head by fascia and the connective tissue of the clavotrapezius and cleidomastoid muscles. In the forward−head posture, the nuchal ligament and various muscles are recruited to re−balance the shoulder suspension apparatus, which, in turn, may cause tightened muscles, myo−fascial pain, poor circulation to the head, head−aches, and inflammation of the joints.

78.2 OTERO, L.M.; HUEY, R.B.*; GORMAN, G.C; University of Puerto Rico, Rio Piedras, University of Washington, Seattle, Paso Pacifico, Ventura, California; *hueyrb@uw.edu*

A Few Meters Matter: Micro−Landscape Variation in Reproduction and Reproductive Cycling a Tropical Lizard

Reproductive cycles and intensity in lizards often vary intraspecifically over geographic scales, in part driven by geographic variation in influential environmental factors such as temperature, rainfall, and photoperiod. Some species, however, occupy multiple habitats at single localities. Whether reproductive cycles vary on a micro−landscape scale has been largely unstudied. In lowland Puerto Rico, the lizard *Anolis cristatellus* often occupies both open (sunny, warm) and deeply forested (shady, relatively cooler) habitats that may be only meters apart. In open habitats this lizard thermoregulates carefully and achieves high and stable body temperatures (weather and season permitting); but in adjacent forests it is a thermoconformer and has lower and more variable body temperatures. We studied the annual cycles of female reproduction in open vs. forest habitats at two localities. Reproductive intensity and phenology differed strikingly between habitats: females in open habitats were more likely to be reproductive throughout the year −− especially in winter −− than were females in adjacent forests. In fact, these between−habitat differences are similar in magnitude to those for populations separated by hundreds of meters in elevation. Environmental differences matter, even on a micro−landscape scale. Reproduction in *Anolis cristatellus* is extremely sensitive to thermal micro−environments.

130.4 OUFIERO, C.E.*; GARTNER, G.E.A.; Towson University, Museum of Comparative Zoology; *coufiero@towson.edu*

The effect of parity (oviparous vs. viviparous) on morphological evolution among Phrynosomatidae

A major transition in life−history evolution is the shift from egg−laying (oviparity) to live birth (viviparity). Viviparity has evolved independently multiple times among vertebrate taxa, with an estimated 100 transitions among squamates alone. Shifts in the mode of reproduction are often accompanied by changes in reproductive physiology and anatomy. Less well−studied are evolutionary consequences of changing reproductive mode on aspects of the body plan not directly related to reproduction. For instance, retention of eggs to produce live young has been proposed to affect locomotor abilities, while the production of eggs may impose certain physical constraints on the pelvic girdle. We therefore might expect that the transition from oviparity to viviparity will affect evolutionary rates of diversification for certain functionally relevant morphological traits. We tested the effect of parity on the evolution of morphological diversity in 108 species of North and Central American phrynosomatid lizards−−which have an estimated six independent transitions to viviparity−−by examining phylogenetically size corrected pelvic, limb and head traits. After mapping parity mode transitions to a recent, time calibrated phylogeny with SIMMAP software, we compared seven evolutionary models that vary in their parameter estimation and mode of evolution for each trait across a sample of SIMMAP trees using the OUwie package in R. Preliminary results suggest that an Ornstein−Uhlenbeck evolutionary model best explains the data often with separate optima for the two reproductive modes. Further, for some traits, viviparous species tend to have increased diversification suggesting physical constraints related to egg laying may limit morphological evolution.

53.1 OUYANG, JQ*; LENDVAI, AZ; DAKIN, R; DOMALIK, AD; FASANELLO, VJ; VASSALLO, BG; HAUSSMANN, MF; MOORE, IT; BONIER, F; Virginia Tech, Queen's Univ, Queen's Univ, Bucknell Univ; *jqouyang@gmail.com*

Breeding under stress: physiological factors influencing nest failure during inclement weather conditions

Brood desertion represents a major reproductive decision, especially for short−lived species that have one breeding attempt per year; however, how animals integrate internal and external conditions to mediate this decision remains to be clarified. Endocrine systems, and in particular glucocorticoids (GCs), a group of highly conserved steroid hormones, are emerging as likely candidates for the regulation of reproductive decisions, as they link environmental stimuli and phenotypic expression. While slight elevations of adult GC levels can increase parental effort during the breeding season, large increases in circulating GCs can have the opposite effect by decreasing parental investment (for instance by causing brood desertion). To investigate the effects of GCs on reproductive decisions, we experimentally increased corticosterone levels in free−living adult female tree swallows (Tachycineta bicolor) during the chick−rearing stage using pellet implants. Incidentally, a period of inclement weather caused 92% of the nests in our study population to fail, which allowed us to analyze the factors that predicted brood desertion. Corticosterone treatment of mothers did not affect offspring survival. When analyzed in combination with weather conditions however, high wind speeds, low ambient temperature, and corticosterone treatment were all associated with reduced offspring survival. High parental feeding rates of the female, but not the male, were associated with increased brood survival time. Our results demonstrate the effect of corticosterone on reproductive decisions under extreme environmental conditions.

P3.62 OWINGS, AA*; YOCUM, G; RINEHART, J; KEMP, W; GREENLEE, K; North Dakota State University, USDA; *aowings27@hotmail.com*

The effect of post−diapause development on respiratory function in the alfalfa leaf−cutting bee, Megachile rotundata

Megachile rotundata, the alfalfa leaf−cutting bee, is a solitary, cavity−nesting bee. *M. rotundata* develop inside brood cells constructed from leaf pieces and sealed with the female's saliva. During development, *M. rotundata* may experience hypoxic conditions from the cavity in which they reside; oxygen levels may vary based on the bees' positions within the cavity. They may also be exposed to hypoxia inside the enclosed brood cell itself. To date, no measurements have been made of the oxygen levels inside a brood cell. To test the hypothesis that pupal bees are tolerant of hypoxia, we measured critical PO_2 (Pc) in pupal *M. rotundata* of varying ages. Pc is defined as the minimum atmospheric oxygen that can sustain a rate process and provides information about respiratory capacity. We measured CO_2 emission rates using flow through respirometry. Bees were exposed to 21%, 10%, 6%, 5%, 4%, 3%, 2%, 1% and 0% oxygen. Pc was determined by comparing mean CO_2 emission in each gas mixture. In support of our hypothesis, the mean Pc was 4% oxygen and ranged from 0% to 10%, similar to that of other insects. Pc was positively correlated with age. As pupae aged, they were less tolerant of hypoxia. To determine if there were developmental changes in tracheal structures that account for the variation in Pc, we used synchrotron x−ray imaging. No visible respiratory movements were detected in hypoxia from bees at various stages of pupal development. Analyses of tracheal diameter showed that abdominal tracheae increased in size as animals aged, while those in the head did not. Understanding the structural basis for the change in Pc will require 3D modeling of whole animal tracheal systems.

60.3 OZPOLAT, B. D.*; BOROVIKOV, A.; ZATTARA, E. E.; BELY, A. E.; University of Maryland, College Park; *dozpolat@gmail.com*

Development and evolution of the enigmatic lateral line of clitellate annelids

The lateral line is a bilateral cord of cells that has been described in many clitellate annelids, but its function and homologies remain enigmatic. It has been proposed to be homologous to lateral organs in polychaetes, and even to the vertebrate lateral line. The tissue origin and function of the clitellate lateral line is poorly understood, although early work suggested it may be muscular, neural, or sensory. We investigated the formation of the lateral line during post−embryonic development (fission and regeneration) in the annelid *Pristina leidyi*, which has a clearly delineated lateral line. Using cell proliferation assays, we found that cells that will form the lateral line arise very early during regeneration and then undergo little to no subsequent cell division. We have cloned a number of Wnt signaling pathway genes and find that several of these are expressed in a segmentally iterated pattern in the lateral line in uncut, regenerating, and fissioning worms. Expression is initiated in clusters of cells very early on in the newly developing tissues, with some converging into the lateral line. Once the new segments are formed, expression is largely restricted to segmentally iterated subsets of cells in the line, creating a dashed−line pattern. Our findings indicate that Wnt signaling is likely involved in the formation of the lateral line; that this structure forms early during post−embryonic tissue development; and that the fully formed lateral line is composed of cells with heterogeneous expression profiles, possibly indicating a more complex function than previously thought. Results from this ongoing study will help clarify the evolutionary origins of the clitellate lateral line, including possible homologies to structures in other annelids.

8.6 PACE, C.M.; GIBB, A.C.*; Northern Arizona University; *alice.gibb@nau.edu*

Modes of sustained terrestrial locomotion in osteichthyian fishes

Sustained terrestrial movements by osteichthyian fishes can be categorized based on the contributions of the paired appendages and/or the axial body to forward propulsion. Elongate fishes with axial−based locomotion (e.g. the ropefish *Erpetoichthyes calabaricus*) generate an anterior−to−posterior wave of undulation that travels down the axial musculoskeletal system and pushes the body against the substrate at multiple points. Appendage−based locomotors, (e.g. the barred mudskipper *Periophthalmus argentlineatus*), produce no axial bending during sustained locomotion, but instead use repeated protraction/stance−retraction/swing cycles of the pectoral fins to elevate the center of mass (COM) and propel the entire body anteriorly. Fishes that use an axial−appendage−based mechanism (e.g. walking catfishes *Clarias* spp.) produce side−to−side, whole−body bending in coordination with protraction−retraction cycles of the pectoral fins; once the body is maximally bent to one side, the tail is pressed against the substrate and drawn back through the mid−sagittal plane, which elevates the COM and rotates it anteriorly about a fulcrum formed by the pectoral fin and the ground. Although appendage−based terrestrial locomotion appears to be rare in osteichthyian fishes, many divergent taxa have converged upon functionally similar axial−based and axial−appendage−based behaviors to move over land. Based on common forms observed across these divergent taxa, dorsoventral axial compression, axial elongation, and/or the presence of robust pectoral fins appear to facilitate the production of effective movements by fishes in the terrestrial realm.

40.1 PADIAN, K.; Univ. of California, Berkeley; *kpadian@berkeley.edu*

When is sexual selection not sexual selection? Surprisingly often ...

Darwin invented the concept of sexual selection in order to explain sexual dimorphism, notably those unusual structures (usually in males) that did not conceivably contribute to the individual's success in its environment, but were used to attract mates or repel rivals for mates. Therefore sexual dimorphism was at the heart of Darwin's concept, which he documented fulsomely in *The Descent of Man, and Selection in Relation to Sex.* This concept has been bowdlerized in recent years because biologists have mistakenly thought that sexual selection, like (also incorrectly) natural selection, is just a matter of leaving more offspring in the next generation. This neo−Darwinian concept of fitness has made us look the wrong way at different types of selection. Focusing only on number of offspring, many biologists have come to think that sexual dimorphism (in structure, function, or behavior) is not necessary for sexual selection. Some have even maintained that sexual selection is "a form of" natural selection, but Darwin wrote two large books to distinguish them, and the two types of selection often work in opposition. A hierarchy of concepts related to intraspecific interactions, comprising (successively) species recognition, social selection, mate recognition, mate choice and preference, mate competition, and sexual selection better explains how animals interact. It also relieves much of the confusion in the current literature regarding the terminology and definitions of social interactions and mechanisms. Many very interesting studies that claim to be investigating sexual selection are really investigating other intraspecific interactions. The term "mutual sexual selection" is an oxymoron; "mutual mate choice" is more apt. Species recognition is often a more likely explanation for "bizarre structures" (and others) that do not differ between males and females, and it is probably more important in evolution than usually thought.

S1.1−3 PADILLA, Pamela*; GARCIA, Anastasia; LADAGE, Mary; TONI, Lee; University of North Texas; *pamela.padilla@unt.edu*

Epigenetic Responses in Caenorhabditis elegans

Inheritance and phenotypic traits are regulated by genotype and epigenetic mechanisms. Through the analysis of various genetic model systems many genes and alleles regulating biological processes have been elucidated. However, what is less understood are the epigenetic changes associated with specific biological processes. Epigenetic molecular mechanisms that regulate gene expression and thus phenotypes include post−translational modifications of histones, activation and regulation of non−coding RNAs, and the methylation of specific DNA sites. These changes grant plasticity to an otherwise rigid genome allowing an alternative response to environmental stimuli. The nematode *Caenorhabditis elegans* has been used extensively to understand the molecular mechanisms regulating many biological processes including development, germline function, lifespan and responses to environmental stress. Through the efforts of many in the scientific community the genetic mechanisms regulating these biological processes, in terms of gene function, has been investigated. Less understood are the epigenetic changes, which regulate specific genetic pathways, are associated with biological processes such as environmental stress responses, development and aging in metazoans. Here, we survey some recent examples of transgenerational epigenetic inheritance in *C. elegans* and describe approaches used to study this phenomenon in a well−known developmental genetic model system.

S6.0 PADILLA, DK*; SWALLA, BJ; TSUKIMURA, B; Stony Brook University, University of Washington, California State University Fresno; *Dianna.Padilla@stonybrook.edu*

A New Organismal Systems Biology: How Animals Walk the Tightrope Between Stability and Change

We will highlight recent efforts to develop a research agenda to address the Organismal Grand Challenge of "How metazoans walk the tightrope between stability and change". Effectively solving this Grand Challenge will require a transformation in the way that organismal animal biologists approach their discipline. After decades of research, we still lack understanding of what characteristics of complex living systems allow them to change in response to either internal or external environments, and what characteristics create inflexibility. To comprehend the dynamics of complex living systems, we must move beyond the traditional approaches of organismal biology, and incorporate methodological tools of other disciplines that also study complex systems, particularly mathematics, engineering, and physics. Not only will we gain a deeper, mechanism−based understanding of how organisms will face future environmental challenges, but in pursuing this research endeavor, we will also reveal nature−inspired solutions to stability and agility of exceedingly complex systems. This symposium highlights the need for, and opportunities created by exchange between engineers, mathematics and organismal biologists. Increased dialog between different fields and collaborations across disciplines will be needed to create the organismal systems biology needed to address this and other Organismal Grand Challenge questions

21.4 PAGANINI, A*; MILLER, NA; STILLMAN, JH; San Francisco State University, University of California Berkeley; *paganini@sfsu.edu*

Physiological responses of the porcelain crab Petrolisthes cinctipes to simultaneous exposure to increased variability of pCO₂, temperature and emersion

Intertidal zone organisms experience daily, dramatic, fluctuations in temperature and pH. These fluctuations are expected to increase along the California coast under future climate scenarios. How intertidal organisms respond to variability in temperature and pH has not been previously examined, even though an accurate understanding of how coastal organisms will respond to ocean warming and acidification must include consideration of realistic current and future levels of habitat variability. We investigated performance of the porcelain crab, *Petrolisthes cinctipes*, under interactive conditions of variation in temperature and pH. Adult *P. cinctipes* were exposed to three temperatures during a simulated daytime low tide (11°C, spikes to 25°C or 30°C), or were held submerged at 11°C. At night the crabs in each treatment were exposed to three pH levels: constant pH (8.1), or pH spikes to 7.6, or 7.15. Following two weeks of acclimation, we measured respiration rates at 11°C and 18°C and upper thermal limits of cardiac performance (CT_{max}). Metabolic depression was observed in crabs that experienced aerial daily heat spikes, and the depression was stronger in low pH acclimated individuals when measured at 18°C. CT_{max} was elevated with acclimation temperature, and the elevation was higher under low pH acclimation, suggesting elevated basal maintenance costs. Our results indicate that there are interactive effects of pH and temperature variability on the temperature sensitivity and thermal limits of these intertidal zone crabs, and that the combination of low pH with elevated temperature causes a metabolic state that is likely not ecologically sustainable for these crabs.

P2.129 PAGE, T. M.*; WORTHINGTON, S.; CALOSI, P.; STILLMAN, J.H.; San Francisco State Univ. , Univ. of Plymouth, MBERC; *tpage@sfsu.edu*

Effects of lowered pH on the exoskeleton mineralogy of porcelain crabs

Ocean acidification (OA) alters biomineralization of calcium carbonate structures across many marine taxa. For example, in mussels and oysters, OA decreases the relative concentration of ions important in calcification, such as calcium and magnesium. OA alters the composition of exoskeletons in crustaceans, such as in prawns, in which Ca:Sr ratio decreased with decreasing pH. However, the effects of reduced pH on biomineralization in arthropod, in particular crab, exoskeletons remains poorly understood. Here, we aimed to test the hypotheses that lowered pH will cause a decrease in minerals found in crab exoskeletons, and lower intertidal species will be more highly affected by pH than higher intertidal species. To accomplish this, we examined exoskeletal composition following 24d of acclimation to pH 8.0, 7.4 and 7.0 in four species of porcelain crab from different intertidal zones and geographic locations. We examined ionic composition ([Ca^{2+}], [Mg^{2+}], [Mn^{2+}], and [Sr^{2+}]) of the exoskeleton using Inductively Coupled Plasma Mass Spectrometry. We observed a significant effect of pH on most ion concentrations, [Ca^{2+}] had an 18.5% decrease from pH 8.0 to 7.4 in the two higher intertidal species, and a 22% decrease in one of the lower intertidal species. [Mg^{2+}] decreased by 16% in two species from pH 8.0 to 7.4, and decreased by 32% from pH 8.0 to 7.0 in another species. [Mn^{2+}] increased by 42.86% with decreasing pH in one of the higher intertidal species, however, there was no change in other species. [Sr^{2+}] decreased by 43.18% from pH 8.0 to 7.4 in one species. Affect of pH on species origin was found to largely coincide to intertidal zone location. Decreases in ion concentration might negatively affect calcification and/or biomineralization in porcelain crabs.

101.6 PAIG−TRAN, EWM*; SUMMERS, AP; Arizona State University, University of Washington; *mpaig@uw.edu*

Filter−feeding models predict feeding selectivity and movement in elasmobranch fishes

The filtration mechanisms used by fishes are reflective of the morphology and composition of the filtering tissues. Filtration modes in the bony fishes have been explored through experimentation; however, the elasmobranch filter−feeders are large bodied and highly migratory, which makes laboratory experimentation infeasible. An alternative is to use physical models to investigate feeding selectivity and the underlying mechanisms of filtration. We used a combination of simple physical models and biologically inspired filters to investigate the size selectivity and fluid flow at the branchial filter. We found the selectivity of the filter is directly connected to both the speed of water through the buccopharynx and also the architecture of the gill/raker complex. We noted fluid flow and particle retention is different for each of the four lineages of elasmobranch filter−feeders and ranges from dead end sieving with ciliary transport to cross−flow filtration and even microscale cyclonic filtration. Our physical models predicted differences in prey selection between species (whale sharks and manta rays) that forage within the same plankton blooms along the Yucatan Peninsula but appear to target vastly different prey. This prey selectivity can be actively adjusted via multiple mechanisms (e.g. adjusting the swimming speed, resistance through the gills, etc) to reduce the amount of prey competition with other sympatric species.

109.2 PAIRETT, A.N.; SERB, J.M.*; Iowa State University; *apairett@iastate.edu*

Identifying the molecular link between photosensitive tissues and the eyes of the bay scallop, Argopecten irradians.

Molluscs utilize a vast array of photoreceptive structures, such as complex eyes capable of spatial vision or simple photoreceptive neurons found in the mantle tissue (extra−ocular photoreception, EOP). EOP is ubiquitous in molluscs, while spatial vision has evolved independently multiple times. This pattern suggests that, through the recruitment of photosensitive machinery from one system to another, EOP may be an evolutionary source for eyes. Scallops (Pectinidae) are well known for mirror−type eyes found along their mantle edge on modified tentacles, and represent an excellent opportunity to study the relationship of EOP and vision. Here we test whether the phototransduction system in the scallop eye is shared with EOP in the mantle by analysing gene expression in visual (eyes), putatively photoreceptive (mantle), and non−photoreceptive (adductor muscle) tissues from the bay scallop, *Argopecten irradians*. If the mantle functions in EOP, it will contain the molecular components of the phototransduction pathway, which are required for photoreception. We predict that photosensitive organs will show increased expression levels of photosensitive genes under light conditions when compared to a dark treatment. Illumina sequencing of the eye, mantle, and adductor muscle transcriptomes resulted in nearly 1.5 trillion reads, which were assembled into over 230,000 transcripts. Genes from the phototransduction pathway and circadian rhythm are shared between the mantle tissue and eyes, suggesting that the mantle tissue is photosensitive. However, only circadian rhythm genes showed differential expression between light and dark conditions in the mantle. Results from this work identifies possible links between two independent photoreceptive systems, thus implicating mechanisms that generated the diversity of molluscan eyes.

103.1 PAITZ, RT*; BELL, AM; Univ. of Illinois; *rpaitz@illinois.edu*

Regulation of maternally−derived steroids by developing threespined stickleback embryos

Exposure to maternal steroids during embryonic development influences offspring phenotypes. Recent studies have shown that in several vertebrate taxa, embryos are capable of metabolizing maternal steroids, thereby modulating their exposure to steroids that might otherwise interfere with development. We tested the hypothesis that developing embryos modulate their exposure to maternal steroids by metabolizing them in threespined sticklebacks (*Gasterosteus aculeatus*). Levels of progesterone, testosterone, estradiol, and cortisol were quantified in unfertilized eggs and at six stages following fertilization. All four steroids significantly declined within 72 hours of fertilization. To determine whether the drop in steroid levels reflects embryonic metabolism, eggs were dosed with tritiated cortisol. Immersion in water containing tritiated cortisol for 30 min resulted in an increase in radioactivity within fertilized and unfertilized eggs, suggesting that cortisol entered the eggs via diffusion. However, 72 hr later, radioactivity was essentially non−detectable within eggs, suggesting that cortisol was eliminated from the egg. If eggs were maintained in tritiated cortisol for 72 hr, fertilized eggs still did not contain radioactivity. Thin−layer chromatography analysis of the both the eggs and water found no evidence of cortisol metabolites being formed. The decline in endogenous steroid levels paired with the lack of radioactivity in fertilized eggs following a 72 hr immersion suggests that embryos are regulating their endocrine environment by eliminating steroids from the egg rather than via metabolism. This elimination of maternal steroids from the egg may serve to buffer the embryo from the effects of maternal steroids in much the same manner that metabolism does in other vertebrate taxa.

P3.91 PALMQUIST, A; PAULE, M; ROMANO, L*; Denison University; *romanol@denison.edu*

Isolation of snail and twist from the pencil urchin to gain insight into the heterochronic shift in the ingression of skeletogenic mesenchyme during echinoid evolution.

We are utilizing the sea urchin as a model system to explore the functional consequence of changes in genes and their cis−regulatory elements during embryonic development. In particular, we are examining genes that are required for development of the larval skeleton. Skeletogenesis is initiated when the large micromeres are specified to form the larval skeleton. These cells ingress into the blastocoel and form two ventrolateral clusters in response to cues from the overlying ectoderm. They then secrete a variety of proteins, which leads to the formation of a pair of triradiate spicules on either side of the archenteron. We are currently focused on the molecular basis for several differences between "modern" species such as the green urchin, *Lytechinus variegatus*, and the "primitive" pencil urchin, *Eucidaris tribuloides*. In modern species, there are two ingression events; the skeletogenic mesenchyme ingresses from the vegetal plate in the early gastrula (while the non−skeletogenic mesenchyme ingresses from the tip of the archenteron in the late gastrula). In the pencil urchin, there is just one ingression event with both skeletogenic and non−skeletogenic mesenchyme ingressing from the tip of the archenteron in the late gastrula. We have cloned two genes, *snail* and *twist*, from the pencil urchin. These genes are known to be important for the epithelial−mesenchymal transition (EMT) that occurs upon ingression in the green urchin. We are currently examining the transcriptional regulation of these genes to gain insight into the molecular basis of the heterochronic shift in the ingression of the skeletogenic mesenchyme that has occurred during echinoid evolution.

72.3 PAN, F.*; APPLEBAUM, S.L.; SAWYER, R.J.; MANAHAN, D.T.; Univ. of Southern California; *tienchip@usc.edu*

Ocean acidification alters energy allocation in developing sea urchins

Ocean acidification (OA) is known to have dose− and species−specific impacts on developmental stages of marine invertebrates. While many species appear capable of withstanding the stress of OA, less is understood about the mechanisms underlying the metabolic basis of resilience. We studied changes in energy (ATP) allocation for the two major physiological processes that regulate metabolism in developing sea urchins − protein synthesis and ion regulation (Na^+, K^+−ATPase). During the first two weeks of development, metabolic responses were investigated under present−day (380 ppm) and near−future (800 ppm) CO_2 levels in seawater. Acidification treatment had little effect on size, biochemical composition, or physiological rates in pre−feeding stages (1−4 days post−fertilization). For later stages, the effect of OA on size and metabolic rate was absent or remained small; however, absolute rates of protein synthesis and *in vivo* ion pump activity increased. For same−sized larvae with similar metabolic rates, OA treatment resulted in a doubling of the proportion of ATP allocated to protein synthesis and ion transport (in some cases, more than 90% of available ATP). Our results show that while growth and morphological characteristics remain minimally impacted by OA, studies limited to those levels of biological analysis do not reveal the major mechanisms of response to OA. It is instead the major changes in rate processes at the biochemical level that result in differential allocation of ATP in response to OA. Biological variance in the ability of organisms to re−allocate energy usage, while still remaining within the tightly constrained available pool of total ATP, will likely establish the resilience of organisms to respond to OA and other stressors under natural conditions.

74.4 PANG, Y.*; DONG, J.; THOMAS, P.; University of Texas at Austin; *yfpang@utexas.edu*

Membrane progesterone receptor alpha (mPR±) mediates the non−genomic action of progesterone to increase nitric oxide production by human umbilical vein endothelial cells

Although the beneficial effects of progesterone (P4) on the human cardiovascular system through increasing cellular nitric oxide (NO) production in vascular endothelial cells are well recognized, but the receptors mediating these effects of P4 remain unclear. Using human umbilical vein endothelial cells (HUVECs) as a model, we show that P4 binds to plasma membrane of HUVECs with the characteristics of membrane progesterone receptors (mPRs). The selective mPR± agonist, Org OD 02−0 (02−0) displayed high binding affinity for membrane progesterone receptor, whereas the nuclear PR agonist R5020 had low binding affinity. Immunocytochemistry and Western blotting confirmed that mPR± is expressed in HUVECs and localized on the plasma membrane. P4 activated an inhibitory G protein in HUVECs, in agreement with previous findings with mPR± expressed in other cell types. P4 and 02−0, but not R5020, significantly increased the activity of endothelial nitric oxide synthase (eNOS) as well as the phosphorylation of eNOS and activation of ERK, Akt; resulting in elevation of cellular NO levels in HUVECs. These progestin effects were abolished when the cells were co−treated with ERK and Akt inhibitors. P4 and 02−0 treatments also decreased cellular cAMP levels, but the cAMP response action and the progestin−induced increase of cellular NO levels were attenuated by co−treatment with an adenylyl cyclase inhibitor. Knockdown of mPR± expression in HUVECs by treatment with antisense siRNA oligos blocked the stimulatory progestin effects on NO production and phosphorylation of eNOS. Taken together, the results provide convincing evidence that the protective effects of P4 on NO production by HUVECs are largely mediated through mPR±.

P2.152 PANHUIS, T.M.*; KWAN, L.; FRIS, M.; TUHELA−REUNING, L.; RODD, F.H.; ROWE, L.; Ohio Wesleyan University, University of Toronto; *tmpanhui@owu.edu*

Structural characterizations of the Poeciliopsis fish placenta

Fish species in the genus *Poeciliopsis* are livebearers (i.e. viviparous) and vary in their degree of embryonic maternal provisioning. Variation in *Poeciliopsis* maternal provisioning has been quantified using the matrotrophic index (MI) and species fall into three MI categories: none, (lecithotroph; MI<0.7), moderate matrotroph (0.7<MI<5), and extensive matrotroph (MI>5). Regardless of reproductive−trophic mode, individual *Poeciliopsis* embryos develop within a maternal ovarian follicle until birth. In matrotrophic species, however, the follicle is specialized to act as a placental−like tissue aiding in embryonic nutrient transfer. In addition, embryonic surface structures and the pericardial sac are believed to efficiently absorb maternal nutrients. The goal of this project is to characterize and compare the maternal and embryonic placental structures across a range of *Poeciliopsis* species, which vary in their MI value. Surface structure variation of the maternal follicle and embryonic body and sac was examined using scanning electron microscopy. Quantification of follicle thickness variation between species was analyzed with a sectioning, staining, and Image J measurement approach. Our results underscore the placenta structural differences between *Poeciliopsis* species and shed light on surface structures and follicle remodeling necessary for different modes of *Poeciliopsis* viviparity.

111.3 PARANJPE, D.A.*; MEDINA, D.; COOPER, R.; SINERVO, B.; Univ. of California, Santa Cruz; *dhana4shree@gmail.com*

Blood parasites and the side−blotched lizards: do the parasites drive negative frequency dependent cycles of three throat color morphs?

We report, for the first time, the occurrence of malarial parasite "*"Plasmodium mexicanum"*" along with another apicomplexan parasite "*"Schellackia "*" sp. in the side blotched lizard "*"Uta stansburiana"*". The effects of parasites on host behavior, physiology, fitness and population dynamics were investigated using multiple years data. In a laboratory thermal gradient, infected lizards showed lower temperature preference than uninfected individuals. Moreover, infected lizards were not able to thermo−regulate as precisely as uninfected lizards. The parasites did not affect reproductive output of females. However, the parasites may be partially responsible for driving the negative frequency dependent population cycles of male throat color morphs in this system. This previously unknown host−parasite system may shed some light on how parasites can influence host population by multiple ways.

92.3 PARKER, M.R.*; PICKERING, A.; BLAUSTEIN, A.R.; MASON, R.T.; Monell Chemical Senses Center, University of Hawaii, Oregon State University, Oregon State University; *rparker@monell.org*

UV−B exposure diminishes a potent sexual signal, the female sex pheromone of red−sided garter snakes

Excess UV radiation can negatively affect multiple aspects of animal life, from reproduction to survival. Though many species use UV reflectance in sexual signaling, it is unknown whether UV itself can decrease the potency of sexual signals. The red−sided garter snake uses its sexual attractiveness pheromone to facilitate reproduction, and pheromone composition reflects female quality and serves as a species identifier. We found that UV−B exposure decreases the concentration and composition of the sex pheromone *in vitro* and *in vivo*. Further, the alterations in the pheromone imposed by UV−B decreased the attractiveness of the sex pheromone to males during the breeding season. Our results implicate increased UV−B radiation as a catalyst dissolving species isolation barriers such as pheromones.

69.1 PARKER, S.E*; MCBRAYER, L.M; Georgia Southern University; *sp03499@georgiasouthern.edu*

The Effect of Multiple Obstacles on the Locomotor Behavior and Performance of a Terrestrial Lizard Sceloporus woodi

The flexibility to negotiate variable terrain in three dimensionally complex environments is important for many terrestrial vertebrates. Variation in the substrate due to coarse woody debris, vegetation, rocks or a variety of other obstacles can alter escape paths and running performance. The ability to navigate obstacles is likely to directly influence survivorship via predator evasion, finding potential mates, and foraging. Earlier work has established that locomotor posture (quadrupedal, bipedal) and sprint performance are altered when organisms face an obstacle. In this study we focus on how multiple obstacles influence running behavior and locomotor posture in the Florida scrub lizard *Sceloporus woodi*. This species uses a variety of substrates (e.g. open sand, litter, and coarse woody debris) throughout its range. We hypothesize that an increasing number of obstacles will increase the frequency of bipedal running. We also hypothesize that using bipedal locomotion over multiple obstacles will allow a greater proportion of maximum sprint velocity to be maintained than quadrupedal running. Lizards were filmed running in a 2m long racetrack containing zero, one, two, or three obstacles. Velocity data will be explored by examining sprint sensitivities among the three trial types (one, two or three obstacles). Preliminary data show that the frequency of bipedal running is greater in lizards that encounter one or two obstacles, and lower for three obstacles. Trials in which bipedalism occurred were completed with fewer strides compared to quadrupedal runs. Overall this study will shed light on the locomotor behavior of lizards when interacting with obstacles in their environment. The broader implications of this research will be addressed as we attempt to provide further evidence in understanding why bipedalism occurs in so many lizard lineages.

P2.125 PARMELEE, A.L.*; GOULDER, K.D.; GILLEN, C.M.; ITAGAKI, H.; Kenyon College; *itagaki@kenyon.edu*
RNAi mediated knockdown of KAAT1 and measurement of surface area in the Manduca sexta midgut.
To investigate factors in the gastrointestinal system that influence metabolic scaling, we measured midgut surface area and manipulated nutrient transporter expression in larvae of the tobacco hawkmoth (*Manduca sexta*). Surface area was measured in composite micrographs of more than 150 sections from more than 20 larvae ranging from first through fifth instar. The scaling exponent for the relationship between midgut luminal perimeter and body mass was 0.49, indicating that midgut surface area becomes increasingly folded as larvae grow. Anterior, middle, and posterior midgut all scaled with approximately the same relationship. In previous work, we have measured a 2 to 3−fold increase in the expression of mRNA encoding the potassium−amino acid transporter KAAT1 in 5th compared to 4th instar larvae. To assess the functional consequences increased of KAAT1 in the 5th instar, we used RNAi interference to decrease KAAT1 expression. Injections of a 453bp KAAT1 dsRNA on three consecutive days caused an approximately 6−fold decrease in expression of KAAT1 in middle midgut. In contrast, KAAT1 levels in the posterior midgut were unchanged, while mRNA encoding the related gene CAATCH1 were decreased approximately 10−fold. (NSF−DMS0827208)

2.5 PARRIN, AP*; YAEGER, MA; BLACKSTONE, NW; Northern Illinois University; *apparrin@gmail.com*
Quantification of symbiont fate in bleaching octocorals
Octocorals form a major component of reef diversity and are often the dominant space occupiers. Many octocorals contain photosynthetic symbionts of *Symbiodinium* sp. As with other symbiont−containing cnidarians, octocorals are susceptible to bleaching in which symbionts die or exit the colony and the host becomes bleached. Recently, in three species of alcyonacean octocorals, *Phenganax parrini*, *Sarcothelia* sp., and *Sympodium* sp., we have shown that in addition to dying and exiting the colony, symbionts can migrate into the stolons. Symbiont fate may have implications for host fate, e.g. sequestered symbionts in the stolons may repopulate polyps after perturbation ceases. Consequently, quantification of symbiont fate is important. This is accomplished by using microscopy of thick sections from fixed specimens, colony morphometrics, and symbiont expulsion counts. For example, comparing thick sections of control and bleached colonies of *Sarcothelia* sp. shows a decrease in symbiont densities in the polyp tissue (mean ± SE, symbionts/ mm^2, 3027.53 ± 536.20, 180.22 ± 72.54, control and bleached respectively) and an increase in the stolon lumen (21.79 ± 6.67, 4731.78 ± 1059.33, respectively). When these mean densities are combined with colony morphometrics the initial (I) and final (F) number of symbionts in a bleached colony can be determined. With counts of the number of symbionts expelled (E), the number that died (D) can also be calculated (I=F+D+E). Such calculations indicate that after perturbation, roughly 74% of the initial number of symbionts remained in the colony, 26% died, and a fraction of a percent were expelled. Results suggest that these three octocorals may sequester symbionts in the stolons during a bleaching episode.

P1.85 PARROTT, B.B.*; KOHNO, S.; CLOY−MCCOY, J.A.; GUILLETTE, JR, L.J.; Department of Obstetrics and Gynecology, Medical University of South Carolina and Hollings Marine Laboratory, Charleston, SC; *benbparrott@gmail.com*
Gonadal DNA methylation patterning is affected by incubation temperature in the American alligator, a species undergoing temperature−dependent sex determination
Epigenetic mechanisms have been implicated as key mediators of interactions between the genome and the environment. DNA methylation is a well−characterized epigenetic modification and is generally thought to result in transcriptional repression in vertebrates. Sex determination in many taxa is dependent upon environmental cues, and in the American alligator incubation temperature of the egg determines sex. Here, we incorporate multiple approaches to examine the relationship between incubation temperature and DNA methylation patterns at critical loci in the sex determining genetic cascade. Aromatase (CYP19A1) is an enzyme that coverts androgens to estrogen and plays a pivotal role in specifying ovarian development in non−mammalian vertebrates. We find that incubations at male producing temperatures (MPT) result in increased gonadal DNA methylation in the *CYP19A1* promoter region when compared to incubations at female promoting temperatures (FPT). Conversely, the promoter region of *SOX9*, a key gene involved in the initial specification of testis development, is hypermethylated in gonads from embryos incubated at FPT compared to those incubated at MPT. We also examine expression levels of *CYP19A1* and *SOX9* in these tissues and find that whereas methylation status at particular nucleotides is tightly associated with transcriptional activity, methylation at other nucleotides is non−informative. These data are consistent with a role for DNA methylation in the negative regulation of transcriptional activity and suggest epigenetic patterning plays a role in sex determination in the American alligator.

24.6 PARSLEW, B*; CROWTHER, W J; The University of Manchester, UK; *ben.parslew@manchester.ac.uk*
Far from Cruise: Avian Flapping−Flight Dynamics
Avian flight is so much more than just steady, level cruise. Some birds bound intermittently while they fly, and others dive while capturing prey. Some even fly upside down! This work describes the development of a theoretical model that can simulate these far−from−cruise conditions, and offers a pathway for future research into animal flight dynamics.

Recently, predictive simulation methods have been used to derive power−optimal wing motions in hover and cruise. The model developed here follows a similar philosophy, but extends the context to modes of flight that feature significant accelerations of the body. This includes both linear accelerations, such as in breaking flight, and rotational accelerations, as seen in pull−up and pushover manoeuvres. The model provides insight into how birds induce such extreme, yet graceful, dynamics using the flight apparatus available to them. Results from the model are presented as a series of animated flight trials, each focussing on a mode of flight that is observable in nature. The predictive methodology determines plausible wing and tail kinematics and also indicates the energetic cost of undertaking these different modes.

83.1 PASCH, B*; ABBASI, M; PHELPS, SM; WILSON, PS; RYAN, MJ; University of Texas at Austin; *bpasch@utexas.edu*
Steering sound beams: The influence of social context on acoustic radiation patterns in Neotropical singing mice
The efficacy of animal communication depends upon signal detection by receivers following propagation through an oft−cluttered environment. Most studies of acoustic displays used in sexual contexts focus on the role of spectral and temporal characteristics in signal evolution. However, sound waves generally radiate from a vocalizing animal with unequal amplitude in different directions. This favors adaptations that exploit or compensate for acoustic directionality. In this experiment, we used a hemispheric microphone array in an anechoic chamber to record from male Alston's singing mice (*Scotinomys teguina*) before and after playback of a conspecific vocalization. In this species, males commonly emit stereotyped and elaborate vocalizations that serve to repel rival males. Upon hearing conspecific song, males oriented towards the speaker and produced vocalizations that were longer (+1 s), lower in frequency (−1 kHz), and greater in intensity (+ 4 dB), which contributed to changes in acoustic directionality. Our data suggests that males dynamically adjust vocal output and directionality to expand the signals' active space and advertise aggressive intent.

P1.29 PASCUAL, C.J.*; BOWER, C.; BURROWS, S.; LEVINSON, B.; POLK, T.; BLATZHEIM, L.; GONZALEZ, V.H.; BARTHELL, J.F.; PETANIDOU, T.; Univ. of Maryland, College Park, Bloomsburg Univ. of Pennsylvania, Utah State Univ., Univ. of California, San Diego, Southwestern Nazarene Univ., Southwestern Oklahoma State Univ., Univ. of Central Oklahoma, Univ. of the Aegean, Lesvos, GREECE; *cam.pascl@gmail.com*
Comparison of bee visitation on blue and white−pale pink morphs of Vitex agnus−castus in Lesvos, Greece
At least five distinct color morphs have been identified of *Vitex agnus−castus*, a lilac bush native to the Mediterranean region. In this study, relatively uniformly−colored bushes of *V. agnus−castus* were categorized into two visually distinct groups and studied: white−pale pink and blue. Both the overall bee visitation rates (Wilke's Lambda = 0.139, $F_{3,6}$=12.44, P=0.006) and the peak visitation times differed between the two morphs. The white−pale pink morphs received slightly higher visitation rates at all time intervals, although this was not significant at most sample intervals. There was a visitation time by flower interaction where visitation peaked on the blue morphs at 12:00 hours ($F_{2,8}$=2.534, P=0.140) and on white−pale pink morphs at 14:00 hours ($F_{2,8}$=5.883, P=0.027). The number of pollinator species did not differ between the blue and white−pale pink morphs ($F_{1,3}$=1.02, P=0.698). Higher nectar quality should increase floral attractiveness for bees, and higher nectar volume could suggest that the bushes produce more nectar and can thus support a greater number of pollinators. We studied these two characteristics of nectar in both morphs. The nectar volume of the white−pale pink morphs were not significantly lower than the blue ($F_{1,3}$=0.64, P=0.792), and the nectar quality of the blue and white−pale pink inflorescences did not differ significantly either ($F_{1,4}$=0.91, P=0.723). These findings suggest that factors other than nectar are influencing different bee visitation patterns between the two morphs.

P1.30 PASCUAL, C.J.*; BOWER, C.D.; BURROWS, S.; LEVINSON, B.; POLK, T.J.; BLATZHEIM, L; GONZALEZ, V.; BARTHELL, J.F.; PETANIDOU, T.; HRANITZ, J.M.; University of Maryland, College Park, Bloomburg University of Pennsylvania, Utah State University, University of California, San Diego, Southern Nazarene University, Southwestern Oklahoma State University, University of Central Oklahoma, University of the Aegean, Mytilene, GREECE; *jhranitz@bloomu.edu*
Comparison of bee visitation at blue and white morphs of Vitex agnus−castus in Lesvos, Greece
Distinct color morphs of *Vitex agnus−castus*, a flowering bush native to the Mediterranean region, have been described in the literature and were identified on the Northeast Aegean island of Lesvos. Our studies examined whether these color differences impacted bee foraging behavior among plants in a restricted area near the shoreline of Kalloni Bay. Uniformly colored bushes of *V. agnus−castus* were categorized as either white or blue and monitored for numbers and types of bees visiting them. Both the overall bee visitation rates and the peak visitation times differed between the two morphs (Wilke's Lambda = 0.139, F=12.44, P=0.006). The white morphs received slightly higher visitation rates at all time intervals, although this was not significant at most sample intervals. There was a visitation time by flower interaction wherein visitation peaked on the blue morphs at 12:00 hours (F=2.534, P=0.140) and on white morphs at 14:00 hours (F=5.883, P=0.027). The frequency of visitation by members of different bee families differed between transect intervals (X^2=54.451, df=9, P<0.001) and between blue and white morphs (X^2=17.337, df=3, P<0.001). The results suggest, at least in the insular region where we studied them, that neither species will receive a significant gain in pollinator visitation rates. Ancillary data describing nectar quality and volume from the two inflorescence types are discussed in the context of pollinator foraging dynamics and the breeding system of *V. agnus−castus.*

47.6 PASSAMANECK, Y.J.*; SHIN, J.; MARTINDALE, M.Q.; University of Florida, University of Hawaii; *yale@whitney.ufl.edu*
Analysis of gene expression during regeneration in the anthozoan cnidarian Nematostella vectensis
Polyps of the anthozoan cnidarian *Nematostella vectensis* display rapid and robust regeneration of oral structures, including the mouth, pharynx, and tentacles, following amputation. This regeneration process is characterized by a dramatic increase in cell proliferation at the wound site, which has been shown to be required for the morphogenesis of the oral structures. To identify genes involved in cell proliferation and morphogenesis we have performed genome−wide microarray analyses to determine differential gene expression during regeneration. Microarray analyses were conducted for time points before and during the period of increased cell proliferation, as well as for treatments with the cell proliferation inhibitors hydroxyurea and nocodazole. Validation of microarray results by *in situ* hybridization has identified several transcription factors whose expression is localized to the region of oral regeneration, including members of the *Sox*−class. In addition, expression of Wnt−pathway components supports a previously suggested role for this signaling pathway during oral regeneration.

20.4 PASSOW, CN*; GREENWAY, RS; JEYASINGH, P; TOBLER, M; Oklahoma State University, Stillwater; *Courtney.passow@okstate.edu*

Genetic and plastic variation in metabolic rates of locally adapted extremophile fish

Extreme environments profoundly affect energy budgets of organisms, as the maintenance of homeostasis under stressful conditions requires costly morphological, physiological, or behavioural adaptations. Whether long−term exposure to extreme environmental conditions drives adaptive shifts in energy metabolism remains an open question. Here, we studied variation in routine metabolic rate in genetically distinct and locally adapted populations of extremophile fishes (*Poecilia mexicana*) living in toxic, hydrogen sulfidic−rich springs and caves. Routine metabolism was measured in field and laboratory trials to isolate genetic and plastic sources of variation. Specifically, we quantified routine metabolic rate in wild−caught individuals from four habitats (non−sulfidic surface, sulfidic surface, non−sulfidic cave, and sulfidic cave) and laboratory−raised individuals from the same populations exposed to experimental manipulations of resource availability. Results showed that both laboratory and field experiments indicated elevated routine metabolic rates in populations from cave compared to surface habitats, which may be linked to previously established behavioural differences. Fish from non−sulfidic and sulfidic habitats did not differ in routine metabolic rates in the field, but common garden experiments revealed that sulfidic populations exhibited higher routine metabolism when energy availability was abundant and reduced routine metabolism when resources were scarce. The results of this study indicate that adaptation to extreme environments directly impacts energy metabolism. Different abiotic stressors have unique effects on the evolution of energy metabolism in extremophile fish; cave environments are associated with genetically based changes in routine metabolic rates, while sulfidic environments favour metabolic rate plasticity.

P1.177 PATE, J.H.*; SALMON, M.; Florida Atlantic University; *jpate10@fau.edu*

Determining the Sensitive Period for Magnetic Imprinting in Loggerhead Sea Turtles

Loggerhead sea turtles (*Caretta caretta*) emerge from Florida beaches as hatchlings and return decades later to the same regional beaches to lay their eggs. How they accomplish this feat of migration is unknown. It has been hypothesized that the turtles imprint to the magnetic field at the beach during some portion of their early development and then use this information to return to the same general region as adults. If loggerhead turtles do imprint to the magnetic properties of the beach, then that period of imprinting might occur during embryonic development. Furthermore, we speculated that their might exist a sensitive period during embryonic development during when this process might occur. We experimentally tested for a sensitive period during embryonic development by distorting the magnetic field around clutches during different portions of incubation. We created three experimental groups in which clutches were surrounded by magnets during the beginning, middle or end of incubation. Control nests were either left undisturbed or exposed to non−magnetic aluminum bars; thus, both control groups incubated in the ambient magnetic field. Upon hatching, turtles were tested for their ability to orient while swimming in total darkness, using only magnetic cues. If the experimental turtles demonstrated this ability, then they were considered behaviorally competent and the corresponding time of exposure to a distorted magnetic field during development was not considered a part sensitive period. Turtles in both control groups oriented normally but all three experimental groups failed to show significant orientation. These results suggest that for loggerhead sea turtles, an ability to use a magnetic compass for orientation requires exposure to a natural magnetic field for the entire period of incubation.

P3.198 PATEL, N.T.*; KROHMER, R.W.; Saint Xavier University, Chicago, IL; *krohmer@sxu.edu*

Neuronal Plasticity in the Forebrain of the Male Checkered Garter Snake: Effect of Sex Steroid Hormones on Dendritic Spine Formation

In many seasonally breeding species, changes in the density and/or morphology dendritic spines appears to be an active process within neural regions essential for the control of reproductive behaviors. In many cases, this neuronal plasticity has been found to be in response to changes in circulating sex steroid hormone levels. Previous studies in the red−sided garter snake found a seasonal response in dendritic spine formation as well as changes in dendritic spine density in response to circulating levels of sex steroid hormones, with dendritic spine formation greater under the influence of estrogen compared to testosterone. The current study examines the role of sex steroid hormones on the density and morphology of dendritic spines within regions shown to be critical for the regulation of reproductive behaviors in the male checkered garter snake (*Thamnophis marcianus*). Our study revealed that animals receiving either testosterone or estradiol exhibited greater density of dendritic spines than control animals. However, animals implanted with estrogen exhibited greater dendritic spines density compared to testosterone implanted animals. These results add to the increasing amount of evidence suggesting that estrogens, aromatized from circulating testosterone may be the active hormone setting up the pathways critical for the regulation of reproductive activity in a reptile.

86.8 PATELUNAS, A.*; NISHIGUCHI, M.K.; New Mexico State University; *nish@nmsu.edu*

Aerobic indicators and vascular distribution in the bacteriogenic light organ of Euprymna tasmanica (Cephalopoda: Sepiolidae)

Symbiosis between the Southern dumpling squid, *Euprymna tasmanica* (Cephalopoda: Sepiolidae) and its luminescent bacterial symbiont, *Vibrio fischeri*, provides an experimentally tractable system to examine interactions between a eukaryotic host and its bacterial partner. *V. fischeri* luminescence provides light to the squid for a behavior termed "counterillumination," which allows the squid to mask its shadow during downwelling moonlight, also known as silhouette reduction. Although this association is beneficial, light generated from the bacteria (via the *lux* operon) requires large quantities of oxygen to maintain this energy consuming reaction. Previous work has noted the presence of vascularization within the light organ, but the extent and location of these blood vessels remains unknown. Using serial section scanning electron and confocal laser scanning microscopy, we have examined the vascular network within the light organ of juvenile *E. tasmanica*. Morphological features, including vessel type, diameter, and location of vessels, were measured. Differences between squids that are infected with symbiotic *V. fischeri* compared to aposymbiotic squids will allow us to better predict whether the presence of *V. fischeri* influences the extent of vascular branching upon development. Additionally, this project seeks to identify if there is an increase in the metabolic stress on the squid via the production of anaerobically induced enzymes in squid tissue. Knowledge gained from this research will provide a framework to understand how beneficial bacteria influence the development of a closed vascular network, and will provide insight to the evolutionary dynamics that form mutualistic associations.

75.1 PATTERSON, J.T.*; WALKER, F.L.; GREEN, C.G.; Louisiana State Univ. Agricultural Center; *JPatterson@agcenter.lsu.edu*

Reproductive physiology of a euryhaline teleost consuming low levels of highly unsaturated fatty acids

Relative activities of fatty acid (FA) elongases and desaturases are highly variable in fishes. Generally, freshwater species have the ability to biosynthesize longer chain highly unsaturated fatty acids (HUFA) from unsaturated C_{18} substrates while marine species have not evolved this ability due to an abundance of highly unsaturated C_{20} and C_{22} FA at the base of their food web. *De novo* biosynthesis of HUFA remains largely unexplored in fishes living at the margin of fresh and salt water. The euryhaline Gulf killifish *Fundulus grandis* is increasingly used as a model species for teleost physiology. We utilized *F. grandis* to investigate impacts of dietary HUFA content on reproductive and subsequent larval stress physiology. Four experimental diets were formulated to contain graded amounts of HUFA by incrementally replacing corn oil as the lipid component with marine source fish oil. Diets were fed to replicate tanks during an 8−week inclusion period and 10−weeks of spawning. Gas chromatography was used to quantify FA in eggs, ovary, liver, and muscle. Newly hatched larvae produced by experimental groups were examined for endogenous nutritional resource quantity, upper−limit salinity tolerance, and critical thermal maximum. Low levels of dietary HUFA significantly changed body tissue and egg FA profiles while increasing HUFA in diets resulted in significantly greater endogenous nutritional resources, tolerance of high salinity, and critical thermal maximum. These data further an understanding of the roles HUFA play in the reproductive physiology of teleost fishes.

P2.99 PATTON, M.P*; TEMKIN, A.; ELLISOR, D.; KOHNO, S.; GUILLETTE, L.J., ; SPYROPOULOS, D.D.; College of Saint Benedict & Saint John's University, St. Joseph, MN and Medical University of South Carolina (MUSC), Charleston , MUSC; *michaelapatton6491@gmail.com*

Using Molecular Markers to Rapidly Characterize Adipogenic Stem Cell Differentiation

Research demonstrates that embryonic exposure to contaminants considered obesogens may cause a predispostion to obesity. The obesogenic potential of crude oil and dispersant from the 2010 Gulf of Mexico Deepwater Horizon incident is of particular interest due to large numbers of exposed marine organisms and humans. We are developing a novel method of investigating adipogenic induction in stem cells exposed to oil/dispersant mixtures. Cell type−specific molecular markers were selected to characterize the adipogenic differentiation pathway. Human mesenchymal stem cells (hMSCs) were cultured under adipogenic conditions. RNA was isolated from untreated hMSCs, preadipocytes and cells at day 15 of adipogenic differentiation. Quantitative real time PCR showed hMSCs highly express specific markers CD166, CD105, CD90 and CD44, with CD105 being the most stringent MSC−specific marker. Differentiating stem cells showed increasing expression of adipocyte markers FABP4, LEP and ADIPOQ and decreasing expression of MSC markers and the preadipocyte marker FSTL1. To address the potential obesogenic effects of the oil/dispersant mix in an ecologically−relevant model organism, American alligator stem cells were generated from stage 19 embryos. Adipogenic induction in these cells was demonstrated via Oil Red O staining, and adipocyte−specific genetic markers are currently being developed for alligator cells. Future studies will utilize molecular markers to determine the obesogenic potential of the oil/dispersant mix on human, alligator and pygmy sperm whale stem cells in more rapid, quantitative manner than current techniques, such as triglyceride quantitation.

127.6 PEARISH, S.*; BELL, A.M.; Univ. of Illinois, Urbana; *pearish1@illinois.edu*

Behavioral type − environment correlations in three−spined stickleback

There is growing evidence for consistent individual differences in behavior. It is likely that different behavioral types of individuals within populations are nonrandomly distributed in the environment, creating behavioral type−environment correlations. Relatively timid individuals might be more likely to occur in relatively safe microhabitats, for example. However we know little about the prevalence of behavioral−type environment correlations, the mechanisms that generate them or their ecological and evolutionary consequences. Here I present evidence for behavioral type−environment correlations in a wild population of three−spined stickleback. Relatively exploratory sticklebacks were more likely to occur in open microhabitats in the field, and relatively bold sticklebacks that quickly emerged from a refuge were more likely to occur in shoals with other sticklebacks rather than by themselves. I discuss the stability of behavioral types and environment use in sticklebacks, mechanisms that might generate the observed behavioral−type environment correlations and present the results of a mark−recapture experiment.

P3.44 PEHLIVANOVIC, M; HECK, M*; PURCELL, JU; HAHN, DA; HATLE, JD; Univ. of North Florida, Univ. of Florida; *jhatle@unf.edu*

Allocation of ingested nitrogen upon life−extending dietary restriction in grasshoppers

Dietary restriction reduces reproduction and extends lifespan in most animals. The disposable soma hypothesis predicts that upon dietary restriction, allocation of ingested nutrients will be shifted toward somatic tissues (i.e., away from reproduction), enhancing tissue maintenance and increasing lifespan. This has been tested rigorously only in fruit flies. Here, we test this prediction of increased allocation to somatic tissues and maintenance upon dietary restriction using grasshoppers. These large insects allow estimating allocation to multiple tissues (e.g., muscle, storage proteins, and fat body) and simultaneous analysis of protein damage (i.e., carbonyls), none of which was possible in fruit flies. Artificial diets for grasshoppers do not allow normal development. Hence, to produce diets with distinct signatures of nitrogen−14 and nitrogen−15 that also allow normal development, we grew Romaine lettuce hydroponically and spiked the nutrient solution with KNO_3 high in nitrogen−15. Within each feeding level (i.e., ad libitum or dietary restriction), four diet regimes were used: 1) high nitrogen−15 throughout (the ceiling of nitrogen−15 levels), 2) low nitrogen−15 throughout (the floor of nitrogen−15 levels), 3) initially high, switched to low nitrogen−15 during a 28−day test period, or 4) initially low, switched to high nitrogen−15 during the 28−day period. This allows determination of the percentage of nitrogen in tissues that originated from the diet during the 28−day test period. Results will be discussed in terms of the hypothesis, which predicts dietary restricted grasshoppers will show greater allocation of ingested nitrogen to somatic tissues and fewer damaged proteins.

90.6 PENDAR, H*; SOCHA, JJ; Virginia Tech; *hpendar@vt.edu*
Computational methods to determine the instantaneous respiratory patterns of animals from respirometry data
Flow−through respirometry is a commonly used technique to record gas exchange patterns of CO_2 and O_2. This powerful technique has yielded great insight into animal physiology, but the true gas exchange that occurs by the animal is not recorded due to experimental limitations. This well−known problem results from both geometric and scale effects of experimental system and the gas flow rate. In order to draw time−accurate interpretations from the data or to sync it with other signals, gas exchange data must be transformed to instantaneous data. Mathematically, the recorded pattern of gas exchange is a convolution of the actual gas exchange of the animal and a transfer function. Depending on the transfer function, convolution could strongly change the actual pattern by smoothing the high frequency components, stretching the individual pulses, and combining the pulses together. These problems are more pronounced in small animals, which exhibit faster respiratory dynamics. This study presents two new methods to deconvolve respirometry data to reveal the instantaneous gas exchange patterns of animals. In the first, we use a stochastic approximation method, which is more accurate than previous methods and robust against the level of noise. In addition, it is not required to have prior knowledge about the noise. In the second method, we provide a novel but simple algorithm to find the transient CO_2/O_2 concentration point by point throughout the dataset. In contrast to other methods, this algorithm places no restriction on the number of data points. These new methods, which are validated with experimental data from insects, are broadly applicable for the quantification of physiological processes such as hormone secretion, insulin dynamics, and hepatic glucose production. Supported by NSF 0938047.

P2.87 PENDAR, H*; SOCHA, JJ; Virginia Tech; *hpendar@vt.edu*
A 3D kinematic analysis of abdominal motion in darkling beetles
Although abdominal pumping in insects is well known to be involved in respiration, it is unclear how specific movements of the abdomen produce airflows. Some motions may cause a volumetric displacement of the tracheal system, but it is also possible that the abdomen induces hemolymph flow or that no net volumetric change occurs. To better understand the relationship between abdominal movements and their internal effects, a comprehensive geometrical analysis of the abdomen concurrent with internal measurements is needed. In this study, we construct a real−time 3D model of abdominal cuticle in the darkling beetle (*Zophobas morio*) based on computational stereo techniques. After removing the elytra and soft wings and marking the surface with paint dots (size, ~50−200 μm), we used two synchronized cameras to record abdominal movements. In addition, we simultaneously recorded two other physiologically−relevant behaviors: 1) A third camera captured movements of tracheal tubes through the transparent metathoracic cuticle, revealing tracheal compression without the use of x−rays; 2) Internal pressures of the hemolymph in the prothorax were recorded using a fiber optic pressure transducer. Videos were analyzed using a custom Matlab program to quantify the 3D motion of the abdomen including volume displacement. A principal component analysis on the geometrical shape of the abdomen revealed that the beetle employs three major types of abdominal movements. In the most commonly observed type of abdominal motion, all tergites synchronously compressed in the ventral direction; concurrent to this compression, there was a substantial increase in hemolymph pressure, and tracheal tubes collapsed. The observed variation in behavior demonstrates that the abdominal pump likely serves multiple physiological functions. Supported by NSF 0938047.

118.5 PENNOYER, K*; FURINESS, S; COCKETT, P; GURSKI, L; BIRD, C; Texas A and M University −Corpus Christi; *Kelly.Pennoyer@tamucc.edu*
Adaptive genetic differentiation across the depth ranges of intertidal invertebrates
The drivers affecting realized species ranges are important in the prediction of global climate change impacts on biotic communities. Intertidal species are particularly well suited to studies of vertical range limits due to the extremely narrow gradient in habitat characteristics from the marine to terrestrial realm. Realized vertical species ranges are the result of both biotic and abiotic factors, where lower limits are most often directly controlled by competition and predation and upper limits are more directly impacted by abiotic factors and positive biotic interactions. Here we employ genome−wide analyses of genetic variation (~20,000 SNPs) in an oviparous snail (*Littoraria pintado*) and a broadcast−spawning limpet (*Cellana exarata*) at the upper, mid, and lower ends of their vertical ranges across several Hawaiian Islands to test for parallel patterns of selection. *L. pintado* was characterized by much less population structure among islands than *C. exarata*. In both *L. pintado* and *C. exarata*, several genes experienced significant levels of purifying selection at the upper and lower ends of their ranges. We also identified a handful of genes experiencing disruptive selection between the upper and lower shore limits. We are presently working on identifying the adaptive genes, such as HSP70, and determining whether they are likely to be responding to biotic or abiotic stressors. Overall, we find that RADseq and population genomic techniques are quite effective at identifying critical genetic variation that affects survival, and species range limits.

P2.47 PERDICHIZZI, MS; University of Massachusetts, Lowell; *MaryAlice_Perdichizzi@student.uml.edu*
Morphology of the freshwater peritrich ciliate Scyphidia n. sp. in symbiotic pulmonate snails
Certain peritrich ciliates live as symbionts and associate with a variety of invertebrates. As bacterial filter−feeders, they may act as ectocommensals by attaching to the exposed surfaces of mobile invertebrate hosts like snails, small crustaceans, and fish. Some species of peritrich ciliate are also known to contain endosymbiotic green algae (*Chlorella*), a relationship that confers a mixotrophic benefit. In this research, I provide details on the morphology of a new *Scyphidia* species and its relationship to endosymbiotic *Chlorella* and its host pulmonate snails. To identify this ciliate species and understand its host specificity, scanning electron microscopy was used to reveal the surface placement of pores on the peristomial lip and pellicle. Dry silver nitrate staining was also used to measure the quantity of species−specific silverlines, and both DIC and brightfield imaging determined scopula width, macronucleus dimensions, and body size. I also set up experiments to determine if and how ciliates colonize new hosts. Ciliates were monitored for telotroch formation and dispersal after host death to determine host specificity and telotroch formation times. Details on the structure of the ciliate and its relationships to both the algal symbiont and host snails is provided.

103.6 PEREZ, JH*; WINGFIELD, JC; RAMENOFSKY, M; Univ. of California, Davis; *jhperez@ucdavis.edu*

Development of vernal migration and breeding stages in the White−crowned Sparrow (Z. Leucophrys gambelli): a role for thyroid hormones?

With the annual increase in photoperiod, migratory White−crowned Sparrows (*Z. l. gambelii*) undergo preparations for vernal migration and initiate preparations for breeding. The transition between wintering and these two stages requires major changes in physiology, morphology and behavior regulated by endocrine and neuroendocrine mechanisms, which are not completely understood. Previous studies have identified a potential links between thyroid hormones and the spring events associated with migration and breeding. Work by Nair et al. (1994) showed that surgical thyroidectomy abolished two characteristics of migration: spring fattening and nocturnal migratory restlessness. Building on this work, we are exploring the role of thyroid hormones (T3, T4) in additional spring events that include changes in flight muscle as well as gonadal development. In order to avoid potential complications of surgical excision or irradiation of the thyroid, the anti−thyroid agent Methimazole was delivered with subcutaneous silastic implants and oral administration. This drug reversibly inhibits thyroperoxidase, the enzyme responsible for conjugation and organification of T4. White−crowned sparrows were exposed to a naturally increasing photoperiod from early December to May 5th. Methimazole suppressed the following migratory traits: fattening, hypertrophy of the pectoralis muscles, a visual measure of fat accumulation within flight muscle, and pre−alternate molt. Additionally, testicular recrudescence was curtailed. Our findings suggest that the HPT axis is important for the coordination of key spring events regulating both development of migration and breeding in migratory songbirds.

53.4 PERFITO, N.*; GUARDADO, D.; BENTLEY, G.E.; Univ of California, Berkeley; *nperfito@berkeley.edu*

RAPID CHANGES IN GENE EXPRESSION WITHIN THE HYPOTHALAMO−PITUITARY−GONAD AXIS IN FEMALE EUROPEAN STARLINGS.

Producing fertile eggs requires that mates have functional gametes simultaneously. Prior to fertilization, female birds' ovarian follicles must form a pre−ovulatory hierarchy and accumulate sufficient amounts of yolk. Birds use behavioral displays and courtship behavior to synchronize internal physiology between pair members; these interactions are particularly important for fertilization. We recently demonstrated that female starlings (*Sturnus vulgaris*) deprived of physical access to a mate dramatically slowed follicle maturation and expression of genes regulating vitellogenesis compared females with mates. Further we showed that reproductively delayed females could quickly stimulate follicle development and yolking with seven days of de novo access to males. Seven days is a short time, but it has not been clear exactly how rapidly the female reproductive axis can be stimulated in response to the presence of a mate. In the present study, we attempt to pin−point rapid changes in gene expression along the reproductive axis after only 46 hours of de novo access to males. These data will determine critical points of transduction of environmental cues into the physiological reproductive response. We will test changes in expression for genes already known to play a key role in reproductive activation as well as novel candidate genes identified by RNAseq analysis. These data will help to illuminate how females orchestrate the decision to begin egg−laying; a critical but largely ignored component of reproductive success.

112.6 PERLMAN, B.M.*; ASHLEY−ROSS, M.A.; Wake Forest University; *perlbm0@wfu.edu*

Motor patterns of aquatic and terrestrial escape responses in the mangrove rivulus (Kryptolebias marmoratus)

The aquatic C−start escape response in teleost fishes is driven by a well−studied network of reticulospinal neurons that produce a stereotyped muscle activation pattern of simultaneous contraction of axial muscle along the body on the side away from the stimulus, followed by a traveling wave of contraction on the contralateral side. Superficially, the kinematics of the terrestrial tail−flip resemble the aquatic C−start, with the anterior body rolling up and over the tail into a tight C shape, followed by straightening as the fish launches off of the caudal peduncle into ballistic flight. We asked if similar motor control is used for both behaviors in *K. marmoratus*, the mangrove rivulus. Four fine−wire bipolar electrodes were percutaneously inserted into repeatable locations in four individual fish: paired (left and right sides) anterior epaxial muscle, right posterior lateralis superficialis muscle, and in the body cavity to act as a ground. Electromyographic recordings synchronized with high−speed video (500 fps) were made of aquatic C−starts in a 10−gallon tank, immediately followed by terrestrial tail−flips. Motor patterns in both environments were grossly similar, with muscle ipsilateral to the concave side of the bend activating first, followed by contralateral muscle(s) activating after a delay. Tail−flips took longer to complete than aquatic escape responses; muscles were activated for longer durations on land. Differences also exist in specific features of the motor pattern: in the tail−flip, activity was seen in posterior axial muscle contralateral to the bend during the formation of the C shape, likely to press the caudal peduncle against the ground in preparation for launch. Thus, the tail−flip is not simply a C−start performed on land, but represents a distinct locomotor behavior.

P1.49 PERNET, B; California State University, Long Beach; *bruno.pernet@csulb.edu*

Differences in feeding performance between larvae that capture particles using different mechanisms

Feeding larvae of marine invertebrates capture particles by such mechanisms as reversal of cilia in a single band (e.g., echinoderms) or trapping particles between two parallel bands of cilia beating in opposite directions (e.g., many annelids). The consequences of alternative feeding mechanisms for performance are unclear, because planned comparisons of feeding among larvae are rare. In an effort to answer a simple question − are different feeding mechanisms associated with differences in feeding performance? − we are examining feeding over ontogeny in diverse larvae. Here I report on studies of plutei of the echinoderm *Dendraster excentricus* and trochophores of the annelid *Hydroides gracilis*. For each species, clearance rates on uniformly−flavored polystyrene spheres 0.45−30 µm in diameter were estimated from ingestion rates across ontogeny, at constant temperature. Plutei consumed spheres ≤3 µm in diameter at very low rates, and had their highest clearance rates on 10−30 µm spheres. The length of cilia in the feeding band did not increase over ontogeny, and band length−specific clearance rate (~2 ml/d/mm) was roughly constant over ontogeny. Trochophores had their highest clearance rates on 6−15 µm spheres, and captured very few spheres e20 µm in diameter; however, they captured the smallest spheres (0.45 and 1 µm) at rates much higher than those of plutei. In trochophores, specific clearance rate increased over ontogeny, in part due to increases in the length of prototrochal cilia. Clearance rates estimated here are as high or higher than those obtained using other methods (e.g., direct observation, depletion of particles in suspension), suggesting that simple ingestion rate methods provide useful estimates of larval feeding abilities for comparative studies.

127.7 PETELLE, M/B*; BLUMSTEIN, D/T; Univ. of California, Los Angeles; *mpetelle@ucla.edu*

The maintenance of risky personalities in yellow−bellied marmots

Animals vary in the risks they take and this may be a personality trait. There are three hypotheses for the maintenance of risky personality traits. First, the residual reproductive value hypothesis uses the asset protection principle to suggest that younger individuals are more cautious than older individuals because of their potential future reproduction. Second, the growth−mortality tradeoff hypothesis states that individuals that grow faster will be more risk−prone to maintain that growth, but will incur a higher mortality as a tradeoff. Third, the state−dependent safety hypothesis suggests that individuals with more energy reserves, or better body condition, will be able to cope with risky situations and maintains this condition through positive−feedback loops. We capitalized on a long−term study of yellow−bellied marmots (*Marmota flaviventris*) to evaluate these alternative hypotheses. We conducted 8990 trapping events (to measure docility) on 1201 individuals and 614 open−field and mirror image stimulation trials (to measure activity/exploration) on 226 individuals. Our results provide some support for state−dependent safety but oppose the residual reproductive value hypothesis. We found no evidence for growth−mortality tradeoffs. Thus, individuals in better body condition are better able to cope with the potential stresses. Additionally, older individuals were more risk−averse than younger individuals, suggesting that older individuals potentially value their remaining reproduction more than younger individuals.

S2.1−3 PETERS, S.*; SEARCY, W.A.; NOWICKI, S.; Duke University, University of Miami; *speters@duke.edu*

Developmental stress, song learning and cognition

The evolution of enhanced cognitive ability has sometimes been attributed to sexual selection. An association between male mating success and cognitive ability could arise either through male−male competition or through female choice. Especially in the latter case, sexual selection would act more readily if males advertised their cognitive ability through display. Most traits involved in sexual display, however, seem unlikely to have any inherent relationship with cognition beyond that which arises through the effect of cognitive abilities on resource acquisition and, in turn, the effect of resource acquisition on development of the display trait. In contrast, for displays whose development and expression require learning, a direct link with cognition is possible because of a shared dependence on brain function. The parallel effects of developmental stress on song learning and cognition provide a compelling explanation for an association between song attributes and cognitive ability. We outline the hypothesis that sexually selected song qualities serve as an indicator of cognitive abilities. We first present evidence that song learning is itself a challenging cognitive task. We then give evidence that sexual selection favors well−learned song. Next, we review evidence that song and general cognitive ability are both affected by developmental stresses. Finally, we present recent experimental data testing the relationship between song and other cognitive abilities.

132.4 PETERSEN, AM*; VON HIPPEL, F; BUCK, CL; POSTLETHWAIT, JH; CRESKO, WA; University of Oregon, Eugene Oregon, University of Alaska, Anchorage Alaska; *annp@uoregon.edu*

Aquatic vertebrates developing in a perchlorate world; the genetic effects of an endocrine disruptor during early development in threespine stickleback

In experimental studies of threespine stickleback fish we have found that the aquatic contaminant perchlorate causes reproductive abnormalities and cell hyperproliferation in thyroid and gonad tissues. Effects of this contaminant include disrupted sexual differentiation, small size, craniofacial malformaties, and increases or decreases in circulating thyroid hormones. We hypothesize that perchlorate exerts wide−ranging effects by interfering with gene expression patterns of the large SLC5 gene family. Perchlorate may also be affecting reproductive development by altering cell differentiation of primary germ cells during critical periods of development. To test these hypotheses that perchlorate acts to cause transcriptional disregulation and endocrine disruption, we have raised two aquatic models, the threespine stickleback and the zebrafish, in perchlorate (10 ppm) and control water from fertilization until 18 days post fertilization. We utilized RNA−seq to document patterns of transcriptome−wide response to perchlorate during the first weeks of development. In addition, analysis of gene expression, oxidative damage, cell proliferation, germ cell maturation, and histochemistry were used to broadly test the mechanisms by which perchlorate is generating such a multitude of phenotypes. Our findings are widely applicable to the understanding of how chronic developmental exposure to individual chemicals such as perchlorate can exert myriad effects in adult vertebrates, including humans.

P1.112 PETERSON, A.N.*; PAIG−TRAN, E.W.M; SUMMERS, A.P.; University of Washington, Seattle, Arizona State University, Pheonix, Friday Harbor Labs, Friday Harbor; *anpetey@gmail.com*

Fluid flow in filter feeding rays: Size XL

Mobulid fishes (mantas and devil rays) filter prey smaller than the pore size of their gill rakers. The filter array is formed from the five branchial arches. Each arch presents an anterior face directed at the incoming flow and a posterior face that is shielded from the incoming free stream. The flow through these filter elements is complex and varies with the angle and anatomy of the filter. We used four fold enlarged 3D physical models to examine fluid flow over a variation of filter morphologies and with different angles of attack. Models were based on the anatomy of *Manta birostris* filter lobes and created with a 3D rapid prototyper. This allowed us to vary the anatomy by removing projections and changing surface roughness. Fluid movement was investigated with a dye stream aimed to show flow in specific areas of the filter and the results were videotaped. In anterior and posterior orientations the fluid makes contact with the filter lobe and then makes a 90 degree turn into the filter pore. The vorticity of the system is complex and we distinguished three different processes that depend on orientation and fine scale morphology. First, there is vorticity parallel to the plane of the filter that moves downstream. There are also vortices parallel to the free stream and perpendicular to the filter plane continuously maintained in the pore opening. A third type of vorticity is seen in anterior facing filter lobes with projections, and consists of vortices shed downstream above the filter plane. This complicated vorticity indicates that some form of cyclonic filtration, a particle precipitation method that relies on circular flow, is playing an important role in the filter feeding of Mobulids.

79.7 PETIT, M*; VEZINA, F; Univ. du Québec à Rimouski (Canada), Boréas, CEN, CSBQ; *magali.petit@uqar.qc.ca*

Elevating antioxidant defence is part of cold acclimatization in a small forest bird wintering in eastern Canada.

Resident bird species wintering at northern latitudes increase their heat production capacity (Msum) in response to cold weather conditions. Studies reported that increased oxygen consumption (e.g. sudden activity; cold stress) in animals might also be associated with elevated production of reactive oxygen species (ROS), which are deleterious for the organism. This could therefore represent a cost of elevated metabolic performance in wintering birds. However, animals are also able to adjust antioxidant (AO) levels to balance ROS production and minimize oxidative stress. In this study, we tested whether the increase in Msum associated with winter acclimatization in small passerines was correlated with an elevation in ROS production. We also investigated if this was paralleled by an elevation in AO levels. We captured 175 free−living black−capped chickadees (*Poecile atricapillus*) over 2 consecutives winters and measured their maximal thermogenic capacity (Msum) as well as their plasma levels of ROS and AO. As expected, wintering chickadees increased their Msum (32%) during the winter and we observed positive relationships between MSUM and both ROS and AO levels. Consequently, Msum was not correlated with oxidative stress (ROS/AO). Our findings therefore suggest that 1) the increase in cold tolerance in small wintering passerines is indeed associated with elevated ROS production but 2) that these birds are able to counterbalance this effect by increasing their AO levels to maintain a stable level of oxidative stress throughout winter. Up−regulation of AO levels therefore seems to be part of seasonal cold acclimatization in chickadees.

P1.4 PETZOLD, J.M.*; SMITH, G.T.; Indiana University − Bloomington; *jpetzold@indiana.edu*

Encoding of species−specific waveform of electric fish signals in the amplitude envelopes created by social interactions

Apteronotid weakly electric fish use weak electric fields for communication. The frequency and the waveform of the electric organ discharge (EOD) vary substantially across species and may serve as species−identifying signals (Turner et al., 2007). Numerous studies have examined how fish determine the EOD frequency of other fish by decoding the beat pattern that is created as the EODs move in and out of phase with each other. We examined how EOD waveform is encoded in the amplitude modulations (envelopes) created by the interacting EODs of signalers and receivers. We simulated social interactions by using recordings of weakly electric fish that vary substantially in degree of waveform complexity. Our results show that EOD waveforms that were more harmonically complex also produced envelopes that were more harmonically complex. However, the relationship between the harmonic content of EOD waveform and the envelope was not linear. Thus information about EOD waveform can be extracted from the amplitude envelope, but subtle variation in EOD waveform may be difficult to detect. Weakly electric fish also modulate the frequency and amplitude of the EOD on short timescales to produce chirps that create abrupt disruptions in the envelope. We used an auto−correlation algorithm to quantify conspicuousness of chirps on envelopes across species. We found that chirps vary in the degree to which they disrupt the envelope. We will use this approach to assess how EOD frequency and waveform influence the coding of chirps in the amplitude envelope across species with diverse signals. This comparative approach will provide insight into how different signal parameters co−evolve in relation to the encoding abilities of the electrosensory system. Supported by NSF IOS 0950721.

106.2 PFALLER, JB*; BAEZA, JA; University of Florida, Gainesville, Clemson University, South Carolina; *jpfaller@ufl.edu*

Social monogamy in Planes major, a facultative symbiont of loggerhead sea turtles

Theory suggests that symbiotic crustaceans should exhibit social monogamy and long−term heterosexual pairing when inhabiting small, scarce hosts in environments where mortality risk away from hosts is high. This prediction was tested in *Planes major*, a facultative but common symbiont of loggerhead sea turtles (*Caretta caretta*). In agreement with theory, crabs were found dwelling as heterosexual pairs in the inguinal space of host turtles more frequently than expected by chance alone. Additional observations, however, suggest that male−female pairing in *P. major* is not necessarily long−term. First, solitary females were commonly found brooding eggs, which suggests some degree of post−copulatory host switching. Second, body size of male and female crabs found in pairs and body size of crabs and host turtles were weakly correlated, which suggests the crabs form short−term associations with their individual hosts and, consequently, with the other crab inhabiting the same host. Third, we found sexual dimorphism in weaponry, which suggests that males compete for and/or defend receptive females via overt aggression. Collectively, these results suggest that *P. major* is indeed socially monogamous (males and females frequently inhabit host individuals as heterosexual pairs), but monogamy is not long lasting as males (and/or females) switch among host individuals in search of extra−pair copulations. Additional experimental studies are needed to understand the conditions favoring the evolution and adaptive value of short− and long−term monogamy in symbiotic crustaceans and other marine invertebrates.

69.3 PFEIFFENBERGER, J.A.*; HSIEH, S.T.; Temple University; *jpfeiffe@temple.edu*

Autotomy−induced effects on the maximum locomotor performance of ghost crabs in the field

Atlantic ghost crabs (*Ocypode quadrata*), as many arthropods, can voluntarily drop, or autotomize, limbs in response to aggressive inter− and intra−specific interactions. Although survival is the obvious short−term benefit for this response, long−term costs can include hampering locomotor performance. When running at high speeds, ghost crabs adopt a quadrupedal gait using their 1^{st} and 2^{nd} pair of legs while raising their 3^{rd} and 4^{th} pair of legs off the ground. This suggests that some limbs may be more important for achieving maximal locomotor performance than others. The goal of this study was to quantify the effects of limb loss on maximum locomotor performance and to determine whether crabs adjusted their gait in response to limb loss. Based on the observations above, we hypothesized that autotomizing the 3^{rd} and 4^{th} pair of legs will have less of an impact on locomotor performance as compared to loss of the 1^{st} and 2^{nd} pair of legs. To elicit maximum performance, we tested crabs in the field within 24 hours of capture at the Cape May National Wildlife Refuge in New Jersey. A total of 75 animals were collected at night and assigned to one of four autotomy treatments or the control group, then run in a sand trackway while filming at 500fps. The fastest, constant velocity run per individual was selected for analysis. In their natural environment, we were able to elicit very high running speeds in intact animals (2.23±0.04 m/s). Whereas autotomy of the 4^{th} pair of legs did not significantly impact running performance (2.06±0.10 m/s), removal of the other limbs significantly decreased running speeds (1^{st}: 1.70±0.03 m/s; 2^{nd}:1.67±0.07 m/s; and 3^{rd}: 1.58±0.11 m/s), as compared to the control runs. There was no significant effect of limb loss on pitch (23 − 30°) and roll (−0.8 − 2.5°) as these were highly variable within and among treatments.

104.6 PHILLIPS, N.; KNOWLES, K.; BOMPHREY, R.J.*; The Royal Veterinary College, Cranfield University;
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The effect of petiolation on the leading−edge vortex of an insect−like flapping wing

In general, animal wing planforms are broad close to the wing hinge and taper towards the tip. However, in many insect species, such as craneflies, the wings are petiolated (on stalks) leaving a gap between the thorax and the effective wing base. The impact of this architecture on lift−generating flow is not yet known, but its implications for the insect are significant. More petiolated wings will confer certain aerobatic benefits, but incur additional energetic costs. We investigated the effect of varying wing petiolation on the flow fields generated by flapping wings and, in particular, the lift−augmenting leading edge vortex (LEV) − a key aerodynamic structure exploited by many insects, birds and bats. Experiments were accomplished using a custom−designed, mechanical flapping apparatus (the *Flapperatus*) that produces highly repeatable insect−like kinematics with an adjustable wing beat frequency up to 20 Hz in air. Stereoscopic Particle Image Velocimetry (stereo−PIV) was employed to reconstruct spatially−dense, three−dimensional, velocity measurements throughout a volume enclosing the wing at eleven time steps throughout a half stroke cycle. Our findings reveal the impact of petiolation on the structure, size and strength of the LEV.

112.7 PHONEKEO, S*; CANTOR, A; HUANG, Q; HU, D; Georgia Institute of Technology , Tsinghua University;
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Fire ants repair bridges in response to vibration

To cross gaps in their path, fire ants link their bodies together to form a bridge. Ant bridges, like rafts and bivouacs are built without coordinated leadership, but instead using local rules from which the structure gradually emerges. Such bridges are sometimes built on unstable surfaces such as leaves or reeds, which can be perturbed by passing waters or winds. In this experimental study, we use time−lapse videography to visualize the self−repair of fire ant bridges in response to periodic shaking of the bridge's endpoints. Shaking causes ants in tension to contract their limbs, reducing the bridge's arc length and increasing its rigidity. Shaking also causes ants walking along the bridge to veer from points of high acceleration, congregating instead at the bridge's endpoints. The combined action of these behaviors reduces the amplitude of vibration of the bridge's midpoint, which decreases the bridge's internal stresses along its entire length, a consequence that is adaptive for all ants within the bridge.

124.2 PHILLIPS, J.G.*; EMEL, S.L.; FENOLIO, D.B.; BONETT, R.M.; University of Tulsa, Washington State University, San Antonio Zoo; *john−phillips@utulsa.edu*

Phylogeography and conservation genetics of troglobitic salamanders

The biology of many cave−dwelling organisms (troglobites) are poorly known due to their cryptic lifestyles and habitat inaccessibility. Some widespread troglobites whose molecular phylogenies have been examined display geographic genetic structure due to low dispersal rates and their highly fragmented habitat. However, an insufficient amount of phylogeographic studies of troglobites exist. This is particularly important given the potential for unrecognized cryptic species within troglobitic taxa, which are commonly imperiled by anthropogenic hazards such as land development, water pollution, and climate change. The Grotto Salamander (*Eurycea spelaea*) is endemic to the Ozark Plateau and its adults are confined to life in caves. There is only one currently recognized species of Grotto Salamander, but recent work has revealed high levels of genetic diversity, indicating the presence of cryptic lineages. In this study, we further investigate the fine scale genetic diversity and geographic structure within *E. spelaea*. Mitochondrial DNA shows evidence of three highly divergent lineages across the Ozarks. To further examine the relationships among the lineages and define species boundaries, we used high throughput sequencing to acquire a vast panel of nuclear loci. We will compare patterns of mitochondrial and nuclear divergence and test if these patterns are correlated with geographic features of the Ozark Plateau. We will also compare the phylogeographic structure in *E. spelaea* with structure in other troglobitic salamanders to better understand the pressures that have directed evolution of cave−dwelling vertebrates.

P1.45 PINEDA, J.R.*; HENDERSON, S.Y.; BURNAFORD, J.L.; University of Washington Friday Harbor Laboratories, Cerritos College, California State University Fullerton;
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Effects of low tide conditions on susceptibility to herbivory in the kelp Saccharina sessilis

Conditions in the intertidal zone differ at high and low tide. One potential low−tide stressor is wind, which can cause desiccation. Algae, unable to escape stressful conditions, accumulate damage over repeated low tides. We investigated whether damage from desiccation alters susceptibility to herbivory in the low intertidal canopy−forming kelp *Saccharina sessilis*. We assessed overall herbivory risk in the field by counting *S. sessilis* and three major consumers (the chiton *Katharina tunicata*, the isopod *Idotea wosnesenskii*, and the snail *Lacuna* spp.) in 0.25m^2 quadrats. We assessed the effects of desiccation on herbivory in the laboratory. We collected *S. sessilis* blades and cut two 25cm^2 samples from each. For 90 minutes once a day for three days, one sample from the pair experienced a "no−wind" simulated low tide while the other member of the pair experienced a "windy" low tide with airflow of 1 m/s. Before and after each low tide we measured area, wet weight, and the amount of visible damage on the kelp. After the third day, we placed paired kelp samples into a container either with or without herbivores. We conducted separate trials with *K. tunicata* and *I. wosnesenskii*. Once ~50% of the *S. sessilis* tissue in a herbivore container was consumed, we terminated the trial for a pair of herbivore and non−herbivore containers. Trials lasted 1 to 5 days. Our results showed that herbivore distribution in the field was patchy, and preference for damaged vs. undamaged tissue differed between herbivores. Overall, susceptibility to herbivory likely varies among individuals in the field due to differences in low−tide damage and the varying abundance of herbivores with different preferences.

88.3 PINSHOW, B*; ZUCKER, D; BRICKNER−BRAUN, I; TURNER, JS; BERLINER, P; Ben−Gurion University of the Negev, SUNY−ESF, Syracuse; *pinshow@bgu.ac.il*

Boundary layer turbulence induces penetration of eddies into rodent burrows

Gas exchange between burrows and the atmosphere occur by its convection through the burrow and diffusion through burrow and soil. Wind−induced convection is most commonly thought of as unidirectional and caused by pressure gradients; air flowing at the surface enters a burrow through one entrance and leaves it through another. This model is based on the notion of laminar air flow at the surface, while in reality the surface is rough, inducing random vertical and horizontal velocity components resulting in turbulent flow and irregular gusts called eddies. Initially, we investigated the pattern of air movements through a two−entranced artificial burrow by a pulse−chase experiment using butane as a tracer and found that the gas left the burrow, alternating between entrances. We then tested the hypothesis that the underlying mechanism for the ventilation of burrows is by penetration of eddies that convey atmospheric air to the depths of the burrow from both entrances. We found that burrow ventilation occurs by several mechanisms, the importance of which varies depending on ambient conditions, especially wind speed (u). At $u > 2$ m/s, burrows are likely to be well ventilated by eddies. Although eddies do not penetrate directly into parts of the burrow that branch out from the main tunnels, such as a nest chamber, we suggest that these parts are also well ventilated due to the gas concentration gradients maintained between them and main tunnel. This gradient facilitates the diffusion of CO_2 into the main tunnel where it is removed by eddies. At low wind speeds gas diffusion through the burrow and into the soil may become an important mechanism for ventilation.

P3.65 PIRTLE, E.I.; TODD, J; TRACY, CR; TRACY, CR*; Univ. of Melbourne, Univ. of Nevada Reno, California State Univ. Fullerton; *ctracy@fullerton.edu*

Can physiological flexibility mitigate the effects of climate change in desert lizards? Part I: Thermal performance

It has been hypothesized that, in the next hundred years, climate change will cause mass extinctions of reptiles because hotter thermal environments will cause detrimental effects on body−temperature−specific physiological processes and performance. It is therefore important to understand how a species might adjust its physiology to mitigate the effects of climate change and improve function in more extreme environments. The ability to perform well across a wide range of temperatures would buffer a species against detrimental effects of climate change. Similarly, populations adapted to local conditions might mitigate effects of climate change on the species, but some local populations would still be vulnerable. We used a desert iguanid, the common chuckwalla (*Sauromalus ater*) as a model species and measured several characteristics of performance and physiology at both a warm, low−elevation site and a cooler, high−elevation site at two points in the lizards' active season, and found different responses to temperature between both sites and seasons. The results of our performance testing suggest there has been some population−level specialization of the common chuckwalla, where high elevation lizards are able to alter their response to temperature as the season progresses, presumably maximizing performance first in the cooler spring months and then again in the warmer summer months, while low elevation lizards show fixed traits that maximize performance at the high temperatures that they experience during the entire season. Thus, there may be sufficient variability across the species to mitigate effects of climate change, but some local populations may be vulnerable.

P2.126 PITMAN, E.*; KOHL, K.D.; CONNELLY, J.W.; DEARING, M.D.; FORBEY, J.S.; Univ. of Utah, Idaho Dept. of Fish and Game, Boise State Univ.; *e.x.pitman@gmail.com*

It takes guts to specialize: Digestive enzymes of Greater sage−grouse resist inhibition by chemical defenses of sagebrush

Greater Sage−grouse (*Centrocercus urophasianus*) are dietary specialists on sagebrush (*Artemisia spp.*), which are heavily defended by a variety of plant secondary compounds (PSCs). Monoterpenes, a group of PSCs found in sagebrush, may inhibit grouse digestive enzymes, consequently restricting nutrient availability. Some herbivores have evolved digestive enzymes that are tolerant to high concentrations of PSCs; however, such an adaptation has never been studied in an avian herbivore. We hypothesized that sage−grouse produce tolerant digestive enzymes to overcome the inhibitory effects of monoterpenes. We measured the inhibitory effects of isolated monoterpenes on aminopeptidase−N, a digestive enzyme that hydrolyzes dietary proteins. Inhibition rates were compared between the sage−grouse and a related, naïve animal, the domestic chicken (*Gallus gallus*). Compared to chickens, the aminopeptidase−N enzyme produced by sage−grouse retained ~2.5−times higher relative activity at high concentrations of monoterpenes, such as borneol and 1,8−cineole. This research demonstrates that adaptations of digestive enzymes may be a common trait in specialist herbivores. We hypothesize that these adaptations allow herbivores to maximize digestion and absorption of nutrients despite high concentration of PSCs in their diet. Future research should investigate the molecular changes in enzyme structure that yield this tolerance.

P1.61 PITTS, N.L.*; CHANG, E.S.; MYKLES, D.L.; Colorado State University. Fort Collins, CO, Bodega Marine Laboratory, University of California Davis, Bodega Bay, CA; *pittsn@rams.colostate.edu*

Analysis of nitric oxide production in the sinus gland of the green crab, Carcinus maneas, using a copper−based fluorescent ligand

Nitric oxide (NO) is a unique gaseous signaling molecule involved in a wide variety of biological processes. NO is synthesized from L−arginine, oxygen, and NADPH by nitric oxide synthase (NOS). In decapod crustaceans, we hypothesize that NO modulates the secretion of neuropeptides such as molt−inhibiting hormone and crustacean hyperglycemic hormone, from the sinus gland (SG) in the eyestalk ganglia. A copper fluorescent ligand (CuFL) was used to measure NO production in the SG of the green crab, *Carcinus maneas*. Using confocal microscopy, NO−CuFL fluorescence was distributed throughout the SG. The effects of an NO scavenger (cPTIO), NO donor (SNAP), and an NOS inhibitor (L−NAME) on total fluorescence were quantified using Metamorph analysis of whole SGs *in vitro*. CuFL had a higher affinity for NO than cPTIO, preferentially binding NO when the compounds were present in the same solution. Fluorescence was maximally reduced in a solution containing both cPTIO and L−NAME; fluorescence was recovered one hour after loading SGs with CuFL in the absence of cPTIO. L−NAME partially inhibited post−cPTIO CuFL fluorescence recovery, indicating that NO is generated from NOS. However, the lack of complete inhibition of CuFL fluorescence recovery by L−NAME suggests that NO is released from endogenous storage molecules. SNAP had no effect on the recovery of fluorescence after cPTIO treatment, suggesting that endogenous NO production and release was sufficient to saturate CuFL. These experiments showed that CuFL can be used to localize and quantify NO in the SG. NO metabolism is complex and we hypothesize that NO produced by NOS can bind and activate NO−dependent proteins or bind to NO storage proteins. Supported by NSF (IOS−1257732).

89.7 PLACE, N.J.*; JOHNSTON, R.E.; Cornell University; *njp27@cornell.edu*
Effects of age on selectivity for dominant males in female golden Syrian hamsters
Under most circumstances life history theory predicts that old females should be less selective in choosing a mate than young females. Relatively few studies have investigated this concept experimentally, and most experiments demonstrating reduced selectivity in old females involved insects. Research on guppies has provided strong evidence for an age−associated decline in choosiness in female vertebrates, but reports of this phenomenon in mammals are lacking. To address this deficiency, young and old female golden hamsters (*Mesocricetus auratus*) were evaluated for their preference for dominant vs. subordinate males. Females were placed in an arena in which they observed male dyads as the dominance relationship was established. Dominant and subordinate males were then placed within enclosures at the opposite ends of a Y−maze, and the first approach, scent marking, lordosis, and time spent near each male were evaluated in young and old females. During estrus, neither young nor old females demonstrated a preference for the dominant male; the only age effect being that lordosis was more commonly displayed by young than by old females. Conversely, during proestrus − a time when females solicit visits by prospective mates by leaving vaginal scent marks − all young females first approached the dominant male, whereas only 50% of old females did. Similarly, the number of vaginal scent marks left by young females favored the dominant male, but old females left slightly more vaginal scent marks near the subordinate male. Both young and old females spent more time near the dominant than the subordinate male, but the time differential was greater in young than in old females. Collectively, these preliminary results are consistent with a decline in selectivity for dominant males by old female hamsters.

S6.2−3 PLACHETZKI, David*; GROSBERG, Richard; KOPP, Artyom; University of New Hampshire; *plachetzki@ucdavis.edu*
Origins of metazoan gametes: phylogenetic subtraction and network analyses of transcriptome data reveal an ancestral eumetazoan gametogenic gene set
Advances in sequencing technology have forced a quantitative revolution in Evolutionary Biology. One important component of this renaissance is the recognition that network structures underpin many dimensions of biological complexity. Recent empirical and theoretical studies in Evolutionary Developmental Biology have begun to highlight the utility of the network perspective in a comparative context. In order to further this objective, we use the evolution of the metazoan gametogenesis gene networks as a model. Here we analyze 24 RNA−seq libraries from mature, morphologically, sexually and genetically distinct polyp types from the gonochoristic colonial hydrozoan *Hydractinia symbiolongicarpus* (Cnidaria), together with 12 similar bilaterian datasets from ovary and testis tissues of fly and mouse. Bionformatic and phylogenetic subtraction reveals rough historical estimates of male and female gametogenic gene sets at key nodes in metazoan phylogeny. Interaction networks between co−expressed genes inferred from tissue−type and species contrasts of DE gene sets across taxa provide a further refinement of the functional genomic landscape of eumetazoan gametogenesis, which we infer to include several deeply conserved modules. Caveats of our approach and the potential for future improvements are discussed.

118.4 PLOUGH, L.V.*; MARKO, P.B.; University of Maryland Center for Environmental Sciences, Horn Point Laboratory, University of Hawaii; *lplough@umces.edu*
Population genomic analysis of the Pacific gooseneck barnacle Pollicipes elegans comparing two sampling strategies
Next generation sequencing (NGS) technologies, particularly restriction site−associated DNA (RAD) marker methods have revolutionized the field of population genetics, making it possible to examine 1000's of markers in a non−model organism at relatively low cost. However, sequencing large numbers of individuals can be prohibitively expensive prompting alternative sampling strategies (pooling), and restriction digestion approaches still suffer from technical issues (null alleles) that plague standard population genetic analyses, especially in highly polymorphic species such as marine invertebrates. In this study we use genome−wide marker data generated with genotyping−by−sequencing (GBS; a restriction digestion method similar to RAD) to investigate population genetic structure in the Pacific gooseneck barnacle *Pollicipes elegans*, which has a relatively long−lived larval stage and is distributed in a disjunct fashion across the equator in the eastern Pacific ocean. We sequenced GBS libraries created with individuals and population pools made up of those individuals to examine the accuracy of a pooled sampling approach for estimating standard population genetic parameters such as allele frequency and F_{st}. Preliminary analysis of individual samples showed relatively high polymorphism, population structure over large geographic distances (Peru and Mexico), and evidence of null alleles at some markers. We will present the results of our F_{st} outlier analyses, compare population genetic parameter estimates between pooled and individual samples, and discuss how temperature and current patterns may be structuring populations in this species. Additionally, we will discuss the complexities of population genomic study design and the analysis of population genomic data in highly polymorphic marine invertebrates.

72.5 PODOLSKY, RD*; BENFIELD, C; DOOLEY, T; College of Charleston, Cornell University; *podolskyr@cofc.edu*
Using gamete characteristics to model fertilization kinetics in latitudinal comparisons of fertilization success for sea urchins under variable temperature and pCO2
Populations evolving under different conditions may show regional adaptation to variation in environmental parameters that are predictable. Although latitudinal patterns of adaptation have been described in adult size, form, coloration, and physiology of several species, less is known about latitudinal adaptation of performance characteristics at early life−history stages. We examined differences in fertilization kinetics between northern and southern populations of the sea urchin *Arbacia punctulata*. Fertilization assays found that the proportion of eggs fertilized per sperm dilution factor was substantially higher in individuals from the northern population compared to the southern population under all combinations of temperature, pCO2, and sperm age tested. These results suggest that gametes from colder water populations demonstrate greater fertilization efficiency, consistent with expectations in biochemical adaptation under different temperature conditions. We measured and incorporated into a fertilization kinetics model population differences in sperm motility, sperm swimming speed, sperm density of spawn, and egg size to understand whether physical characteristics of gametes and their interactions could explain latitudinal differences in fertilization success. Our results will be presented in the context of the potential for responses of populations of free−spawning organisms to future changes in temperature and pH levels in the ocean.

P3.113 POLICH, R.L.*; JANZEN, F.J.; Iowa State University; *rlpolich@iastate.edu*

Evaluating Anthropogenic Impacts on Hormone Levels and Behavior of Breeding Turtles in the Wild

The painted turtle (*Chrysemes picta*) is a freshwater turtle found in marshes, wetlands, and the backwaters of large rivers. Throughout much of its range, this turtle is found in close proximity to humans with little evidence of detrimental effects. However, these animals could be impacted by humans in sub−lethal ways that are currently poorly understood. To address this knowledge gap, I designed a study to evaluate potential sub−lethal effects of humans on painted turtles during the breeding season. I evaluated a human−impacted population at Thomson Causeway, a popular campsite in Illinois, to a non−human−impacted population nearby at Lost Mound, an ex−military base. I compared three components between the two populations: basking behaviors, flight initiation distance (FID), and basal corticosterone levels and the corticosterone stress response. Human presence could potentially cause turtle stress hormones to be elevated or reduced compared to normal seasonal levels. As the endocrine system influences behavior, these changes could seriously affect typical turtle behaviors such as basking, which are influential in key physiological processes such as egg development and digestion. If behavioral or endocrinological differences are detected between these populations, these findings could have implications for management, such as limiting human access to breeding sites during the nesting season. My work will determine if such management processes are necessary for the painted turtle and also give insight into the need for addressing this issue in other species of turtle, one of the most imperiled taxa on the planet.

P2.166 POLK, T.J.*; BOWERS, C.; CAKMAK, I.; HRANITZ, J.M.; Southern Nazarene University, Bloomsburg University of Pennsylvania, Uludag University, Bursa, TURKEY; *trpolk@mail.snu.edu*

The effect of imidacloprid on sucrose sensitivity of the honey bee proboscis extension reflex

The proboscis extension reflex (PER) is an important motor program integrated (with motor coordination of locomotion, other feeding reflexes, memory, learning, and social communication) in the honey bee feeding behavior. In the PER, antennal stimulation with sugar solution, nectar in nature, elicits extension of the proboscis for feeding. Honey bees are very sensitive to sucrose concentration in solutions and can distinguish between nectar rewards in nature and in the laboratory. A sucrose sensitivity test has been widely used in studies of the effects of pesticides on honey bees. Our study investigated the effect of sublethal doses, ranging from 1/5 to 1/500 of the LD50 reported for imidacloprid, on the PER of Anatolian honey bees (*Apis mellifera anatoliaca*) in a Turkish apiary. We tested the PER using 0% sucrose (water), 10% sucrose, and 30% sucrose solutions at 1h before and after the administration of imidacloprid to harnessed honey bees. Bees in our study exhibited a scaled response to the different sucrose solutions, with a higher rate of response to 30% sucrose solution than the 10% sucrose solution. Repeated measures ANOVA of the PER tests revealed that sublethal doses of imidacloprid at 1/5 LD50 impaired the sucrose sensitivity response in honey bees (Wilke's Lamba=0.549, F=2.819, P=0.0006). At lower doses of imidacloprid (<1/5 LD50), bees did not perform differently than controls. Our results show that sublethal doses of this commonly used neonicotinoid pesticide can impair an important motor reflex in honey bee feeding behavior. These results, along with the effects of imidacloprid on motor coordination, indicate impairment at different levels (PER, motor coordination) of the integrated behavior of foraging in honey bees.

57.5 POLNASZEK, T.J.*; STEPHENS, D.W.; Univ. of Minnesota, Twin Cities; *polna005@umn.edu*

Why not lie? Costly signals enforce honesty in an experimental signaling game

Communication depends on reliable signals, so the concept of honesty is important in discussions of communication. Theory provides several mechanisms which can stabilize honesty, even in the face of conflicting interests. A particularly influential approach to studying honesty is the handicap principle', which predicts that the costs of signaling stabilize honesty. We tested this prediction using pairs of blue jays (*Cyanocitta cristata*) in an experimental signaling game. While there is no doubt that many signals do have costs, we lack definitive experimental evidence showing that honesty persists when costs are high, and disappears when costs are low. Using our signaling game, we ask how increasing signal cost affects signaler strategy. The results show that signal cost has no influence on honesty if signalers and receivers share a common interest (signalers are consistently honest). Conversely, conflict between players causes dishonesty in low cost conditions. This deception decreases dramatically when signal costs increase. The approach we developed offers two distinct advantages; direct control over signal cost and a clear operational definition of honesty.

P2.63 POOL, R.; TURNER, G.D.; BOETTGER, S.A.*; West Chester University; *aboettger@wcupa.edu*

Topic Coverage in Introductory Biology Courses: A Comparison

The need for ecological literacy and problem solving has increased in recent years, but there is no evidence that this need is reflected by increased ecology coverage at institutions of higher education (IHE) across the United States. As introductory biology courses may serve to direct student interest toward specific biological categories such as ecology, time devoted to topics in these categories within introductory biology courses may be crucial for captivating student attention. Surveys for administrators and members of the National Association of Biology Teachers (NABT) College and University Sections identified 20 topics they considered essential for inclusion in introductory biology courses. The present study evaluated the actual coverage of eight topic categories compared to previous recommendations and according to location. For this purpose, lecture and lab syllabi were collected from 26 rural, suburban, and urban IHEs from the Mid−Atlantic region. Course content was divided into eight categories, percentages of total lecture and lab time per category were calculated and coverage (%) was analyzed using a One−Way−ANOVA. The actual coverage was compared to the administrator and NABT recommendations. Actual coverage of ecology was not significantly different from recommended coverage, whereas cell/molecular/biochemistry and evolution were lower and genetics, development, and taxonomy were higher than recommended. Comparing course content by location showed no significant effect of institutional location on coverage with the exception of taxonomy which was covered to a lesser extent in rural locations. Overall topic coverage, with the exception of a few currently emphasized topics, corresponded to the coverage level recommended by the NABT, while there is no educational standardization by topic category or location.

27.4 PORTER, ME*; WAINWRIGHT, DK; LOWE, AT; HALVORSEN, MB; SUMMERS, AP; Florida Atlantic University, Harvard University, University of Washington, Pacific Northwest National Laboratory, University of Washington, Friday Harbor Labs; *me.porter@fau.edu*

Anisotropy in the skin and blubber of killer whales suggest no hydrostatic function

Skin is a network of elastin and collagen fibers with variable amounts of organization. While alive, skin is under tension and has been shown to work as an exotendon in some species. The anisotropic properties, direction of elastic and collagen fibers, are largely attributed to the tendon like properties of skin. Marine mammals have a blubber layer located deep relative to the skin. The blubber layer is rich in proteoglycans, lipids and collagen, which change depending on diet and developmental stage. Our goal was to examine the anisotropic mechanical properties of skin and blubber from an orca *Orcinus orca* adult and calf. We obtained frozen skin and blubber samples from the head region of an adult female (L112) and from a male calf. After the specimen was thawed, we separated skin from the blubber layer with gross dissection. From each layer, we dissected samples to test both strength (MPa) and stiffness (MPa) from the longitudinal (cranial−caudal) or hoop (circumferential) orientation. We tested samples on a Synergie 100 test system (MTS, Eden Prairie, MN, USA) with a 500N load cell. We found maximum strength in the adult skin was 40% greater in the longitudinal compared to the hoop orientation. In the calf skin, a similar 30% increase in strength was found in the longitudinal orientation. Adult skin was four−fold stiffer in the longitudinal orientation relative to the hoop and calf skin was three times stiffer. If an orca were a pressurized vessel, the hoop strength expectation would be twice the longitudinal. Since the reverse is true we postulate that killer whale skin is not acting as a whole body exotendon.

31.2 PORTER, ML*; DOWD, SE; University of South Dakota, Vermillion, Molecular Research LP, Shallowater TX; *Megan.Porter@usd.edu*

Stomatopod opsin expression patterns in simple larval versus complex adult eyes

Larval stomatopod eyes have relatively simple compound eyes with a single spectral type of photoreceptor. Adult stomatopod crustaceans, by comparison, have complex and diverse visual systems, with the most complex stomatopod eye containing 16 physiologically different photoreceptor classes. To achieve the adult retinal complexity, rather than modify existing larval ocular structures, stomatopods build an entirely new retina medially adjacent to the existing larval eyes. Thus, during the late larval and early post−larval stages the animal possesses two retinas within a single eye. The development of sequential, but morphologically and physiological distinct, eyes in one organism provides a remarkable system for understanding the genetic mechanisms leading to sensory system complexity. To study this major sensory change at the molecular level, we generated transcriptomes of retinal tissue collected from different ontogenetic stages in two species of stomatopods. In the species *Haptosquilla trispinosa*, transcriptomes of adult versus embryonic eyes were sequenced. In the second species, *Alima pacifica*, we were able to dissect apart and sequence separately the degenerating larval and developing adult retinas of a larval compound eye just prior to metamorphosis. We present here the first molecular investigations of stomatopod visual system development, focusing specifically on comparisons of larval versus adult opsin transcripts. Opsin expression in in these two species suggests that similar to adults, larval eyes express more opsins than predicted based on physiology. Continuing studies are using transcriptomics to elucidate larval versus adult phototransduction networks and the developmental genetics responsible for adult stomatopod retinal complexity.

P3.8 PORTER, DT*; MARUSKA, KP; Louisiana State University; *dport14@tigers.lsu.edu*

Neural basis of feeding and reproduction in the maternal mouthbrooding fish, Astatotilapia burtoni

Reproduction in vertebrates is an important but energetically costly process, especially for females who invest in parental care. Reproductive and feeding processes are often tightly linked and individuals must constantly sense and integrate cues from both the internal body and the external environment to make critical decisions about when to eat and when to reproduce. Little is known, however, about which neurochemicals are involved in regulating a switch between parental care and feeding. The model cichlid fish *Astatotilapia burtoni* is ideal for studying the neural regulation of feeding and reproduction because females of this species undergo a two−week period of forced starvation while holding developing young inside their mouths. To determine which neuropeptides might be involved in regulation of neural circuits associated with mouthbrooding, we performed immunohistochemistry for appetite−stimulating peptides (neuropeptide Y, NPY; agouti−related protein, AgRP) and appetite−inhibiting peptides (cocaine and amphetamine−regulated transcript, CART; alpha−melanocyte stimulating hormone, alpha−MSH). We mapped the distribution patterns of each neuropeptide, and then compared cell sizes for each neuron population between gravid−feeding and mouthbrooding−parental states. Labeled neurons for all four neuropeptides were located in known feeding and reproductive brain regions similar to that observed in other fishes, including the preoptic−hypothalamic area and lateral tuberal nucleus of the hypothalamus. Ultimately, this work will provide crucial information on how the brain switches' an individual's motivational state from feeding to parental care, which not only has broad implications for other fish species with parental care, but for all vertebrates.

126.4 PORTUGAL, S J*; WILSON, A; USHERWOOD, J; Royal Veterinary College, University of London; *sportugal@rvc.ac.uk*

Position of Center of Body Mass and Flight Dynamics in Birds

The center of mass for a flying bird is the balance point between its two wings and between its head and tail. This position of body mass will have important implications for flight costs, and both aerial maneuverability and flight speed. Little is known about the consequences, with respect to cost of flight, of experimentally manipulating the center of mass in free−flying vertebrates. Using data from innovative custom−built GPS and accelerometer loggers, we will present research in homing pigeons demonstrating the response in flap frequency and wing amplitude to changes in the center of mass of free−flying pigeons during 12 km homing flights. These findings will additionally have important ethical considerations for the use and placement of externally attached logging devices on flying animals.

P3.161 POUNDSTONE, M.M.*; HOOD, W.R.; Auburn University ; *mmp0015@auburn.edu*

Growing up in the dark isn't so bad, part II: Development of cavity nesting bluebirds is not limited by access to UVB light

Cavity nesting birds have young that typically display slower growth rates than their open nesting counterparts. It has been argued that faster development in open nesting birds has evolved in response to a greater risk of predation. Recent work in chickens has shown that vitamin D enhances skeletal growth, immune function, and gut development in chicks maintained in dark conditions, and low vitamin D inhibits brain development in mouse pups. Thus, we reasoned that differences in the rates of development between cavity nesting and open nesting birds might be explained by differences in available sunlight, its effects on vitamin D synthesis, and the effect of vitamin D on development. A prior study suggested oral supplementation with vitamin D had no impact on offspring development. Yet, vitamins are inherently labile and thus, it is possible that the lack of effect was due to low vitamin D activity rather than an inability of the birds to respond to the treatment. As a follow up, we asked if natural production of vitamin D through exposure to UVB light would impact development. We compared the skeletal size, mineral content, and organ size between Eastern Bluebird chicks exposed to UVB light for 1h per day between days 2−13 post−hatching. Treatment groups were compared on day 14. We found no effect of treatment on body mass, body size, bone mineral content, length of the intestine, and size of any of the major visceral organs. These findings provide further evidence that access to sunlight during postnatal growth in bluebirds does not limit growth. Assuming that vitamin D is important for development in bluebirds, it is likely that mothers are depositing sufficient vitamin D in their egg yolk to support pre−fledging development.

123.4 POWDER, KE*; COUSIN, H; JACOBS−MCDANIELS, NL; ALBERTSON, RC; UMass Amherst, Syracuse Univ; *kepowder@bio.umass.edu*

A novel transcriptional regulator, lbh, regulates adaptive craniofacial variation in East African cichlids via neural crest cell migration

Diversification of craniofacial structures to exploit new feeding niches is a cornerstone of adaptive radiations. We have identified, using complementary developmental and evolutionary approaches, a novel modulator of craniofacial development, *limb bud and heart homolog (lbh)*. First, we observed altered *lbh* expression in a zebrafish model of CHARGE syndrome, which includes defects such as micrognathia and results from abnormal migration of cranial neural crest cells (NCCs), which give rise to the craniofacial skeleton. Second, we determined that a genomic interval containing *lbh* contributes to variation in mandible length in cichlid fish. Re−sequencing this region in wild−caught populations identified two single nucleotide polymorphisms (SNPs) within *lbh* that are alternatively fixed (FST=1.0) in two cichlid species with differing jaw morphologies, including one micrognathic species. One of these SNPs is intronic and the other encodes a non−synonymous change within a region necessary for the transcriptional activity of *lbh*. To expand on these putative roles of *lbh* in craniofacial disease and evolution, we evaluated the function of *lbh* in NCC and facial development. We observed *lbh* expression in NCCs, and found that depletion of Lbh results in cell−autonomous inhibition of NCC migration and discrete facial defects including a severe reduction of the lower jaw precursor. Notably, Lbh variants isolated from cichlids with alternate jaw morphologies differentially regulate NCC migration. These data strongly implicate *lbh* as a mediator of both clinical and evolutionary micrognathism, and suggest a cellular mechanism of adaptive craniofacial evolution in cichlids.

P3.37 POWELL, D.L.*; ROSENTHAL, G.G.; Texas A and M, College Station; *dpowell@bio.tamu.edu*

The fitness effects of early generation hybridization in two northern swordtails, Xiphophorus birchmanni and X. malinche.

A growing body of work has highlighted the evolutionary importance of genetic exchange between divergent populations. Such exchange ultimately depends on the mating decisions of individuals within sympatric populations. Therefore, understanding the evolutionary consequences of hybridization requires us to identify the mechanisms underlying mate choice. Specifically, it is crucial to understand how natural and sexual selection act on mating traits in hybrids. Swordtail fish, members of the genus *Xiphophorus*, are ideal models for such studies and can offer insight into the causes and consequences of interspecific hybridization. This is true for several reasons. First, they possess both easily identifiable male secondary sexual traits, as well as female mating preferences for these traits that can be readily characterized. More importantly however, natural hybrid zones between two closely related swordtail species, *X. birchmanni* and *X. malinche*, have been identified, and are distributed over at least seven drainages, each of which likely represents an independent hybridization event. Interestingly, despite extensive collections across all known hybrid zones, the presence of F_1 hybrids has not been detected. This suggests that hybrids observed in the field are all later generation hybrids or extensively backcrossed to the parental species, and thus have undergone many generations of selection. Since later−generation hybrids and backcrosses in the wild ultimately arise from F_1 and F_2 hybrids, it is important to estimate the fitness effects of hybridization in the first few generations. It is the aim of my proposed work to use controlled reciprocal laboratory crosses to to evaluate early generation hybrid fitness with respect to sexual selection.

P2.73 POWELL, M/L*; VALENZANO, D; ALLISON, D/B; WATTS, S/A; Univ, or Alabama at Birmingham, Max Plank Institute for Aging Biology; *mpowell@uab.edu*

Emerging Models in Nutrition and Aging Research: the short−lived Killifish Nothobranchius furzeri

Fish species can offer advantages over more traditional mammalian model organisms for aging research. The ability to obtain large cohorts from a single mating, reasonably short life spans (relative to many mammalian species), and low husbandry costs make fish an attractive alternative to traditional mammalian aging models. Zebrafish (*Danio rerio*) have all these advantages as well as a fully sequenced genome and access to numerous mutant strains and transgenic lines. However, the lifespan of zebrafish is similar to that of mice (3−5 years). *Nothobranchius furzeri* is a fish species native to Africa that has recently been gaining interest as an aging model because of its extremely short life span and its rapid aging onset. *N. furzeri* reaches sexual maturity at 4 weeks and the life cycle is completed in only 12−16 weeks. During this time *N. furzeri* exhibit many of the phenotypes of aging including effects of dietary restriction on mortality, age−dependent cognitive/behavioral decline, expression of age−related biomarkers, and susceptibility to lifespan manipulation. The unique life cycle of *N. furzeri* allows eggs to be held for extended periods on a moist substrate and hatched within 24 hours of returning the eggs to water. Larvae begin feeding within 24 hours post hatch (ph). A live diet (*Artemia* nauplii) at first feed promotes high rates of growth compared to first feed with formulated diets. Growth rates are extremely rapid, with larval fish increasing over 34% in body length in only four days. Introduction of formulated feeds in combination with live diets at day 10 ph can increase growth rates further. We will test how early nutrition and resource allocation affect overall fish lifespan and modulates the progression of aging biomarkers.

64.5 POWERS, DR*; WETHINGTON, SM; LANGLAND, KM; SCHROEDER, RJ; CANEPA, JR; George Fox Univ, Newberg, OR, Hummingbird Monitoring Network, Patagonia, AZ; *dpowers@georgefox.edu*

Physiological Sensitivity of Hummingbirds to Warming Environmental Temperatures

Hummingbirds, key pollinators across many landscapes, are tiny endotherms that exhibit rapid metabolic response to changes in environmental temperature. Most landscapes in which hummingbirds play an ecological role are expected to experience unusually rapid increases in environmental temperature as a consequence of global climate change. Of particular concern are landscapes in the southwestern US, which provide migratory corridors and breeding habitat for most North American hummingbird species. In this study we examined the vegetative structure and thermal profiles of two hummingbird landscapes near Patagonia in SE Arizona (Harshaw Creek, HC; Sonoita Creek, SC) to assess their complexity and potential to provide refugia during periods of temperature extreme. We also measured daily energy expenditure (DEE), surface heat dissipation, and torpor use in male broad−billed hummingbird (*Cynanthus latirostris*, ~3.2 g; BBLH) the dominant species at both sites to assess physiological performance at both sites. Both daytime and nighttime temperatures at SC were 5−10 °C higher than HC with highest daytime temperatures at SC > 50 °C. Even so both landscapes exhibited sufficient thermal complexity to provide escape from high temperatures. DEE in BBLH was ~15% higher at SC which might in part be accounted for by lower torpor use (i.e. higher nighttime energy costs) at this site likely due to higher nighttime temperatures. Even so under conditions measured in this study BBLH males at both sites showed no obvious signs of physiological bottlenecks even during periods when temperature was high.

P3.74 POWERS, SD*; POWERS, DR; TOBALSKE, BW; WETHINGTON, SM; George Fox Univ, Newberg, OR, Univ. of Montana, Missoula, MT, Hummingbird Monitoring Network, Patagonia, AZ; *seandpowers@gmail.com*

Using an endotherm energetic model to predict hovering metabolic rates of hummingbirds

Hummingbirds provide a unique opportunity to understand the response of small endotherms to climate change. They inhabit a broad range of ecosystems and because of their small size operate at the limits of endothermic physiology (i.e. energy expenditure is carefully managed). Increased thermoregulatory costs and changes in energy resources likely tied to climate change might profoundly impact daily energy expenditure. Since hummingbirds are key pollinators in many important ecosystems understanding the impact of climate change on metabolic costs is crucial. Our goal was to model heat generation in hovering hummingbirds in order to predict hovering metabolic rate (HMR) over a range of environmental temperatures (endotherm model; Porter et al., 1994; Porter and Kearny, 2009). To model HMRs we used infrared thermography (IRT) to measure surface body temperatures. From these IRT measurements we calculated the HMR needed to maintain core body temperatures of hummingbirds during hovering. To validate the model we did a sensitivity analysis using linear regression with observed HMR. We found that the relationship between predicted and observed values was not significant ($F = 0.002$, $p = 0.997$). The slope of this relationship ($m = 0.425$) also indicated the endothermic model was not in agreement with the observed values. Our results demonstrate two problems. First is how the extra heat generated by the flight muscles contributes to the determination of surface body temperatures. Second is the integration of IRT measurements with the endotherm model. To do this we need to better understand the role plumage plays in heat dissipation. We plan further experiments to explore these issues.

57.4 PRADHAN, DS*; WILLIS, MC; SOLOMON−LANE, TK; CRUTCHER, JB; THONKULPITAK, K; GROBER, MS; Georgia State Univ., Atlanta, Rhodes College, Memphis, Georgia State Univ., Atlanta, GA; *dpradhan1@student.gsu.edu*

Female courtship solicitation is associated with reproductive success in Bluebanded Gobies

Courtship and territorial defense may reduce the quality or quantity of parental care, thus limiting the chances for offspring survival. The bluebanded goby, *Lythrypnus dalli*, is a haremic marine fish that has multiple overlapping broods during the breeding season. The role of the male is highly dynamic: he demonstrates requisite parental care and territory defense, maintains the highest rank, and courts using jerk swims. Thus, traits that allow a male to invest heavily in parenting may interfere with territoriality, status or courtship. Females interact to maintain a linear social hierarchy and demonstrate courtship solicitations. Here, we tracked eggs laid over 3 weeks to investigate the role of courtship and parenting in reproductive output. Using groups consisting of one male and two status−mismatched females, we generated natural variation in egg numbers and periods without any eggs in the nest. Rates of parenting, male jerks, and female solicitation were not affected by egg presence. Overall, females solicited at a higher rate compared to male jerks. Number of eggs was not associated with male parenting, males approaching or jerking towards females. However, number of eggs was associated with rate of female solicitation. More specifically, numbers of eyed eggs were associated with alpha solicitation. Transition matrix analysis revealed that alphas frequently interrupted beta solicitation and solicited the male. Overall, these data illustrate that there are limited tradeoffs with regard to the expression of male behavior and alpha female behavior has a big impact on male reproductive success.

14.2 PRAET, T; ADRIAENS, D*; NEUTENS, C; MAIA, A; DE BEULE, M; VERHEGGHE, B; Ghent University, IBiTech − bioMMeda, Ghent University, Evolutionary Morphology of Vertebrates, Eastern Illinois University, Dept. of Biological Sciences; *dominique.adriaens@ugent.be*

Understanding the mechanics of tail grasping in seahorses using a parametrized computer model

Seahorses are intriguing fishes for several reasons, one being their prehensile tail. Syngnathid fishes, to which seahorses, pipefish, seadragons and pipehorses belong, are characterised by a body armour of bony plates. They form a serially articulated system that encloses the vertebral column and its musculature. In the ancestral condition, as in pipefish, the tail is straight with limited flexibility, and mainly used for steering (pectorals and dorsal used for swimming). During evolution, the tail became modified into a grasping apparatus multiple times independently within the syngnathid family. Less known than the seahorse prehensile capabilities, pipehorses also show different morphologies related to grasping performance. To better understand the structural basis of tail grasping mechanics, a parameterized model of the seahorse tail was developed. By combining multibody dynamics analysis with finite element analysis, we analysed the implication of partial contribution of epaxial and hypaxial muscles, versus ventral median muscle, as well as that of the bony plate geometry. Natural bending postures, as observed in living seahorses, can be obtained up to some degree. The analyses showed particular relations between morphology and bending kinematics. Using this seahorse model, functional implications of evolutionary changes in in syngnathid tails can be further analysed, as well as to develop biomimetic designs of serially articulated systems that meet particular application demands.

S10.2−4 PRAKASH, M*; MUKUNDARAJAN, H; Stanford University; *manup@stanford.edu*

Insect Flight on a Fluid Interfaces and Chaotic Oscillators

Here we present the discovery of a novel mode of interfacial "2D flight" in water lily beetles (Galerucella nymphaeae), that are capable of multiple modes of flapping−wing locomotion along a fluid interface, as well as fully−fledged airborne flight. 2D flight is characterized by a novel set of physical constraints because of it's coupling to a fluid interface (say, surface of a pond) and the role of of capillary−gravity wave trains behind the moving insect. Here, we analyze the kinematics of 2D flight, highlight key differences in this unique mode of flight and develop a dynamic model to explain flight characteristics. Finally, we present an analysis of the vertical oscillations in the flight trajectory due to the non−linear forced oscillator created by vertical wing lift and surface tension. Utilizing this technique, we further outline a method for tether−free measurement of flight forces in insects.

P2.161 PRATER, C/M*; CARR, J/A; GARCIA, C; HARRIS, B; Texas Tech University, Lubbock; *christine.prater@ttu.edu*

Food Deprivation and Stressor Exposure Alter Tectal CRF Concentrations in African Clawed Frogs Xenopus laevis

The 41 amino acid peptide CRF alters visually guided prey capture in anuran amphibians. A physiological role for CRF in regulating visually guided behavior is suggested by the presence of CRF neurons and CRF R1 receptors in the anuran optic tectum (Carr et al., 2013). Whether tectal CRF neurons respond to changes in energy balance or stress is unknown. We examined the effects of food deprivation and stressor exposure on tectal CRF content in the male and female African clawed frog. For the food deprivation studies, frogs received no food or normal food (n = 8 per group) rations for 8 d. For stress studies, frogs were untreated or exposed to ether vapors (1 min) or shaking stress (4 h). CRF content of the telencephalon (Tel), optic tectum (OT), hypothalamus/ thalamus (H/T), and the brainstem (BS) was measured using a homologous radioimmunoassay. The rank order for CRF concentrations in each brain area was H/T > OT > Tel > BS. Food deprivation significantly decreased CRF content of the OT but did not alter CRF content of the Tel or H/T when compared to controls. Interestingly, CRF content of the BS increased in response to food deprivation. Exposure to a shaking stressor increased CRF in the H/T but did not alter CRF in the OT. In contrast, exposure to the systemic stressor (ether) elevated CRF in the OT relative to untreated controls. These data suggest that tectal CRF neurons may play a physiological role in modulating visually guided behavior during stress and in response to changes in energy balance.

99.8 PRESNELL, JS*; SCHNITZLER, CE; BROWNE, WE; University of Miami, FL, National Human Genome Research Institute, NIH, Bethesda, MD; *j.presnell@umiami.edu*

Klf/Sp transcription factor family expansion, diversification, and innovation in the Unikonta

The *Krüppel−like factor (Klf)* gene family consists of two groups of transcription factors, *Klf* and *Specificity protein (Sp)* factors. KLF/SP proteins bind GT box and GC−rich DNA sequences associated with gene regulatory regions through a highly conserved DNA binding domain (DBD) composed of three C−terminal C2H2 zinc fingers (KLF−DBD). Members of the *Klf* gene family influence transcription via interactions with other transcription factors, cofactors, chromatin remodeling factors, and transcriptional machinery components. These protein−protein interactions are mediated by an array of transactivation domains typically found N−terminal of the KLF−DBD. Collectively the *Klf/Sp* genes play key roles in a variety of critical biological processes including cell proliferation, stem cell maintenance, embryonic development, and tissue differentiation and they have been implicated in a number of human diseases and cancers. Many *Klf/Sp* genes have been characterized in a handful of bilaterian lineages, however very little is known about the *Klf* gene family in non−bilaterians and virtually nothing is known outside of the metazoans. We identified and characterized the complete *Klf/Sp* gene complement from the genomes of 14 lineages spanning the Unikonta. We also examined the phylogenetic distribution of transactivation domains associated with the Klf gene family. Within the Metazoa, the expansion of the *Klf* gene family transactivation repertoire is strongly associated with the expansion of cell type complexity. Our results indicate that expansion of the *Klf* gene family is paralleled by transactivation domain diversification via both the acquisition of pre−existing ancient domains as well as by the appearance of novel domains exclusive to the *Klf* gene family.

98.3 PRICE, E.R.*; CAVIEDES−VIDAL, E.; KARASOV, W.H.; University of Wisconsin−Madison, Universidad Nacional de San Luis; *eprice2@wisc.edu*

Mechanistic correlates of paracellular nutrient absorption in protein specialists

Water−soluble nutrients (e.g., glucose and amino acids) can be absorbed across enterocytes via protein−mediated transport, or paracellularly through the tight junctions between enterocytes. Previously we demonstrated that absorption of arabinose (a nutrient−sized paracellular probe) was higher in intact insectivorous bats (*Tadarida brasiliensis* and *Myotis lucifugus*) when compared to insectivorous rodents (*Onychomys leucogaster* and *Peromyscus leucopus*). This phenomenon can also be observed in isolated intestines: in intestinal perfusions, arabinose clearance was higher in insectivorous bats compared to insectivorous rodents when compared on a nominal surface area basis. This implies that bats have either more tight junctions per nominal surface area (for example via longer villi) and/or bats have leakier tight junctions (perhaps achieved via differential expression of the proteins that form the tight junctions). We investigated these mechanistic correlates using histological examination of intestines and by measuring gene expression of several claudin proteins. Supported by NSF Award 1025886.

19.4 PRICE, S. A.*; HOPKINS, S.S.; Univ. of California, Davis, Univ. of Oregon; *saprice@ucdavis.edu*

Macroevolutionary relationships between size and diet in mammals.

Living mammals exhibit remarkable variability in body mass, spanning eight orders of magnitude from the bumblebee bat (~1.3g) to the blue whale (~160 tonnes). Due to the high energy demands of homeothermic endothermy, diet and mass are expected to be tightly linked in mammals: as size increases dietary quality decreases. The observation that mammalian basal metabolic rate usually scales to 3/4 power of mass (Kleiber's law) explains why larger mammals are able to subsist on lower quality diets, as their energy requirements are lower per unit of mass. This predicts, amongst other things, that herbivores should be larger than carnivores. Using data from 1,300 mammals we tested for different size optima among different diets with generalized Ornstein−Uhlenbeck models. Across all mammals the best−fitting model was one that allowed both the optima and the rate of evolution to vary with diet. The model−averaged optima reveal that in general herbivorous mammals are much larger than carnivores, with an optima of 30kg and 4.5kg respectively. However, there is little difference between the optima for omnivores (5kg) and carnivores, suggesting perhaps that carnivorous and omnivorous mammals have similar overall diet qualities. Our results confirm that, despite the very different constraints on mass in terrestrial, volant and aquatic species, herbivory is linked to larger size across all mammals.

P1.152 PROFFITT, JV*; MIDDLETON, KM; CLARKE, JA; University of Texas, Austin, University of Missouri, Columbia; *jvproffitt@gmail.com*

Patterns of morphological evolution during a locomotor transition: Lessons from the evolution of wing−propelled diving in penguins

Evolutionary transitions in locomotion provide excellent opportunities for exploring patterns of whole−organism morphological change associated with shifts in ecology. More specifically, these scenarios can act as investigatory frameworks for examining differential rates of evolution in separate anatomical regions, informing our understanding of the relationship between adaptation, anatomical form, and biological function. The evolution of wing−propelled diving in penguins represents a model system in which to pursue these questions due to penguins' distinctive modes of locomotion relative to immediate outgroups, robust fossil record, and well−constrained phylogeny. New morphological characters developed through study of fossils and dissection of extant taxa were combined with previously developed character matrices to form the most complete dataset of penguin osteological characters to date. Patterns of character change in the forelimb and hind limb of penguins were assessed in parsimony and Bayesian frameworks to infer relative rates of evolutionary change in each anatomical region across penguin phylogeny. In contrast to hypotheses of sequential modification for forelimb and hind limb morphology, we find similar rates of character change early in penguin evolution. Our results emphasize the importance of examining whole−organism patterns of change rather than approaches only based on single character complexes or key innovations. These data, when combined with further anatomical and functional data obtained from extant penguins, will provide greater insight into the evolution of ecological and morphological diversification within birds.

10.2 PULPITEL, T.J.*; SIMPSON, S.J.; PONTON, F; University of Sydney, N.S.W, Australia; *tamara.pulpitel@sydney.edu.au*

Selective cannibalism: "Don't eat me, I'm infectious!"

Uncovering the links between nutrition, cannibalism and locust migration has been a major step forward in developing a better understanding of the biology and population dynamics of the Australian plague locust, *Chortoicetes terminifera*. Limiting resources within crowded migratory bands often leads to mass cannibalism, where locusts seek to satisfy protein and salt deficiencies by turning to an alternative nutrient source; each other. As with most predator−prey interactions vulnerable locusts, whether young, small or injured, are generally first to fall victim to cannibalism. While such victims are easy to catch, targeting the weak may not always be the safest way of obtaining a meal. As with any food item, locusts must assess food quality prior to consumption of their conspecifics. Indeed, victims harbouring pathogens or disease may impose a higher risk of infection to the cannibal. Our research investigated whether cannibalistic locusts have the capacity to discriminate between fungal infected and non−infected victims. In a series of experiments, we used the acridid−specific fungus, *Metarhizium acridium* to identify whether starved locusts strategically avoid potential infection during cannibalism, while simultaneously satiating their protein appetites. This work gives a new appreciation of the costs associated with pathogen transfer through cannibalism. With a new grasp on how locusts weigh these infection costs against nutritional gain, we will present how cannibalism in locusts has facilitated our understanding of insect immune function and behaviour as well as implications for the management of this destructive pest species.

P1.187 PURI, S; FAULKES, Z*; The University of Texas−Pan American; *zfaulkes@utpa.edu*

Thermal nociception in Louisiana red swamp crayfish (Procambarus clarkii)

Nociceptors are neurons tuned to tissue damage. Many invertebrate taxa, including insects, have nociceptors, but there is no clear evidence for nociceptors in crustaceans. We examined the behavioural responses of crayfish (*Procambarus clarkii*) to extreme high (>45°C) and low (<5°C) temperatures, which are normally considered noxious to other organisms. Crayfish reacted more strongly to the touch of high temperatures compared to room temperature controls, but did not differ in their response to low temperatures compared to controls, providing evidence of nociceptive behaviour. We then tested the physiological responses of sensory neurons in the antenna using extracellular recording. Small amounts of water of different temperatures were applied to isolated antennae in vitro. Preliminary data suggest that high temperatures frequently cause an increased neural response compared to controls, while low temperatures rarely differ from room temperature controls. There do not appear to be neurons that fire only in response to noxious stimuli; instead, neurons fire at an increased rate to noxious stimuli. These combined behavioural and physiological data are consistent with the hypothesis that crayfish have polymodal sensory neurons that act as nociceptors, not merely thermoreceptors.

114.3 PUSCH, E. A.*; THOMPSON, J. A.; NAVARA, K. J.; University of Georgia; *epperfectchoice@gmail.com*

GnIH expression is effected by chronic stress in white leghorns

Stress through the actions of glucocorticoids, exerts inhibitory influences on reproductive behavior and physiology in birds, but we do not fully understand the mechanism responsible for stress−related reproductive inhibition. The hypothalamic neuropeptide gonadotropin inhibitory hormone (GnIH) is known to inhibit reproductive physiology and behavior in birds. Yet, it is still unknown if GnIH is part of the mechanism responsible for reproductive inhibition from stress. The objective of this study was to determine if chronic stress increased GnIH expression in the hypothalamus in white leghorn hens. To induce chronic stress, hens were exposed to food restriction, corticosterone administration, or social stress. We predicted if GnIH is part of the mechanism responsible for reduced reproduction under the condition of chronic stress, birds exposed to chronic stress would have higher levels of GnIH expression compared to controls. Plasma corticosterone levels and tonic immobility test results showed that all three treatments induced chronic stress, with two of the treatments causing decreases in reproductive output. Hens that received corticosterone stopped producing eggs, had regressed ovaries, increased body fat, and enlarged livers. Hens in the social stress and corticosterone groups had eggs with significantly reduced mass compared to control. Contrary to predictions, corticosterone significantly decreased GnIH expression while social stress and food restriction did not exert a significant influence. Further experimentation is required to understand how GnIH expression responds to stress and if this correlates with stress−related reproductive inhibition.

41.1 QIAN, F*; ZHANG, T; GOLDMAN, DI; Georgia Tech; *qianfeifei1114@gmail.com*

Towards a terradynamics of heterogeneous granular media

Recently, we have made progress in understanding aspects of legged locomotion on flowable ground [Li et al, Science, 2013], proposing a "terradynamics" for movement on homogeneous granular media. However, many substrates are composed of particulates of varying size, from fine sand to pebbles and boulders. Locomotion on such heterogeneous substrates is complicated in part due to fluctuations introduced by heterogeneities. To systematically explore how heterogeneity affects locomotion, we study the movement of a legged robot (Xplorerbot, 15 cm, 150 g) in a trackway filled with <1 mm poppy seeds (the "sand"), with a single embedded 4 cm diameter plastic sphere (the "boulder"). We investigate how the presence of the boulder affects the robot's trajectory under open−loop control, a minimal model for a rapidly running organism. We use an automated terrain creation system (including an air fluidized bed, tilting motors, and a universal jamming gripper) to set the initial condition of the substrate, including sand compaction and boulder location/burial depth. The kinematics of the robot are recorded and tracked by a high speed camera system. After each test, a universal jamming gripper retrieves and redistributes the boulder and robot, while the fluidized bed resets the compaction of the sand. We observe that before the interaction with the boulder the trajectory is straight; after the interaction the trajectory is angled relative to this line, and the angle depends sensitively on the leg−boulder contact position, leg phase at contact, and the boulder mobility within the sand. We view this as a scattering problem: analysis of the robot trajectory indicates that the interaction can be modeled using an attractive potential whose shape and magnitude depend on the parameters above. We expect that a terradynamics of locomotion on heterogeneous substrates can be informed by our scattering picture.

S5.2−2 QIAO, M; JINDRICH, D. L.*; University of Omaha, California State University, San Marcos; *djindrich@csusm.edu*

Compensations During Unsteady Locomotion.

Locomotion in a complex environment is seldom steady−state, but the mechanisms used by animals to power and control unsteady locomotion (stability and maneuverability) are not well understood. We use behavioral, morphological, and impulsive perturbations to determine the compensations used during unsteady locomotion. At the both the whole−body and joint levels, quasi−stiffness models are useful for describing adjustments to leg and joint function associated with maneuvers. However, alterations to leg and joint mechanics are often distinct for different phases of the step cycle or specific joints. For example, negotiating steps involves independent changes of leg stiffness for compression and thrust phases of stance. Moreover, the compensations used to reject impulsive lateral perturbations may be gait and step phase dependent. Unsteady locomotion also involves parameters that are not part of the simplest reduced−parameter models of locomotion (e.g. the Spring−Loaded Inverted Pendulum). Extensive coupling among translational and rotational parameters must be taken into account to stabilize locomotion or maneuver. For example, maneuvers with morphological perturbations (increased rotational inertia turns) involve changes to several aspects of movement, including initial rotation conditions and ground−reaction forces. Coupled changes to several parameters may be employed to control maneuvers on a trial−by−trial basis. Compensating for increased body inertia during turns is facilitated by the opposing effects of several mechanical and behavioral parameters. Consequently, reduced−parameter models can be useful for describing unsteady locomotion, but animals may employ coupled changes to many parameters that depend on context.

P2.69 QUICAZAN−RUBIO, EM*; FLEUREN, M; VAN LEEUWEN, JL; POLLUX, BJA; Wageningen University; *elsa.quicazanrubio@wur.nl*

The use of 3D recording of fast−start escape response to study the evolution of placentation in Poeciliid fish

Pregnancy is known to have a negative effect on the locomotor performance of females, exposing livebearing females to a higher risk of predation. It has recently been proposed that the placenta evolved in livebearing fish because it alleviates the costs of pregnancy on female locomotory ability, a hypothesis known as the Locomotory Performance Hypothesis' (Pollux et al., 2009). We test this hypothesis using the fish family Poeciliidae, where the placenta evolved at least 8 times independently. We will work with two closely related species from the genus Poeciliopsis that differ in the degree of post−fertilization maternal provisioning, yet have the same level of superfetation: the non−placental species Poeciliopsis gracilis and the placental species Poeciliopsis turneri. We will assess changes in the metabolic oxygen requirements using a closed respirometry system, and sustained (aerobic) swimming performance (Ucrit) of females throughout their pregnancy using a newly designed state−of−the art recirculating flow tunnel. The tunnel is designed such that fish will swim in the centre of the tunnel. A camera (topview, 500fps) is used to record tailbeat frequency and amplitude during the swimming trials. We will present some preliminary data on the effects of pregnancy on the oxygen consumption and sustained swimming performance of P. gracilis.

P1.68 QUINDE, J*; MORANTE, K; BAYNHEM, H; MCCAFFREY, A; GARCIA, J; PRIYAMVADA, L; HECKMAN, K; TEMKIN, M; SCHREIBER, A.M.; St. Lawrence University, NY; *aschreiber@stlawu.edu*

Estradiol and Atrazine induce apoptosis and regression of the thymus gland in Xenopus laevis embryos and tadpoles.

High levels of endogenously−produced or exogenously−administered estradiol are known to cause the thymus to atrophy in mammals, similar to the suppressive effects of glucocorticoids on the immune system. However, the influence of estradiol and estrogenic compounds on thymus gland development in tadpoles and other aquatic vertebrates remains unknown. Here we show that treatment of embryos (2 days post−fertilization, dpf) and young tadpoles (7 dpf; Nieuwkoop and Faber stage 50) for 4 or 6 days, respectively, with estradiol (10 uM) significantly reduces thymus gland size by approximately 35%. Treatment of tadpoles with estradiol induces maximum active caspase−3 expression (a mediator of programmed cell death) in thymocytes within 48−72 hours, after which levels of thymus cell apoptosis decrease. Treatment of NF stage 50 tadpoles with atrazine (100 ug/L) for 7 days reduced thymus size by 35%. Atrazine is a widely−used herbicide that is also known to disrupt vertebrate estrogen signaling by increasing endogenous estradiol synthesis by activating p450 aromatase. In contrast, treatment of either embryos or NF stage 50 tadpoles for 7−14 days with bisphenol A (BPA, 5−15 uM) had no effect on thymus size. BPA is a common constituent of plastics that has also been reported to function as a weak estrogen receptor agonist. Ongoing experiments using estrogen and glucocorticoid receptor antagonists (fulvestrant and RU−486, respectively) are being conducted to determine if atrazine−induced thymus regression is mediated entirely by the estrogen receptor, or if atrazine also induces thymus regression via stimulating the production of glucocorticoids.

P3.70 QUINN, MM*; BUSH, JM; DILL, AK; BALREIRA, EC; JOHNSON, MA; Trinity University ; *mquinn2@trinity.edu*

Mathematical model of the dynamic energy budget of the green anole lizard (Anolis carolinensis)

All animals must allocate the energy they obtain from their food among the processes that support their survival. While different animal species use energy in different ways, few studies have yet examined energy allocation in reptiles. In this study, we developed a mathematical model of energy use in the green anole lizard, *Anolis carolinensis*, to determine the amount of energy used for basic metabolism and growth in a laboratory setting. To build this model, we first quantified the extent of available energy (defined as energy from food, minus energy lost through excretion). We collected empirical data by housing 19 adult male lizards in the laboratory for 40 days, feeding each lizard 3−5 crickets of known mass each day. Every third day, we measured each lizard's snout−vent length (SVL), mass, and excreta. We determined the energy in the crickets and excreta via bomb calorimetry, and we used a respirometer to measure each lizard's resting metabolic rate (RMR), a measurement of the energy required for basic maintenance. Using these data, we developed several alternative models, combining different functions of metabolism and growth and using linear and nonlinear regression to create a dynamic energy budget. We only considered biologically reasonable models, which we defined as those that included a positive relationship between available energy and growth, and showed growth as a decreasing function of SVL. Our best model used an approximation for relative growth as a decreasing nonlinear function of SVL and did not include an estimate of metabolism, indicating that energy spent on simple metabolic processes only utilized a very small amount of the lizards' overall energy budget.

P3.196 QUISPE, R*; GAHR, M; Max Planck Institute for Ornithology; *rquispe@orn.mpg.de*

Seasonal Patterns of Testosterone Production and Singing Behavior but not Variation in Song Control Region Volumes in Ramphocelus carbo (Thraupinae), an Endemic Amazon Songbird.

In songbirds, the development and production of song are regulated by a network of interconnected brain nuclei known as the song control system. One central nucleus of this neural system is the HVC. The HVC functions as a sensorimotor integrator that projects to the descending motor pathway and to the anterior forebrain pathway involved in song learning. In several species, the HVC volume change seasonally, paralleling changes in the reproductive and singing activity. The HVC is sensitive to androgens and estrogens, and its size is thought to depend partly on circulating testosterone levels, being larger during the breeding season. Studies of high−latitude songbirds have served as important models for understanding the seasonal neuroplasticity of the song control system. However, in equatorial songbird species the mechanism seems to be different, as they are suppose to show a lower degree of seasonality in their annual cycles. In the equatorial lowland Amazon, there is little to no annual variation in photoperiod, but there are seasonal fluctuations in rainfall. In our study, we tracked changes in HVC volume and testosterone plasma level of male Silver−beaked Tanagers (*Ramphocelus carbo*) for one year in an equatorial population of the Brazilian Amazon. In addition we followed the singing activity of males during the transition from dry season to rainy season. Our results demonstrate a highly seasonal pattern in plasma testosterone levels and singing activity. Nevertheless, we found no significant variation in HVC volumes across the year. This study provides valuable information about the neuroplasticity, song behavior and significance of the environment on an endemic Amazon songbird.

91.5 RADE, CM*; SANFORD, CP; HERNANDEZ, LP; The George Washington University, Hofstra University; *cristinarade@gmail.com*

The multi−functional properties of a cypriniform feeding novelty

The cypriniform palatal organ is a dorsally located, tongue−like muscular mass that spans the buccal roof and has various lateral connections to the branchial elements. It has most often been associated with benthic feeding behaviors. Prior research on carp and goldfish has shown that this taste bud−studded structure produces localized protrusions that selectively sort organic matter from inorganic matter during bottom feeding behaviors. Its possible role in other feeding modes has been largely ignored as the palatal organ is suggested to only function in sorting during benthic feeding events. Using electromyography and high−speed video to examine palatal organ activity in the common carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*), muscle activation patterns demonstrate that the palatal organ is likely employed just prior to suction generation, prey processing events, and may even play a role in respiration during stressful conditions. Furthermore, the palatal organ shows behavioral modulation when different food types are used including attached prey and items offered in the water column. These data suggest that the palatal organ is a multi−functional structure with a wider range of functional repertoires than previously shown. While sorting during benthic feeding may have been the primitive function of the palatal organ, it has likely been secondarily adapted for other feeding behaviors during the course of cypriniform evolution.

16.5 RADER, J. A.*; DILLON, M. E. ; MARTINEZ DEL RIO, C.; University of Wyoming; *rader@raderstudios.com*

Delineating ecological niches and their evolution from stable isotopes and museum specimens

The niche is a fundamental concept in ecology, but is often difficult to operationalize and quantify. We used stable isotopes to explore the evolution of the ecological niche in 12 species of *Cinclodes* ovenbirds. We analyzed the carbon, nitrogen, hydrogen, and oxygen isotopic composition of feathers from 254 museum specimens. Carbon and nitrogen isotopes defined three conditions in isotopic space: reliance on marine resources, reliance on terrestrial resources and reliance on island resources subsidized by marine organisms. Hydrogen and oxygen were tightly correlated, and were negatively correlated with the elevation of the site at which specimens were collected. We used the area of the 95% confidence ellipse in either C/N or O/H space to assess the breadth of the isotopic niche in resource use and elevational range, respectively. Phylogenetically independent contrasts analyses showed that the evolution of niche breadth in C/N isotopic space was positively correlated with than in O/H space. Species that evolved broad elevational ranges seem to have evolved wide resource use as well. In general, broad isotopic niches were phylogenetically derived relative to narrow niches. The marine and island habits each evolved once, respectively, in the clade. Broad niches appear to have evolved twice in the genus, and concurrently with long halluces and relatively convex wings. The evolution of a marine habit was correlated with the evolution of concentrating kidneys. The well−resolved *Cinclodes* phylogeny and isotopic values with unambiguous interpretation made possible this first study characterizing the evolution of isotopic niches. Stable isotopes are a promising tool in the study of ecological niches and their evolution.

102.5 RADZIO, T.A.*; O'CONNOR, M.P.; Drexel University; *tar55@drexel.edu*

Does Burrow Temperature Constrain Antipredator Behavior in Juvenile Gopher Tortoises?

Ectotherms may experience a tradeoff between predator avoidance and thermoregulation, particularly when refuge temperatures are physiologically suboptimal. Theory predicts that ectothermic prey will adjust hiding times following unsuccessful attacks to optimize the benefits (predator avoidance) and costs (e.g., reduced physiological performance) of refuge use. Tests of this hypothesis have primarily focused on lizards, organisms that often engage in precise behavioral thermoregulation. We examined how temperature influences hiding time in juvenile gopher tortoises *Gopherus polyphemus*, which are not known to be precise thermoregulators. We found that juvenile gopher tortoises engage in extensive behavioral thermoregulation by frequently shuttling between relatively cool burrow and warm surface microhabitats. In simulated predator approaches that used video cameras to document tortoise responses, basking juveniles exhibited long flight initiation distances and entered burrows rapidly. These observations suggest that individuals rely on both early, non−visual detection of predator presence and rapid escape speed to avoid attack. Burrow temperatures explained variation in reemergence times, with juvenile tortoises reemerging sooner when burrows were cool and remaining below ground longer when burrows were warm. These results suggest that, similar to some lizards, juvenile gopher tortoises appear to optimize a tradeoff between predator avoidance and physiological performance.

P2.170 RAHMAN, M.S.*; THOMAS, P.; University of Texas at Austin; *rahman@utexas.edu*

Hypoxia−induced global DNA methylation and IGF regulation in a marine teleost, red snapper

Epigenetic modifications such as DNA methylation and histone acetylation impact developmental processes in vertebrates. However, little is known about the epigenetic modifications occurring in aquatic vertebrates during exposure to environmental stress. In this study, we investigated the changes in global DNA methylation and regulation of the related enzyme, DNA methyltransferase (DNMT) as well as the expression of insulin−like growth factor−I (IGF−I) in hepatic tissues after chronic exposure of red snapper to hypoxia (dissolved oxygen 1.7 mg/L for 4 weeks). Colorimetric *in situ* TUNEL assay and immunoreactive (IR) staining were conducted to evaluate DNA fragmentation and global DNA methylation, respectively. Plasma IGF−I levels were measured by enzyme immunoassay to determine whether changes in IGF−I regulation are associated with the changes in global DNA methylation during hypoxia exposure. Chronic hypoxia exposure caused marked increases in the immunoreactive expression of ssDNA, dsDNA, and 8−hydroxy−2−deoxy guanosine, a key marker of oxidative DNA damage, in hepatic tissues. Massive DNA damage detected by TUNEL signals was also observed in hepatocytes after hypoxia exposure. The IR intensities of DNMT, 5−methylcytosine (5mC, a methylated form of DNA base cytosine), and histone H3K4 trimethyl (H3K4me3, a histone protein involved in the structure of chromatin) were markedly increased in hepatic tissues after hypoxia exposure. In addition, hypoxia exposure caused a marked decline in plasma IGF−I levels to 25% of original levels. Collectively these results suggest that hypoxia leads to induction of DNA methylation through the related enzyme, DNMT, which might be involved in the regulation hepatic IGF−I expression in aquatic vertebrates.

P1.123 RAM, YV*; IRIARTE−DIAZ, J; ROSS, CF; Univ. of Chicago; *yashesvini@uchicago.edu*

Muscle Coordination during Mastication in Primates

Previous studies indicate that trigeminal muscles can be divided into triplets that fire in synchrony and may be controlled by a small number of neural factors. In this study, EMG and kinematic data were used to analyze the coordination between the left and right trigeminal muscles (Anterior/Posterior Temporalis, Superficial/Deep Masseter, Medial Pterygoid, Digastric) during mastication in primates. Coordination in amplitude of recruitment and timing of activation were quantified as evidence that two muscles are controlled by a single neural factor. We predicted that muscles that are recruited together (i.e., triplets) would be more tightly coordinated with each other than with other muscles. In the frequency domain, the EMG signal was decomposed into sinusoids of various frequencies to create the power spectrum. The phase spectrum describes the phase shifts that must be applied to each sinusoid to obtain the original EMG signal. Coherence of power and phase in the frequency domain was used to quantify the coordination between muscles. Our results show that triplets of muscles that fire together are not more tightly coordinated with each other than with other muscles. These results indicate that muscles that fire synchronously (triplets) are not necessarily controlled by a single neural factor and their coordination may be a byproduct of other neural influences.

53.8 RAMENOFSKY, M*; CAMPION, A; DILLAMAN, R; KRAUSE, J S; NEMETH, Z; Univ. of California, Davis, Univer. of North Carolina, Wilmington; *mramenofs@ucdavis.edu*
Comparison of the resident and migratory races of White−crowned Sparrows: new clues for migration
Comparison of the life histories of migrant (*Z.l. gambelii*) and resident (*Z.l. nuttalli*) White−crowned Sparrows reveals both distinctions and similarities that help to characterize the physiological mechanisms and constraints associated with migration. Both races exhibit phenotypic flexibility throughout the annual cycle that matches seasonal and energetic demands. For migrants there are 6 life history stages but 3 for residents. Aligning the stages, it becomes apparent that breeding for the resident extends over 6 months with activation beginning as early as January. During this period, the migrant completes wintering stage, expresses prealternate molt, prepares and executes vernal migration followed by breeding that concludes about the same time as both races become refractory by mid−July. Post breeding events involve prolonged postnuptual molt and wintering stage for residents while migrants molt then prepare and execute autumn migration to return to the over−wintering grounds. GIven this, the most prominent distinctions between the races are prealternate molt for migrants, timing, duration and maximal values of the gonadal steroids with elevations for residents observed from February to June while migrants only show a peak in late May and early June during territory establishment and mate guarding. During migration, migrants show remarkable changes − hyperphagia, fattening, increases in flight muscle profile, fiber diameter and color that alters with incursion of lipid droplets within the myofibrils prior to departure. Focus on these distinctions helps to differentiate the two races, identifies the timing and progression of these processes, and furthers our understanding of the constraints migrants face.

48.2 RAMIREZ, D*; OAKLEY, TH; Univ. of California, Santa Barbara; *ramirez@lifesci.ucsb.edu*
The response of octopus chromatophores to light is independent of the CNS and may be mediated by r−opsin phototransduction genes
Both eyed and eyeless animals depend on sensors in their skin to detect changes in light, a phenomenon known as dispersed photoreception. Currently, the molecular mechanisms of this light sense are known only in a few species. Most mollusks have both light−on and light−off behaviors that depend on dispersed light sensing, but descriptions of these behaviors are minimal in cephalopods. We have found that bright light causes muscle contractions and chromatophore expansion in isolated skin from *Octopus bimaculoides*. These light−on responses are similar to ones described in isolated siphons from *Aplysia* species, and chromatophore responses elicited by directed blue light in midwater cephalopods. We have previously found that r−opsin phototransduction genes are expressed in octopus skin, and also identified r−opsin−expressing peripheral sensory neurons in the skin. Taken together, these data suggest that the light−on chromatophore response of isolated *O. bimaculoides* skin may be mediated by r−opsin phototransduction genes expressed in sensory neurons in the skin.

43.7 RAMSAY, JB*; WILGA, CD; TAPANILA, L; PRUITT, J; PRADEL, A; SCHLADER, R; DIDIER, DA; University of Rhode Island, Idaho State University, Idaho Museum of Natural History, American Museum of Natural History, Millersville University; *jasonramsay@mail.uri.edu*
Mechanics of the Jaws and Tooth−Whorl of Helicoprion davisii, the whorl−toothed ratfish
The discovery of a *Helicoprion* fossil containing the tooth−whorl and intact jaws shows that the symphyseal whorl occupies the majority of the lower jaw. A biomechanical model of the feeding mechanism in these Early Permian predators was developed by using the morphology of the jaws and tooth−whorl, and a reconstruction of the jaw musculature. The mechanics of the jaws and whorl suggest that hard shelled prey would tend to slip anteriorly from the closing jaws due to the curvature of the tooth−whorl, lack of cuspate teeth on the palatoquadrate and resistance of the prey. When feeding on soft−bodied prey, deformation of the prey would trap prey tissue between the two halves of the palatoquadrate and the whorl. The curvature of the tooth−whorl and position of the exposed teeth relative to the jaw joint results in tooth functions that differ from anterior to posterior tooth, which aid in feeding on soft−bodied prey. Furthermore, the paths traveled by the teeth during jaw depression are reminiscent of curved paths used with slashing weaponry and may have allowed the teeth to cut with jaw opening as well as closing.

87.4 RANGE, R.C.*; ANGERER, R.C.; ANGERER, L.M.; Mississippi State University, National Institutes of Health, NIDCR; *rangery@mail.nih.gov*
An ancient deuterostome anterior signaling center patterns and sizes the anterior neuroectoderm territory of the sea urchin embryo
Anterior signaling centers are essential to specify and pattern the early anterior neuroectoderm (ANE) of many deuterostome embryos, such as the vertebrate forebrain. In the sea urchin embryo, the ANE is restricted to the anterior end of the late blastula−stage embryo where it will form a simple centralized neural territory consisting of several types of neurons as well as the apical tuft. Here, we show that during early development, the sea urchin ANE separates into inner and outer regulatory domains expressing the cardinal ANE transcriptional regulators, FoxQ2 and Six3, respectively. This patterning process is driven by FoxQ2, which is required to eliminate *six3* expression from the inner domain. FoxQ2 also activates the expression of two secreted Wnt regulators, sFrp1/5 and Dkk3, the activities of which determine the correct sizes of the inner and outer ANE territories. Furthermore, the levels of sFrp1/5 and Dkk3 are rigidly maintained via auto−repressive and cross−repressive interactions with Wnt signaling components and additional ANE transcription factors. Our data support a model in which Six3 and FoxQ2 initiate an anterior patterning center that implements correct size and positions of ANE structures. Comparisons of functional and expression studies in sea urchins, hemichordates and vertebrates show striking similarities in deuterostome ANE regulatory states and the molecular mechanisms that position and define ANE borders. These data provide strong support for the idea that the sea urchin embryo uses an ancient anterior patterning system that was present in the common ambulacrarian/chordate ancestor.

S5.3−1 RANKIN, J.W.*; PAXTON, H; HUTCHINSON, J.R.; The Royal Veterinary College, London, United Kingdom; *jrankin@rvc.ac.uk*

Integrating experimental and computer simulation methods to reconstruct the evolution of avian bipedalism

Advances in computer technology have enabled biomechanists to use increasingly complex computer models and simulation methods to complement traditional experimental methods. For example, models and simulations provide additional data that are difficult to obtain empirically (e.g., muscle mechanical work, tendon energy flow), which allow researchers to directly address questions essential to understanding muscle coordination, performance limits and form−function relationships. To illustrate how integrating these techniques can be used in comparative studies of terrestrial locomotor biomechanics, we discuss a case study that investigates how morphology influences locomotor capacity in two bird species on opposite extremes of the spectrum: the ostrich (*Struthio camelus*), which is extremely fast ($>13 ms^{-1}$)and economical, and the broiler chicken (*Gallus gallus*), which has difficulty walking ($<1ms^{-1}$). To perform this comparison, a detailed musculoskeletal model of an ostrich and a broiler chicken were developed from dissections of representative individuals. Experimental walking kinematic data were collected from the two species either by using motion capture (ostriches) or combining high speed video with XROMM (chickens). Kinetic data were obtained using force plates. Representative trial data were then combined with the musculoskeletal models to generate two forward dynamics simulations of walking (one for each species), which we use to highlight how differences in morphology may influence locomotor function. In addition, we discuss how any understanding of terrestrial locomotor function in extant birds can help illuminate the evolution of the unusual bipedal gaits of birds and where our case study contributes to this area.

54.5 RAVI, S*; CRALL, J; MCNEILLY, L; COMBES, S; Harvard University, Bunker Hill Community College; *sravi@fas.harvard.edu*

Dynamics of Hummingbirds Flying in Highly Turbulent Winds

Hummingbirds must forage relentlessly in order to meet their high energetic demands, and while foraging they encounter aerial environments that vary considerably, ranging from still air to challenging conditions such as high winds, elevated levels of freestream turbulence, and precipitation. To understand how flying hummingbirds respond to aerodynamically challenging conditions, we quantified the head, body and tail dynamics of female ruby−throated hummingbirds flying in a wind tunnel in three flow conditions with varying levels of freestream turbulence. Across the three flow conditions the turbulence intensity ranged from 1% − 15% and integral length scales up to 4 cm was generated using static planar grids placed at the inlet of the test section. Birds were trained to hover in front of a stationary flower while being subjected to each flow condition. Various points on the head, body and tail of the birds were tracked using high−speed video, and fluctuations in the position and orientation of each body part were analyzed. We found that the head was least stable vertically and the body was least stable laterally. We also found that birds deployed their tails actively to increase stability under challenging flow conditions. The mean fan angle of the tail was higher under elevated levels of turbulence, and there was a high correlation between the tail angle and body pitch angle. This suggests that hummingbirds increase longitudinal stability by fanning their tails and varying tail pitch angle with respect to the body.

P3.170 READER, LL*; BARNES, C; WILKINSON, KC; LEE, DV; University of Utah, University of Nevada − Las Vegas; *L.Reader@utah.edu*

A new transducer for multiple−axis force and torque measurements during arboreal locomotion

Although vertebrates exploit a multitude of complex three−dimensional environments, research attention has focused largely on terrestrial locomotion. Key assumptions permitting the measurement of force and center of pressure by force platforms (1 − that force is exerted only in the plane of the platform surface and 2 − that feet cannot grasp or adhere to the platform) do not apply to the interactions of feet, hands and other structures on three−dimensional arboreal supports. Arboreal vertebrates actually rely on "violations" of the same assumptions to achieve arboreal locomotion on vertical surfaces or slender branches. Most previous studies have measured force by retrofitting force platforms, but few have addressed torque − especially in all three axes, which may be key of key importance to moving in trees. We have designed and built a new six−axis transducer and system for measuring applied forces and torques on horizontal ladder rungs, which can be arranged to measure forces/torques from vertical or steep climbing. We have validated this design using a climbing bird likely to depend upon torque to a high degree; parrots climb with the help of dextrous grasping feet and also use the beak as a third limb. Our modular transducer design should be appropriate for many other arboreal/scansorial vertebrates. Climbing rungs of different lengths and diameters may be interchanged to enhance our ability to examine these locomotor behaviors in context that adequately captures the complete interaction of the animal with its physical environment. The transducer components are relatively inexpensive − consisting largely of readily available hardware and 3−D printed plastic − which should hopefully inspire new "DIY" manufacturers from the fields of biomechanics and functional morphology.

P2.10 REDD, J.R.*; BARTHELL, J.F.; JOURDAN, T.; LORD, W.D.; LEVINSON, B.M.; University of Central Oklahoma, University of California, San Diego; *jredd@uco.edu*

Forensic Application of Honey Bee Foraging Strategies

This study sought to determine whether or not honey bee foraging can be redirected from floral attractants to carrion. Carrion odors were used for simulated carrion odor treatments. In the field, bees were trained to each odor in a series of treatments prior to experimentation by exposure to the odor at the mouth of the hive with gradual movement of the odor away from the hive until the distance was 25m. Three feeding stations were set equidistantly from the hives and each other. Two of the feeders consisted of a 1.5M sucrose solution and scent was added to the third feeder. At 20−minute intervals, the number of bees feeding at each station was tallied. Upon conclusion of the timed intervals, the stations were moved to the next location. This was repeated until the scented station had been in each feeding location. Separate trials took place at 25 and 50m. In the laboratory, proboscis extension response conditioning experiments were performed using each of the carrion odors paired with a sucrose reward as a positive stimulus and no scent as a negative stimulus. Following the conditioning, honey bees were placed in a y−tube to choose between a carrion scented arm and a non−scented arm. In the field, the bees showed a trend of visiting the feeder containing the scent to which they were trained. In the lab, conditioned honey bees chose the carrion odor in the y−tube. Within forensic science, animals have long been used to detect carrion. However, none have been as inexpensive and as easy to train as honeybees have the potential to be. Training honey bees to detect carrion would alleviate much of the time, cost, and energy required to train other animals.

107.2 REDDON, A/R*; HURD, P/L; McGill University, Univ. of Alberta; *adam.reddon@gmail.com*
Water pH during early development influences sex ratio and male morph in a West African cichlid fish, Pelvicachromis pulcher
Environmental sex determination (ESD) is one of the most striking examples of phenotypic plasticity. Individuals from species that exhibit ESD can develop as either males or females depending on the particular environmental conditions they experience during early development. In fish, ESD species often show a relatively subtle effect of environment, resulting in a substantial number of both sexes being produced in both male− and female−biasing conditions, rather than the unisex clutches that are typical of many reptiles. This less dramatic form of ESD allows the opportunity to study the effects of sexual differentiation on within sex variation in behaviour and morphology by comparing same sex individuals produced in male− and female−biasing conditions. Here, we confirm that sex determination in the West African cichlid, *Pelvicachromis pulcher*, is influenced by pH during early development. We show that pH also affects the ratio of two alternative male reproductive types with the polygynous morph being overproduced in male−biasing conditions and the monogamous male morph being overproduced in female−biasing conditions. Our results suggest that the sexual differentiation process may be an important force in maintaining individual variation in behaviour and reproductive tactics.

P2.15 REED, W.; MAHONEY, J.*; LINZ, G.; North Dakota State University, Fargo, USDA, APHIS, WS, and National Wildlife Research Center, Bismarck, North Dakota; *jessica.l.mahoney@my.ndsu.edu*
Behavioral and Physiological Response of Red−winged Blackbirds to Perceived Risks during the Breeding Season
The fitness costs of reproduction include trade−offs between current and future reproduction that must be addressed each breeding season by parental generations. Within a current mating season, risks include decreased survival or decreased self maintenance, and decreased survival of offspring through predation or brood parasitism. The red−winged blackbird (RWBL) is a polygynous bird that has become a classic model of mate choice and reproductive biology for free living species. The long term objectives of this study are to evaluate how female RWBLs assess and respond to combined risks associated with the breeding season by examining female mating choices. The focus of this study was to examine how RWBLs respond to the perceived risk of predation and parasitism across the breeding season. I presented breeding colonies with effigies and calls of either a great horned owl, sharp−shinned hawk, female brown−headed cowbird, purple martin (effigy control), or a control (no effigy) at the start of the nesting period and 18 days later. I measured RWBL interactions with the effigies such as alarm calling and attacking effigy, and collected the second egg in each nest to evaluate yolk corticosterone levels. I predicted that colony response to perceived predator risk would be greater than response to parasites or control treatments, behavioral responses would decrease across the season, and yolk corticosterone levels would be elevated in eggs from females exposed to predators. Results suggest that RWBLs do have a greater response to the perceived risk of predation than to the parasite or control treatments regardless of the timing of predator exposure.

P3.5 REEDY, AM; EDWARDS, A; PENDLEBURY, C; MURDAUGH, L; AVERY, R; SEIDENBERG, J; ASPBURY, AS; GABOR, CR*; Univ. of Virginia, Indiana Univ. of Pennsylvania, Mountain Lake Biological Station, Texas State Univ.; *gabor@txstate.edu*
Male and female newts increase corticosterone during amplexus
Hormones play key functional roles in mediating the tradeoff between survival and reproduction that is the result of different biological processes competing for limited resources. Glucocorticoid (GC) hormones play a role in inhibiting reproduction and improving chances of survival during periods of stress. However, a growing body of work shows that GC hormones are at times associated with successfully engaging in energetically costly courtship and mating behaviors. While corticosterone (CORT), a primary GC hormone in amphibians, reptiles and birds, may be important in activating or sustaining energetically costly mating behaviors, sexual conflict over differences in the optimum mating frequency for males and females sets the stage for sex specific responses of the hypothalamic−pituitary−adrenal axis during courtship and mating. Here we show that an acute increase in CORT is associated with amplexus behavior in male and female red−spotted newts (*Notophthalmus viridescens*). Additionally we demonstrate that males have higher overall CORT release rates both in and out of amplexus than do females. Although costs associated with elevated CORT apply to both sexes, frequent amplexus should confer greater fitness benefits to males relative to females. Our finding of higher CORT in males both in and out of amplexus is consistent with this expectation of greater fitness benefits for males. Our results support the hypothesis that GC hormones can play a key role in energetically costly courtship and mating behaviors.

P3.131 REEVE, MA*; WILSHIN, S; SPENCE, AJ; Royal Veterinary College; *mireeve@rvc.ac.uk*
Dog gait on rough terrain: When does static stability matter?
Most legged animals need to traverse uneven terrain. This task is important as safe and economical traversal of rough terrain can impact reproduction, feeding and survival. One way to facilitate this task may be to adjust the relative leg timings of a particular gait. In previous work we have shown that changes in gait at walking speeds on rough terrain agree with predictions made by a model based on static stability considerations. In the present study we compare trotting behavior on flat and rough terrain. Six dogs of withers height 507.5±66.3 mm (means±s.d.) and body mass 22.6±4.5 kg were fitted with a sensor suite, comprised of GPS and inertial measurement units, and trialed over flat versus rough terrain. With sensors attached to the proximal−most leg segment and the withers, we measured animal speed, position and a continuous estimate of leg phase. We filtered the data to include strides at similar speeds. Speed was not significantly different in any of the subjects between terrain types (filtered data; Mann−Whitney U−test, $p>0.05$; n=3 to 20 strides, median=10.5). On the rough terrain, stride frequency was significantly lower in five of six dogs, and for one of these dogs stride length was significantly higher (Mann−Whitney U−test, $p<0.05$). In addition, a static−stability inspired model fit to data in our past work led us to hypothesize that at trotting speeds, the gait would become more walk−like on the rough terrain. Here we show that this does not appear to be the case (linear mixed−effects model; n=6 dogs, $p>0.05$; n=3 to 20 strides, median=10.5). We conclude that trotting speeds are outside of the domain of validity of our model; this may be a result of the model relying on considerations of static stability at speeds where energetic and dynamic stability dominate.

95.1 REICHERT, M.S.; Humboldt University−Berlin, University of Missouri; *michael.s.reichert@hu−berlin.de*

Assessment and communication in gray treefrog aggressive interactions

Aggressive behavior plays an important role in sexual selection and much research has been devoted to determining the characteristics that influence the outcome and level of escalation of animal contests. Nonetheless, a debate remains over the potential for contestants to assess one another in contests, and very little research has been done on this topic in anuran amphibians. I recently developed a method to stage aggressive interactions between male gray treefrogs, *Hyla versicolor*, that has allowed me to study their contest behavior in detail. Here, I synthesize the major findings of these experiments. Surprisingly, body size plays only a limited role in determining which individual wins or loses, and there was no evidence that individuals assess one another's body sizes during contests. In contrast, acoustic signals are very important. Males modify the characteristics of both their advertisement and aggressive calls with increasing contest escalation. Males lower the pitch of their aggressive calls, which is a strong predictor of contest outcome. In a series of playback tests I obtained evidence for mutual assessment: males' responses varied with the characteristics of the playback stimuli, and males with signals indicating a higher resource−holding potential were more likely to persist in a simulated competitive interaction. In sum, these results suggest that competitive communication interactions involving energetically−expensive signals are a critical component of aggressive behavior in this species. The methods developed to stage aggressive interactions can be applied to other anuran species, which in turn can be used to better understand the role of signals in the processes of assessment during animal contests.

P1.2 REICHERT, M.S.; Humboldt University−Berlin; *michael.s.reichert@hu−berlin.de*

Effects of noise on female preference functions in the acoustically communicating grasshopper Chorthippus biguttulus

The efficiency of animal communication is ultimately limited by the organisms' perceptual abilities and by errors induced by environmental interference with signal transmission. Noise is a major source of communication errors because it is ubiquitous in nature and because in many cases it can degrade signal characteristics to the point that receivers have great difficulties in recognizing and responding appropriately to relevant signals. In the context of mate choice, noise may interfere with or obscure signal characteristics that are strongly preferred by females. Noise may therefore alter the shape of female preference functions, and thus the strength and direction of selection on male signal characteristics. I measured the effects of noise on the shape of female preference functions in the grasshopper *Chorthippus biguttulus*, a species that uses acoustic signals to attract mates. Using an automated female testing apparatus, I exposed females to synthetic male signals that were varied in a single signal characteristic while all other characteristics were held constant. I measured preference functions for variation in each characteristic (duration of pauses between syllables, amplitude of syllable onset, amplitude of syllable offset) in the absence of noise and in the presence of three different levels of masking noise. I found that noise indeed has an effect on the shape of female preference functions, but this effect depends on the characteristic examined. Some characteristics are more robust to influences of masking noise than others and thus may be especially important for communication in the natural environment.

75.6 REITZEL, A.M.*; TARRANT, A.M.; University of North Carolina, Charlotte, Woods Hole Oceanographic Inst.; *areitze2@uncc.edu*

Phylogenetic diversity and transcription dynamics of heat shock proteins in the estuarine cnidarian Nematostella vectensis

Individuals living in estuarine habitats routinely experience dynamic abiotic conditions requiring the inducible expression of gene batteries for maintaining homeostasis. Heat shock proteins (HSPs) are molecular chaperones that serve a central function in mediating the response to environmental stress but also participate in other processes, particularly development. HSPs, especially in the larger size classes, are broadly conserved in eukaryotes and, at the same time, diverse, with multiple genes per class with particular cellular localization and inducibility. Thus, studying the expression dynamics for individual HSPs is informed by an assessment of orthology when comparing among species. We report the phylogenetic diversity of HSPs from the starlet sea anemone *Nematostella vectensis*, a resident of estuaries throughout North America, and quantified gene expression of identified HSP70s (n = 5), HSP90s (n = 3), and a HSP110 (n = 1) during development and when exposed to temperature shock and cadmium. All HSPs surveyed had significant differences in expression over a developmental time course from embryogenesis to adult, typically with peak expression during larval stages. However, in response to temperature shock and metal exposure, about half of the HSPs showed increased expression, with treatment−specific variation in HSP induction. The differences in transcription dynamics correlate with predicted transcription factor binding sites for Heat Shock Factor 1, a common regulator of HSPs. We compare these data with our previously published results on the thermal oscillations in *Nematostella*'s habitat and stage−specific variation in thermotolerance.

95.5 RENDON, N.M.*; DEMAS, G.E.; INDIANA UNIVERSITY, BLOOMINGTON; *nrendon@indiana.edu*

Seasonal Transitions in Reproductive State and Territorial Aggression in Female Siberian Hamsters (Phodopus sungorus)

Seasonally breeding rodents exhibit profound physiological and behavioral responses to changing photoperiods, including changes in reproduction and territorial aggression. We have demonstrated increased aggression in Siberian hamsters during short "winter" days (SDs) when reproduction is inhibited, suggesting that changes in aggression are inversely related to gonadal steroids. Short−day gonadally regressed Siberian hamsters experience spontaneous gonadal recrudescence following prolonged exposure to SDs. It is unknown, however, how changes in aggression track changes in reproductive state during these periods of seasonal transition. The goal of this study is to determine aggression in SD regressed, recrudescing, and recrudesced hamsters compared with long−day (LD) animals. To accomplish this, female hamsters were housed in LDs or SDs for 10, 24 or 30 weeks. These times were chosen to capture variation in reproductive state following 1) gonadal regression, 2) initial transition back to a reproductively active state, and 3) full gonadal recrudescence. LD animals maintained reproductive physiology and displayed low levels of aggression across all time points. By week 10, SD animals displayed regressed gonads and high levels of aggression. At week 24, SD animals displayed intermediate levels of both gonadal recrudescence and aggressive behavior. Specifically, those animals that displayed recrudescence had low levels of aggression whereas those that were still regressed maintained high aggression. Full gonadal recrudescence, and a return to LD−like levels of aggression, was predicted by week 30. Collectively, these results broaden our understanding of seasonal adaptation by examining the linkage between aggressive and reproductive seasonal phenotypes.

P3.7 RENN, SCP*; SCHAUPP, H; SCHMIDT, C; Reed College; *renns@reed.edu*

Molecular Modules of Maternal Care: Neural gene expression in the mouth−brooding cichlid A. burtoni.

Much like rodents at the time of parturition, mother fish at the time of fry release undergo a dramatic behavioral switch from avoidance of offspring to active care, defense, and retrieval offspring when a threat is perceived. Our lab has identified gene expression changes associated with the transition from mouth−brooding to overt maternal care. Importantly, the comparison between fish stocks with high and low maternal eliminate several confounding factors experienced by both stocks and therefore identify gene regulation that is specifically associated the maternal care behaviors. By aligning our gene regulation results with homologous anatomical networks we can determine the extent to which the cichlid maternal brain corresponds to that of mammals implying deep homology across vertebrates.

25.5 REVZEN, S*; BURDEN, S/A; KVALHEIM, M/D; University of Michigan, University of California, Berkeley; *shrevzen@umich.edu*

Why the trot?

The trot and pace gaits of quadrupeds and the alternating tripod gait of running hexapods are just the most familiar of the many multiple contact gaits that multilegged animals utilize. We define "multiple contact gaits" to be those in which multiple legs touch down with near simultaneity. Arguments of collision angle suggest that such gaits are inherently less energetically efficient than rotary gallops and metachronal gaits. We present new results from dynamical systems theory which suggest that multiple contact gaits benefit from a unique, hitherto unknown, form of stability which makes them particularly robust to uncertainties in muscle actuation and ground traction. We conjecture that this advantage, conferred by the inherent the structure of the mechanical dynamics, accounts at least in part for the convergent appearance of multiple contact gaits across virtually all terrestrial animal taxa.

45.1 REYES, ML*; BAKER, J; FOSTER, S; Clark University; *mreyes@clarku.edu*

Compensatory growth and lipid generation in "Threespine Stickleback" (Gasterosteus aculeatus)

Many organisms exhibit compensatory growth (CG), an accelerated growth rate during recovery from a total or partial food deprivation than during periods of continuous food availability. However, many aspects of compensatory growth are still poorly understood, such as how compensatory growth potential may change during the life of the organism. We studied compensatory growth in a model organism, the threespine stickleback (*Gasterosteus aculeatus*), with one objective being to analyze the potential for, and impact of, CG in threespine sticklebacks across their first few months of life, a period corresponding to their first growing season. We hypothesized that fish exposed to a diet deficit in the second month of life, and then returned to an optimal diet, would take longer to achieve a normal growth trajectory than would sticklebacks exposed to diet deprivation in the third and fourth months of life. A second objective was to assess if body lipid content was related to compensatory growth. Our hypothesis here was that stickleback exposed to a diet deficit during earlier stages would fail to recover adequate energy storage reserves. Recent CG models suggest that appetite is regulated in accordance to maintaining a ratio of reserve to body lipid levels. Contrary to our above mentioned hypotheses, our results show that upon comparison with young fish continuously fed an ad libitum diet, one and two month old fish exposed to a diet deficit are better able to regain optimal growth trajectories and regenerate lipids than populations exposed to food deprivation at three months of age.

P1.117 REYNAGA, CM*; DANOS, N; AZIZI, E; Univ. of California, Irvine; *cmmreynaga@gmail.com*

Conflicts between locomotor modes: terrestrial and aquatic locomotion in the Senegal running frog, Kassina senegalensis

Most frog species specialize in either jumping or swimming as a primary mode of locomotion. However, *Kassina senegalensis* (Senegal running frog) primarily uses a unique quadrupedal gait, which is characterized by limbs moving in diagonal pairs. A number of previous studies have focused on the mechanics of frog swimming and jumping, but little is known about the walking and running abilities of frogs. While these frogs are specialized for a quadrupedal gait and utilize it at all speeds on land, they can also swim and jump. We used the diverse locomotor repertoire of *K. senegalensis* to understand how locomotor specialization affects an organism's performance during other modes of locomotion. In this study, we characterize limb morphology and quantify limb kinematics in *K. senegalensis* during walking, running, jumping and swimming. We use 3D high−speed videography to measure the angle and timing of joint extensions in the fore− and hindlimb during all modes of locomotion. We also compare the kinematics and performance of *K. senegalensis* to other anurans specialized for either swimming or jumping. Our preliminary results suggest that the evolution of a quadrupedal gait is correlated with changes in the relative lengths of the forelimb and hindlimb and that such shifts in limb dimensions may limit performance during jumping and swimming. By investigating conflicts among diverse modes of locomotion, we aim to understand how the evolution of novel gaits shapes variation in limb morphology, muscle properties, and motor control strategies.
Supported by NSF grant 1051691.

54.4 REYNOLDS, K.V.*; THOMAS, A.L.R.; TAYLOR, G.K.; University of Oxford, UK; *kate.reynolds@zoo.ox.ac.uk*

Analysis of the function and mechanics of the wing tuck manoeuvre in a steppe eagle Aquila nipalensis

Soaring birds can often be seen to pull their wings down, in a transient manoeuvre that we call a wing tuck. Here we analyse the mechanism, occurrence, and function of wing tucking in a trained, captive steppe eagle *Aquila nipalensis* using video and on−board inertial instrumentation. Over 3,000 tucks were identified automatically from 60 flights. Statistical analysis revealed that the rate of wing tucking is positively related to localised measures of the mean and fluctuating components of wind speed and mean flight altitude, which serve as proxies for mechanical turbulence intensity. The body motions preceding a tuck are initially reminiscent of the phugoid mode in a fixed−wing aircraft: airspeed, pitch angle, and load factor all ramp up whilst angle of attack remains constant. This seems consistent with the bird encountering a headwind gust. Immediately before the tuck movement there is an abrupt fall in angle of attack, and consequently in load factor, which suggests the bird has entered a downdraft. We propose that this loss of loading initiates the tuck manoeuvre as there is no longer sufficient lift generated to fully support the wings. Normal loading is quickly recovered as the wings re−open. We conclude that wing tucks are a gust alleviation mechanism, serving to reset the flow when the wings encounter adverse loading, and thereby allowing flight in more turbulent conditions. Turbulence is generated by thermal and mechanical processes which also produce the updrafts used by birds in soaring flight. From our data we hope to determine other soaring strategies, like the wing tuck, that birds might use to deal with, and potentially, exploit these processes to soar efficiently.

P1.58 REYNOLDS, J. A.*; DENLINGER, D. L.; Ohio State University; *reynolds.473@osu.edu*

Do HDACs regulate Sarcophaga bullata pupal diapause?

Histone deacetylases (HDACs) remove acetyl groups from histone and non−histone protein and are important for a variety of biological processes including gene transcription, cell−cycle regulation, environmental sensing, and stress−response. We tested the hypothesis that HDACs regulate pupal diapause in the flesh fly, *S. bullata*, by measuring differences in HDAC gene expression and enzyme activity in pre−diapause and diapause flies compared to their non−diapause counterparts. We also measured gene expression and enzyme activity in pupae treated with hexane to terminate diapause to determine a possible role for HDACs in post−diapause development. Transcripts of 4 genes encoding HDACs (*rpd3/hdac1*, *hdac3*, *hdac6*, and *sirtuin2*(*sirt2*)) were up to 2−fold more abundant in diapause−destined 1st instars, which suggests a role for these genes in programming diapause entry. Transcripts of *hdac3*, *hdac6*, and *sirt2* were 60, 45, and 30 % lower, respectively, in diapausing pupae compared to non−diapause pupae; there was no difference in the mRNA abundance of *rpd3/hdac1*. Thus, it is unlikely that these genes are required for diapause maintenance. There was also no difference in mRNA abundance of *rpd3/hdac1* 24 h after diapause was terminated with hexane. *Hdac3*, *hdac6*, and *sirt2* were significantly upregulated, up to 3−fold, during this time, and they likely regulate post−diapause development. HDAC enzyme activity was significantly reduced by ~ 60% in diapausing pupae compared to non−diapause flies. After diapause was terminated, HDAC activity remained at a low level for 24 h, but increased so that activity was equivalent to non−diapause pupae by 48 h post−termination. Taken together, our data suggest HDACs participate in diapause initiation and are necessary for post−diapause development, but they are not predicted to have a role in maintaining diapause.

124.7 RHODES, A.C.; LAVELLE, K.A.*; BOURQUE, J.R.; DEMOPOULOS, A.W.; MONTAGNA, P.A.; AMADOR, M.D.; Texas A & M University Corpus Christi, US Geological Survey, US Geological Survey; *Adelaide.Rhodes@tamucc.edu*

Biodiversity of Tanaidacea (Crustacea: Peracarida) in the Northern Gulf of Mexico

For this study, historic data from research cruises composed of more than 8,000 biogeographic observations were compared to data gathered during research cruises led by Texas A&M University−Corpus Christi, Harte Research Institute (TAMUCC−HRI) and the US Geological Survey. The depths targeted by these monitoring cruises (below 1000 m) have been historically undersampled for tanaidacean diversity. New observations from these expeditions have increased total bathyal tanaidacean observations in the Northern Gulf of Mexico (GOM) by 12% (more than 1,000 observations) over previous sampling efforts. Of the approximately 1200 global species of tanaidaceans, 109 were found in the bathyal GOM. More than 10 genera and at least 1 family of tanaidaceans were new records for this region. Minimum and maximum depth ranges of several known families have been expanded. Diversity estimates based on these new observations indicate that tanaidacean diversity is significantly higher than previously reported (e.g. a 72% increase in species richness between 1000 m and 1500 m and a 216% increase in species richness between 1500 m and 2000). These new observations demonstrate that diversity estimates of tanaidaceans in the bathyal region of the GOM have been historically underestimated and are sensitive to sampling effort. Our results suggest that diversity estimates will increase as our expertise and sampling effort increases not only for tanaidaceans, but in other deep−sea taxa as well.

116.5 RHODES, A.C.; LAVELLE, K.A.*; BOURQUE, J.R.; DEMOPOULOS, A.W.; MONTAGNA, P.A.; AMADOR, M.D.; Texas A & M University Corpus Christi, US Geological Survey, US Geological Survey; *Adelaide.Rhodes@tamucc.edu*

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109.1 RHODES, A.C.; Texas A & M University Corpus Christi; *arhodes2@tamucc.edu*

Why Be red? Testing an Alternative Explanation for Color Polymorphism in Diaptomid copepods

A striking color polymorphism exists in diaptomids inhabiting adjacent alkaline lakes in the Grand Coulee area of Eastern Washington. These highly alkaline lakes were formed following the last Ice Age, when the Columbia River became channelized. Copepods isolated from Soap Lake exhibit higher levels of red pigmentation at all times of the year in comparison to copepods from Lake Lenore. Nutrients, salinity, light and predation pressure have all been proposed to explain the difference in pigmentation between the lakes. Copepods from Lake Lenore cannot be induced to express the bright red coloration of Soap Lake copepods, even though Soap Lake copepods can lose their color in the lab. An alternative hypothesis to explain the difference in coloration between the populations of diaptomid copepods is genetic adaptation to the more stressful environment of Soap Lake. It is possible that copepods from Soap Lake and Lake Lenore represent parapatric groups formed by dispersal from allopatric Pleistocene refugia during the formation of the Grand Coulee. Soap Lake is deeper, saltier and more alkaline than Lake Lenore, and the lakes are not connected. These unique mineral and geological conditions could have led to a genetic divergence in coloration, enhanced by the more extreme alkalinities experienced by Soap Lake diaptomid copepods. Carotenoid biosynthesis might be increased in Soap Lake copepods due to a shared pathway for lipid desaturation utilizing oxidoreductase. The production of carotenoids increases antioxidant activity and allows for lipid storage and utilization in highly alkaline conditions. It is possible that intense red color is a byproduct of basic metabolic functions involving lipid storage and utilization in copepods. The function of carotenoid genes in Soap Lake diaptomids could provide clues as to why so many species of copepods in extreme environments are bright red.

82.5 RICO−GUEVARA, A.*; RUBEGA, M.A.; UNIVERSITY OF CONNECTICUT; *a.rico@uconn.edu*

Ecological Implications of Hummingbird Feeding Mechanisms

Our research addresses the overarching question: How do the mechanics of feeding define the limits and adaptive values of feeding behaviors? We study every step of hummingbird nectar capture and transport, in order to generate predictions that can be tested in the wild. We ask: 1) How do tongues collect nectar? 2) How is the nectar transported inside the bill to the throat? 3) How does biophysical modeling predict performance during nectar extraction from real flowers? 4) Do performance measurements in wild flowers support the proposed model? Our previous results demonstrated that capillarity equations are unsuitable to calculate energy intake rate (the building unit of foraging theories); therefore we need a new elucidation of hummingbird foraging ecology. Using our previous demonstrations of nectar trapping and intraoral nectar transport, we generated falsifiable predictions about the action of the tongue, and the volumes of nectar that can be collected and transported inside the bill, in the wild at real flowers. We used high−speed videography of hummingbirds at wild flowers, and direct measurement of floral nectar volumes, to test predictions about nectar extraction rates (fluid volume uptake [µl/s]) for hummingbirds feeding at wild flowers. We obtained detailed measurements of nectar extracted per lick, and bill insertion distance in translucent, wild, flowers founding support for the discarding of the capillarity theory. We propose that the mechanical limitations of tongue−based nectar extraction define foraging behavior for hummingbirds and other nectarivores. Our downstream calculations of the rates at which birds can obtain nectar along several environmental axes inform how and where the limits of nectar uptake have shaped the distribution, ecology and evolution of hummingbirds and other nectar−feeding birds.

20.2 RIDDELL, EA*; SEARS, MW; Clemson University; *eriddel@clemson.edu*

High and Dry: Responses of Evaporative Water Loss Along an Elevational Gradient for Two Species of Lungless Salamanders

With rapidly changing climates, many specialist organisms will need to acclimatize, adapt, migrate, or risk extinction. To forecast the impacts of climatic change, species distribution models incorporate relationships between organisms and their environments. However, these models operate under the assumption that organisms do not adjust behavior or physiology to changing conditions. Plethodontid salamanders are a model organism to understand such responses to environments because they have limited dispersal ability and, lacking lungs, they are restricted to relatively wet environments to breathe. Along typical elevational gradients, populations experience microclimates ranging from cool, wet conditions on mountaintops to warmer, drier conditions at lower elevations. Thus, salamanders may respond to these environmental conditions along an elevational gradient by modifying cutaneous water loss (CWL). Here, we investigated CWL for two species, *Plethodon metcalfi* and *P. teyahalee*, collected over their elevational limits near Cullowhee, NC. Cutaneous water loss was determined in the lab using a flow−through system at two temperatures (12°C, 18°C) and at three vapor pressure deficits (0.2 kPa, 0.35 kPa, 0.5 kPa). Both vapor pressure deficit and surface area of the individual significantly influenced CWL for both species. Interestingly, CWL for *P. metcalfi* was influenced by the elevation at which the individual was captured, suggesting either acclimation or adaptation to local conditions, whereas CWL for *P. teyahalee* was insensitive to elevation at capture. Our results suggest that the abilities to tolerate changing climates will be species specific and dependent on the capacities for individuals to acclimate or adapt.

61.5 RIEDE, T; University of Utah; *t.riede@utah.edu*

Somatosensory feedback during vocal production in a nonhuman mammal

Feedback mechanisms (somatosensory and auditory) are critical for vocal learners such as songbirds and humans in order to develop and maintain normal singing behavior or speech. Feedback is also important in some nonhuman mammals (primates, bat echolocation). In many mammals feedback control may play a smaller role during vocal production, because vocal patterns are mostly hard−wired. To extend comparative data on feedback control, two types of subglottal pressure pertubations were made in awake and spontaneously behaving rats during male−female interactions while recording movements of larynx and respiratory system. When subglottal pressure was suddenly increased by injection of a very small amount of compressed air into the trachea, vocalization can be interrupted prematurely terminating vocalization. In contrast, call duration increased, sometimes dramatically, when subglottal pressure increased slowly and continuously, but only slightly above baseline for a long time. The call elongating effect is probably facilitated via lung stretch receptors, whereby lung inflation causes inspiratory termination and expiratory prolongation. Surprisingly, not only was the expiratory phase elongated, as reported previously for rats, but the association between laryngeal vocal motor pattern and respiration was maintained like during normal ultrasound vocalization. Lung pressure and electromyogram traces indicated that motor patterns of the respiratory system and the vocal organ remain synchronized during the perturbation. Results suggest that somatosensory feedback for vocal control can be facilitated via respiratory receptors, and can, depending on the type of pertubation, lead to different acoustic changes.

P2.106 RIEDE, T*; LI, Z; TOKUDA, I; FARMER, C; University of Utah; *t.riede@utah.edu*

Morphology and mechanical properties of the alligator larynx

Crocodilians have complex vocal communication. The production of sound requires the integration of respiratory and laryngeal functions. The alligator larynx appears to be a primitive vocal organ anatomically and it is not understood how this simple organ can produce such complex sounds. The ability of alligators to vary fundamental frequency is limited to variation in lung pressures and abduction and adduction of the vocal folds, but no stretching mechanism has been identified. In order to elucidate the mechanisms underpinning active vocal fold movement and passive vocal fold oscillations, computed tomography, histology and tensile tests were used to study the larynx. We found that while the abducting mechanism is facilitated by a single, comparatively large, uniform musculus cricoarytenoideus, adduction is facilitated by a more complex multi−belly muscle. Histological sections combined with differential staining were used to identify collagen, elastin, and hyaluronan in the vocal folds. Vocal fold connective tissue is highly organized, consisting of fibrillar proteins in a superficial layer as well as high amounts of hyaluronan, and randomly oriented collagen fibers in a deep layer. The alligator shares the layered vocal fold morphology with those of mammals. The design of vocal fold connective tissue represents an important feature affecting biomechanical properties. Tensile tests demonstrated a linear stress−strain response in the low−strain region and a nonlinear relationship in the high−strain region. These results suggest that alligator vocal folds are initially much stiffer than any mammalian vocal fold tested so far, but stress relaxation is also higher than in mammalian vocal folds. Refined computational modeling indicates that fundamental frequency, an important acoustic feature of alligator calls, can be reasonably well predicted using mechanical properties and a simple string model of tissue oscillation.

P3.192 RIEDMANN, H.L.*; AHADIZADEH, E.N.; MALTBY, R.; MARKHAM, M.R.; The University of Oklahoma; *hriedmann@ou.edu*

Comparative analysis of Na^+/K^+ ATPase alpha subunits from the electric organs of weakly electric fish with low and high discharge rates.

Electric fish image their worlds and communicate by generating and sensing electric fields. These electric organ discharges (EODs) are produced by the simultaneous action potentials of electrocytes within the electric organ (EO). Mounting evidence suggests that EOD production incurs significant energetic demands that are larger for species with high EOD rates. The energetic demand of EOD production is attributable largely to Na^+/K^+ ATPase activity in the electric organ cells (electroctyes) as the Na^+/K^+ ATPase hydrolyzes ATP to actively restore the cell's ionic gradients in the interval between APs. Functional Na^+/K^+ ATPase consist of one alpha and one beta subunit, with the alpha subunit being the primary determinant of pump kinetics. To better understand the relationship of Na^+/K^+ ATPase regulation to EOD characteristics, we compared the Na^+/K^+ ATPase alpha subunits from the electric organs of *Brachyhypopomus gauderio*, a fish with irregular low EOD frequencies, and *Eigenmannia virescens*, a species that generates steady high−frequency EODs. We harvested small sections of EO, extracted total RNA and used RT−PCR followed by 3'− and 5'−RACE to clone and sequence the Na^+/K^+ ATPase alpha subunits from the EO of *Brachyhypopomus* and *Eigenmannia*. The cDNA clones of > 3300 bp each included a 3027 bp open reading frame encoding a 1009−residue Na^+/K^+ ATPase alpha subunit. In both species, the alpha subunits showed amino acid substitutions in functionally significant protein regions, including regions associated with Na^+ binding and regions known to regulate pump rates. We found higher incidence of amino acid substitutions in functionally important regions of the Eigenmannia Na^+/K^+ ATPase.

P2.111 RIEGER, NS*; BUBAK, AN; RENNER, KJ; SWALLOW, JG; Univ. of Colorado−Denver, Univ of South Dakota; *nrieger@wisc.edu*

David vs. Goliath: Serotonin affects aggressive behaviors but not contest outcome of smaller competitors

In aggressive encounters, size discrepancy between competitors is often a primary determining factor of contest outcome, usually resulting in the smaller competitor conceding to its larger rival. Because winning contests can lead to significant fitness advantages, understanding the mechanisms that alter aggression is of great importance. The stalk−eyed fly, *Teleopsis dalmanii*, aggressively defends food resources and roosting sites daily, with a high probability of males winning a contests when faced with a smaller rival (> 5% difference in eye span). Serotonin (5−HT) has been implicated in the escalation of aggressive behaviors in both invertebrates and vertebrates. Studies in our lab have demonstrated an increased probability of winning size−matched contests as well as increasing willingness to engage in high−intensity behaviors by pharmacologically elevating neural 5−HT in this species. We hypothesized that smaller flies with pharmacologically−increased brain 5−HT in a size−mismatched contest would show more aggressive behaviors and a greater win percentage compared to non−treated counterparts. To test this, size−mismatched males were placed in a 10−minute forced fight paradigm where the smaller fly was either treated or untreated with the 5−HT precursor, 5−hydroxytryptophan, and aggressive behaviors were scored. Although probability of winning was not significantly altered by the treatment, aggressive behaviors including contest initiation, total interactions, and high−intensity behaviors were significantly higher in treated animals ($p<0.008$). This data suggests 5−HT plays a role in the willingness to engage and escalate aggressive behaviors warranting future studies investigating the role of 5−HT in rival assessment in stalk−eyed flies.

P2.31 RIESGO, A; FARRAR, N; WINDSOR, PJ; GIRIBET, G; LEYS, SP*; Universitat de Barcelona, University of Alberta, Harvard University; *sleys@ualberta.ca*

Early evolution of molecular complexity in metazoans: an analysis of transcriptomes from all four sponge classes

Sponges (Porifera) are among the earliest evolving metazoans. Their filter−feeding body plan and absence of conventional eumetazoan features suggest they diverged very early from other multicellular animals. Analyses of the *Amphimedon* sponge genome supports this view of uniqueness − many key metazoan genes are absent − but whether this is generally true of other sponges is unknown. We studied the transcriptomes of 8 sponge genera in 4 classes (Hexactinellida, Demospongiae, Homoscleromorpha and Calcarea) specifically seeking genes and pathways considered to be involved in animal complexity. For reference, we also sought these genes in transcriptomes and genomes of 3 unicellular opisthokonts and two bilaterian taxa. Our analysis showed that all sponge classes share an unexpectedly large complement of genes with other metazoans. Although some genera have more genes associated with bacteria, possibly explained by the large number of endosymbionts they possess, the complement of genes in other genera was more similar to that of bilaterians than other basally placed metazoans. We were surprised to find representatives of most molecules involved in cell−cell communication, signalling, complex epithelia, immune recognition and germ−lineage/sex, with only a few, but potentially key, absences. A noteworthy finding was that all demosponge transcriptomes generally showed evidence of loss of some important genes, which might reflect divergence from main−stem lineages including hexactinellids, calcareous sponges, and homoscleromorpha. In all, we conclude that the molecular complexity of sponges in all probability underpins a high level of physiological and morphological complexity.

79.3 RIGGS, C.L.*; PODRABSKY, J.E.; Portland State University, OR; *rclaire@pdx.edu*
Identifying crucial microRNAs supporting extreme anoxia tolerance of annual killifish embryos
Investigating the physiological mechanisms of anoxia tolerance and ischemic preconditioning in vertebrates strengthens our understanding and application of anoxia survival strategies. This study examines the role of microRNA expression associated with anoxia tolerance of *Austrofundulus limnaeus* embryos, a highly anoxia tolerant vertebrate. Embryos of *A. limnaeus* appear to share many characteristics with anoxia intolerant species in their response to anoxia, yet are able to survive for months in the complete absence of oxygen. Thus, it is likely that this species has evolved novel mechanisms to support anoxia tolerance. Several recent studies indicate a potential role for microRNA in metabolic depression during anoxia tolerance, through gene silencing. We hypothesize that changes in miRNA expression during exposure to and recovery from anoxia will identify molecular pathways central to supporting survival of anoxia in *A. limnaeus* embryos. miRNA and mRNA expression patterns were profiled in *A. limnaeus* embryos sampled prior to and following a 24−hour anoxic exposure. Roughly 1000 highly differentially expressed miRNAs have been identified, many of which display high sequence homology to mitochondrial transcripts. Putative mRNA targets for miRNAs of interest were identified using *in silico* target prediction. To test *in vivo* function we designed and injected Vivo−Morpholinos (Gene−Tools, Philomath, OR) to knockdown expression of miRNAs of interest, and subsequently assessed embryos for changes in their anoxia tolerance. These data provide the first detailed study of miRNA expression and function during exposure to anoxia, and may lead to a better understanding of the molecular pathways, particularly involving mitochondria, that support anoxia tolerance in vertebrates.

64.2 RILEY, M.E.*; GRIFFEN, B.D.; University of South Carolina; *rileyme3@email.sc.edu*
Life history plasticity associated with the climate change−mediated range expansion of a coastal decapod
The geographic ranges of most plants and animals are limited by climatic factors, and changes in global climate trends have caused species from a wide array of taxa to shift or expand their distributions into higher elevations and latitudes. Due to differences in the type and timing of species' responses to climate changes, the range expansions of many animals outpace that of their habitat. One such example is the mangrove tree crab *Aratus pisonii*, a mangrove herbivore whose northward movement recently outpaced that of its native habitat, leading to the establishment of populations in salt marsh vegetation. Organisms such as *A. pisonii* that expand their range into foreign environments often alter their life history traits in an attempt to maximize their reproductive success under the challenges presented by these new habitats. In order to explore potential alterations in the life history characteristics of *A. pisonii* as it expands its range, we compared populations from mangroves within the species' historical range and from salt marshes near its current northernmost distribution. We examined body size distributions, size at maturity, and reproductive effort of populations from both areas. Additionally, we investigated differences in the maternal reproductive investment of individuals from both populations by comparing egg size, brood size, and starvation resistance of recently hatched zoeae. This study details the reproductive strategy of a major mangrove consumer as it colonizes novel salt marsh habitats, and provides insight into the potential mechanisms enabling this species and countless others to successfully expand their range into novel environments.

P2.165 RISALITI, RL*; SURMACZ, CA; HRANITZ, JM; Bloomsburg University; *csurmacz@bloomu.edu*
Physiological, Behavioral, and Cellular Responses to Heat Stress in Lumbriculus variegatus
Lumbriculus variegatus, the blackworm, is a useful bioindicator for assessing the health of aquatic ecosystems because it is sensitive to sublethal doses of toxins and displays a number of biological responses that can be easily measured, such as tactile response, pulse and motility. In this study, our goals were to examine the relationship between these behavioral and physiological measures of stress in blackworms and the cellular stress marker Heat Shock Protein70 (HSP70), and to determine the temperature at which these specific responses reach their peak. Individual worms were exposed for three hours to temperatures ranging from 22 to 33^{o}C. Motility and tactile responses were measured before and after heat stress and scored as normal, slight or none. Pulse rate was determined by counting pulsations of the dorsal artery before and after heat stress. HSP70 levels were measured in worm homogenates using an ELISA. Significant changes occurred in motility, pulse, tactile response and HSP70 levels as temperature increased (P<0.001); all variables tested displayed hormetic stress responses. Pulse rate was most sensitive to increased temperature; peak pulse rates were observed at 29^{o}C and differed significantly from worms incubated at 27^{o}C and 33^{o}C (p<0.001). At 31^{o}C, motility was absent and the HSP70 level was maximal. A complete loss of tactile response was observed in worms incubated at 33^{o}C. Our results integrate organismal function across physiological, behavioral and cellular levels of organization and improve our understanding of the blackworm's performance under sublethal stress. Integrating the relationships between physiological, behavioral and cellular stress responses in blackworms will be useful as a model invertebrate for sublethal population effects of pollutants in lentic ecosystems.

58.5 RISTROPH, L*; ZHANG, J; LIAO, J.C.; New York University, Courant Institute, New York University, Department of Physics, University of Florida, Whitney Marine Lab; *ristroph@cims.nyu.edu*
The lateral line system of fish as a hydrodynamic antenna'
The lateral line of fish is a specialized flow detection system comprised of pressure− and shear−responsive sensors distributed over the body surface. Here, we explore how the arrangement of these sensors is related to the hydrodynamic information contained in flows. Using a cast model of a rainbow trout placed in a water tunnel, we devise ways to mimic the flows encountered by swimming fish while measuring the near−body flow field. Comparing our results to anatomical studies indicates that the lateral line sensors are well positioned to detect temporal and spatial changes in flow signals. These findings support a view of the lateral line as a hydrodynamic antenna' that allows sophisticated behaviors such as rheotaxis and prey detection and tracking.

17.1 RIVERA, AM*; MOORE, TY; BIEWENER, A; Harvard University; *amrivera@college.harvard.edu*

Inverse dynamics of J. jaculus jumps

Jerboas (*Jaculus jaculus*) are small (~50g) bipedal rodents capable of jumping >0.5m in the air when startled. We used inverse dynamics to investigate the dynamics of these jumps (N=3; 20 jumps) in order to calculate the percentage of jump PE provided by elastic recoil of the tendons relative to muscle work. Force plate recordings of vertical and horizontal ground reaction forces were synched with high−speed video (250 fps) kinematics of the jump. Total tendon elastic energy storage never exceeded 17% of jump potential energy. This limited tendon elastic energy recovery by jerboas is similar to that observed during hopping in the morphologically convergent heteromyid kangaroo rat, *Dipodomys spectabilis*. To test the hypothesis that *J. jaculus'* digital plantar hair tuft assists in locomotion on loose granular substrates, recordings were also made when jerboas jumped from a 1.5 cm layer of sand overlying the force plate before and after their digital hair tuft was shaved. No differences in jump height were observed for either condition of sand substrate jumps in comparison with earlier solid force plate trials. We conclude that these small bipedal rodents use their muscles to accelerate rapidly for energetically costly and sporadic locomotion, while larger hopping animals, like kangaroos, use their tendons to store and return elastic energy for energetically economical and sustained locomotion.

116.6 RIVERA, J. A.*; BUTLER, M. A.; KRAUS, F. ; Univ. of Hawaii, Manoa, Univ. of Michigan; *julior@hawaii.edu*

Molecular Phylogenetics and Morphological Evolution of Papuan Microhylid Frogs

The third largest amphibian family in the world, the Microhylidae, have a global distribution with 523 know species of which over half (271) are found in Papua New Guinea and northern Australia. The Australo−Papuan microhylids demonstrate classic characteristics of an adaptive radiation but have been largely understudied. This group comprises a myriad of ecologies and morphologies not commonly seen in a single frog clade. Here, we propose that the group is comprised of six ecomorphs: arboreal species (~15mm SVL), scansorial species (~20mm SVL), terrestrial species (~30mm SVL), semi−fossorial species (~50mm SVL), fossorial species (~30mm SVL) and semi−aquatic species (~31mm SVL). We take a phylogenetic approach to study the evolution of morphology, specifically how they are distributed across the phylogeny, whether they have independently evolved, how many times they have evolved and how conserved they are within independent lineages. We also present the most complete and robust phylogeny for the group, which has been notoriously difficult to resolve. Lastly, we would like to use these data in concert with performance data to study whether morphological diversity evolves as an adaptation to the environment.

P2.32 RIZK, H E*; STALEY, M; HILL, G E; Auburn University; *her0007@auburn.edu*

The importance of assessing previous pathogen exposure of wild−caught animals used for experimental infection studies: validating methods for detecting house finch exposure to Mycoplasma gallisepticum.

Pathogens can drastically impact wildlife and exert strong selective pressures, leading to rapid evolutionary change. Research on how pathogens shape evolutionary histories of organisms is increasingly focused on understanding host−pathogen interactions and variation in disease susceptibility. To answer their questions researchers are turning to controlled experimental infection studies using wild−caught animals. When using wild−caught animals, it is important to have accurate, non−lethal means to detect previous exposure to the pathogen. House finch (*Haemorhous mexicanus*) infection by the pathogen *Mycoplasma gallisepticum* (MG) is a valuable system for studying rapid evolution due to pathogen pressure because MG causes severe respiratory disease and its history in finches is known. In 1994, MG shifted hosts from poultry to house finches, killing over 100 million finches. Before infection studies begin, house finches are tested for previous MG exposure with methods used in poultry. However, the accuracy of these methods in finches has not been validated. Our goal was to validate two non−lethal methods, antibody testing and tracheal swabs, used to detect MG exposure in house finches. We collected tracheal swabs, blood, and tracheal tissues from wild−caught house finches. We tested the tracheal swabs and tissues for MG DNA by polymerase chain reactions and plasma for antibodies using an enzyme−linked immunosorbent assay. To assess the accuracy of these methods, we compared the antibody and swab results to those of the tracheal tissues.

P2.28 ROBERTS, KT*; HEIDL, SJ; ZAVALA, NA; MARDULYN, PM; SMILEY, JT; DAHLHOFF, EP; RANK, NE; Sonoma State University, SSU, Santa Clara University, Free University of Brussels, SCU; *roberkev@seawolf.sonoma.edu*

Variation in nuclear and mitochondrial genes important for energy metabolism along a climatic gradient in montane populations of a leaf beetle

Montane organisms live in small, fragmented populations that are vulnerable to climate change, and the ability of these populations to persist depends on whether they possess genetic variation in their capacity to respond and adapt to altered environments. In the Sierra Nevada Mountains of California, the willow leaf beetle *Chrysomela aeneicollis* occurs at high elevations just below tree line (2400−3600 m). Genetic variation at 12 loci was examined along a 75 km transect from the King's River in the southwestern Sierra to Rock Creek in the Eastern Sierra, a cline that corresponds to a latitudinal temperature gradient. Genetic divergence was 10−fold greater at the enzyme locus phosphoglucose isomerase (PGI) and the mitochondrial gene cytochrome oxidase II (COII) than at 10 other loci. PGI and COII alleles that predominate in the south are replaced by northern' alleles in Rock Creek, supporting the hypothesis that these genes are directly or indirectly under selection. In prior studies, we describe functional, physiological, and reproductive differences among PGI genotypes. Here we show that COII haplotype and PGI genotype interact to affect adult running speed, female reproductive success and larval development rate in the face of natural and laboratory manipulated thermal variation. We also found that cytochrome oxidase enzyme activity varies among PGI genotypes. Taken together, these data suggest that natural selection may act jointly on COII and PGI. Thus, genetic variability at mitochondrial and nuclear loci critical for energy metabolism may contribute to population persistence in the face of rapid environmental change.

23.6 ROBERTSON, J.; Westminster College, New Wilmington, PA; *robertjc@westminster.edu*

Development and Growth of the Medullary Cavity in the Rostrum of Paddlefish (Polyodon spathula)

The rostrum is not present in newly hatched paddlefish, but soon grows to about one−third the total body length of juvenile fish, and is known to have electroreceptive and mechanosensory functions. This work focuses on a major internal structural feature of the rostrum, the adipose−filled medullary cavity. This cone−shaped cavity is formed within the hyaline cartilage core of the rostrum. Widest adjacent to the braincase and tapering toward the tip of the rostrum, the cavity can extend more than half the rostrum length. To better understand formation, growth and function of the rostrum and medullary cavity, cavity volume was compared to rostrum length and total body length in groups of size−matched juvenile paddlefish. Medullary cavity volume was modeled as a simple cone. Mid−sagittal sections of each rostrum were imaged, and cavity length and width measurements were obtained by image analysis. Results show significant differences in ratios of cavity volume:rostrum length and cavity volume:body length between the groups. In early development the medullary cavity increases in size rapidly, later the rate of cavity volume increase slows relative to body and rostrum growth. Determining the pattern of growth of the medullary cavity contributes to understanding of the development and functions of the rostrum and the biology of paddlefish.

P1.11 ROBINSON, C.D.*; PATTON, M.S.; JOHNSON, M.A.; Trinity University; *crobins3@trinity.edu*

Evolution of communication modalities and brain morphology in lizards

Animals communicate using a variety of sensory mechanisms, including visual, chemical, auditory, and tactile modalities, but little is known regarding how brain morphology is associated with these modalities in reptiles. In this study, we quantified the communication behaviors of six lizard species from six different families: *Anolis carolinensis* (green anole), *Aspidoscelis gularis* (spotted whiptail), *Hemidactylus turcicus* (Mediterranean house gecko), *Leoicephalus carinatus* (curly−tail), *Sceloporus olivaceus* (Texas spiny lizard), and *Scincella lateralis* (little brown skink). Using data from 110 hours of behavioral observation, our results indicate that anoles and curly tails use primarily visual modalities to communicate, whiptails and skinks use primarily chemical signals, and geckos and spiny lizards used both visual and chemical modalities (other modalities, including auditory, were not assessed in this study). We collected brains of 12 adult male lizards from each species, sectioned them via cryostat at 20 μm, and stained them with thionin for morphological measurements. Measures of the cross−sectional area of the broadest section of the brain, standardized by snout−vent length, indicate that relative brain size is not associated with mode of communication. Measures of neuron size and density in brain regions associated with visual and chemical signaling will also be assessed: the optic tectum and the lateral geniculate nucleus, both thought to be associated with vision, and the nucleus sphericus of the amygdala and the hypoglossal nucleus, both involved in chemical signaling. This study takes an early step toward identifying associations between brain morphology and communication behaviors, contributing to our understanding of the mechanisms underlying the repeated evolution of signaling modalities in reptiles.

P2.112 ROBINSON, S.L.*; EARLEY, R.L.; Univ. of Alabama, Tuscaloosa; *stephrobinson08@gmail.com*

Plasticity and integration in mangrove rivulus: arginine vasotocin as a potential mediator of salinity−induced phenotypes.

Developmental plasticity can drive phenotypic variation and evolutionary change, but the mechanisms powering plasticity are not well understood. Current research demonstrates that endocrine signaling pathways can translate environmental variability into differential expression of an arsenal of phenotypic characteristics such as morphology, mating displays, sexual development, and behavior. By examining these characteristics, we can quantify elaborate trait interaction networks and determine how trait linkages change along an environmental gradient. Our powerful model organism the self−fertilizing, hermaphroditic killifish, *Kryptolebias marmoratus* allows us to isolate the effects of genetic variation and attribute deviations from the norm to environmental influences. Neuroendocrine pathways can help us look beyond hormones and understand how plasticity and trait integration interact and change during development. The arginine vasotocin (AVT) pathway in teleost fishes is one such route. AVT expression is sensitive to environmental parameters such as salinity, possibly because of its role in osmoregulation. AVT also modulates the production of steroid hormones, which in turn, affect the phenotype. We aimed to examine variation in color, body shape, behavior, and growth rate in genetically identical rivulus raised in different salinity conditions, and to determine the relationship between these traits and AVT neuron cell size and number. Based on previous research and preliminary data, we hypothesize any deviation from normal salinity will result in more, yet smaller, AVT neurons, as well as differences in color, body shape, behavior, and growth rate across genotypes within the same population.

P1.9 ROCHELEAU, L.B.*; BONIER, F.; BURNS, S.; MONTGOMERIE, R.; Queen's University; *lbrocheleau@gmail.com*

Color discrimination in the Black−capped Chickadee (Poecile atricapillus)

The perception of color can have a significant impact on the evolution and behavior of many animals. In birds, color discrimination undoubtedly plays a central role in foraging, predator avoidance, mate selection, and interspecific signaling. Nonetheless, we lack some basic information on the ability and extent to which different species are able to discriminate among colors and whether that discrimination ability varies across the bird−visible spectrum. To investigate this, we measured the ability of captive Black−capped Chickadees to differentiate colors, using a training and testing protocol that required the birds to discriminate between increasingly similar colors to obtain a food reward. Our results provide insights into the role of color in the behavior and evolution of this bird.

P2.148 RODRIGUEZ, L.M.; AGUILAR, A.C.; CASTILLO, A.O.*; Univ. del Valle, Cali − Colombia; *acastillo.doc@gmail.com*

Leptin's promoter methylated in pregnant women with a low flow−mediated vasodilation

Context: Leptin is a hormone made by adipocytes that acts on brain to regulate food intake and body weigh. Also, leptin has nitric oxide (NO)−dependent vasodilator actions. Recent study indicates that, under physiological conditions, leptin stimulates both endothelin (ET)−1, and NO activity in the human circulation. Methods: Several promoter region methylation degrees in four placental tissues of pregnant women, whom had, at the end of gestational period, a low change in FMD (flow−mediated vasodilation), were evaluated using the new EpiTect Methyl II Signature PCR Arrays (Qiagen). Results: Placenta samples from women with a low FMD showed high percentages of methylation in the leptin's promoter region, with a range from 58.4% to 76.2%, compared the woman who had a high FMD, with a range from 1,6% to 36.8%. Conclusion: Our results suggest that the regulation in placenta of leptin's gene expression by methylation control affects the flow−mediated vasodilatation. Thereby, these results are important to understand and prevent possible problems associated to placental vascularization.

P1.39 RODRIGUEZ, WB*; JENNINGS, KX; BOUCHARD, SB; WARKENTIN, KM; Otterbein Univ., Westerville OH, Boston Univ.; *sbouchard@otterbein.edu*

Competition−induced gut length plasticity, food intake and growth in red−eyed treefrogs

Red−eyed treefrogs, *Agalychnis callidryas*, vary greatly in larval growth rate, larval period, and size at metamorphosis due to intraspecific competition. High larval density also induces longer guts, which increase diet transit time and presumably digestive efficiency. We tested if gut plasticity allows larvae to compensate for initially slow growth rates, should resources become available. Larvae were reared in mesocosms at three densities. Upon reaching a common size (40 mm total length), at different ages, a subset from each density was transferred to identical low density, high resource conditions. We predicted that, because they have longer guts, larvae from higher densities would grow or develop faster than those from the low density. To understand growth patterns, we used a second subset of size−matched larvae to estimate food intake. We fed them carbon to establish a gut content mark, gave them algae ad libitum for a standard period, then euthanized them and examined their guts. Intake was measured as the length of algae−filled gut anterior to the carbon. Larvae from the low density ate more than did those from higher densities, possibly reflecting intake levels in their original conditions. Despite this difference in intake, one−week growth rates, time from transfer to metamorph emergence, and metamorph snout−vent lengths (22 mm) did not differ, although metamorphs from the high density had slightly lower mass. This suggests that, with ample resources, the combination of low intake and long guts can achieve the same result as high intake and short guts, and that initially slow−growing larvae can dramatically change their growth trajectory late in larval life.

P2.124 ROER, R; VATCHER, H*; DILLAMAN, R; Univ. of N.C. Wilmington; *roer@uncw.edu*

Structure of the meso− and urocardiac ossicles of the blue crab, Callinectes sapidus − molt dynamics and aging

The ossicles of the cardiac stomach of decapods are cuticular structures employed to grind food particles. A recent paper (Kilada et al., 2012) suggested that bands observed in sections of the mesocardiac ossicle in snow crabs, lobsters and shrimp corresponded to the age of the individuals. The present study examined the structure of the meso− and urocardiac ossicles of the blue crab to assess its utility in age determination. The ossicles, for the most part, bear a structural similarity to that of the calcified dorsal carapace. Staining with acridine orange showed the same arrangement of an epi−, exo− and endocuticle. In much of the meso− and urocardiac ossicles, the endocuticle is very reduced, with the exocuticle predominating; the reverse of the dimensions of the exoskeleton. The lamellate structure of the ossicles was confirmed with scanning electron microscopy. However, elemental mapping by energy−dispersive analysis of X−rays (EDAX) revealed that the ossicles are mineralized with calcium phosphate, in contrast to the calcium carbonate biomineral of the exoskeleton. The posterior tooth of the urocardiac ossicle is predominantly organic, not calcified but presumably heavily sclerotized. It also contains appreciable amounts of silicon. Histological examination of the ossicles demonstrated that they are molted during ecdysis, so despite the appearance of bands in the mesocardiac ossicle, it is difficult to hypothesize how these bands could represent a record of chronological age. This work was supported by funds from NC Sea Grant.

37.3 ROGERS, D.V.; WEISBLAT, D.A.*; Univ. of California, Berkeley; *weisblat@berkeley.edu*

Unequal second cleavage (of the CD blastomere) in the leech Helobdella austinensis

Among animals that develop via spiral cleavage (a diverse group that may be synonymous with the super−phylum Lophotrochozoa), D quadrant specification is the process by which the four−fold rotational symmetry of the early embryo is broken to establish the bilateral symmetry of the late embryo/adult. In equal cleavers (the presumed ancestral state), D quadrant specification involves stochastic interactions among cells of initially equipotent quadrants, and may occur as late as the 28−cell stage. In unequal cleavers, D quadrant specification entails the unequal segregation of D quadrant determinants beginning with the first cell division. Among clitellate annelids (oligochaetes and leeches), unequal cleavage entails formation of yolk−deficient, RNA−rich cytoplasm (teloplasm) at the animal and vegetal poles prior to first cleavage. An unequal first cell division segregates teloplasm to the CD blastomere; at second cleavage, the unequal division of cell CD segregates teloplasm to one blastomere at the 4−cell stage, defining it as the D quadrant macromere. The embryo is bilaterally symmetric along the AB−CD axis during the early 2−cell stage; symmetry is broken during mitosis by a rightward shift of the mitotic apparatus (MA). The MA itself is symmetric; its movement depends on non−muscle myosin activity−−movement is blocked and the cleavage is equalized by treatment with blebbistatin (to inhibit non−muscle myosin) and ML−7 (to inhibit myosin activation). The rightward shift of the MA correlates with a change in the radius of curvature of the CD cell at the left vs. right side of the embryo. To determine the sub−cellular site of actomyosin activity, we are using time−lapse video analysis to ask if the radius of curvature in blebbistatin−treated embryos is more similar to the left side or the right side of unequally cleaving controls.

121.2 ROLLINS−SMITH, L. A.*; FITES, J.S.; Vanderbilt University School of Medicine; *louise.rollins−smith@vanderbilt.edu*

MECHANISM OF IMMUNE EVASION BY BATRACHOCHYTRIUM DENDROBATIDIS, THE CHYTRID FUNGUS LINKED TO GLOBAL AMPHIBIAN DECLINES

Amphibian populations are suffering unprecedented losses and extinctions on a global scale. One cause is a recently discovered chytrid fungus, *Batrachochytrium dendrobatidis*, which causes the disease termed chytridiomycosis. Although amphibians have robust immune defenses, the adaptive immune response to this pathogen is limited. We hypothesized that the pathogen has developed strategies to evade immune destruction. The first line of immune defense against most fungal infections is innate immune effector cells such as macrophages and neutrophils. These cells begin to control the initial infection and recruit lymphocyte effectors to clear the infection. Thus, many fungal evasion strategies are directed at the macrophage and neutrophil populations. However, other fungal pathogens also target the lymphocyte effector populations. We found that macrophages and neutrophils are fully capable of engulfing *Bd*. Further soluble *Bd* factors do not affect the viability of macrophages and neutrophils or impair the capacity of these accessory cells to provide help for lymphocyte proliferation. Instead, we found that *Bd* releases factors that induce lymphocyte apoptosis and inhibit the proliferation of other non−lymphoid cell types. Thus, the immune paralysis is due to defects in the effector arm (lymphocyte−mediated) of the response. Support: NSF 0843201 and 1121758.

84.4 ROMBOKAS, E*; SCHEUER, L; DYHR, JP; DANIEL, TL; University of Washington; *eric.rombokas@gmail.com*

A robotic model of inertial flight maneuvering in the hawkmoth

Recent studies have shown that the hawkmoth *Manduca sexta* displays a marked abdominal flexion reflex in response to both visual and mechanical cues associated with pitch perturbations. The extent to which such airframe deformation can be used as a control concept for either animals or synthetic systems remains an open problem. To establish control policies for such systems, we developed a robotic "bi−rotor" that has an actuated mass representing an insect abdomen. Importantly, bi−rotors are inherently pitch unstable without active stabilization mechanisms. As such this platform allows us to test hypotheses about control principles that involve conservation of angular momentum along with inertial redirection of thrust forces. The bi−rotor differs from the popular "quad−rotor" in that it uses only two rotors, approximating the two sets of wings in the insect, and stabilizes pitch by movement of an abdomen−like structure hanging beneath and containing the heavy battery. This platform, suggested by the Hawkmoth studies, exhibits a subset of the dynamics found in the insect and allows us to establish the minimum necessary criteria for control. In particular we show how abdominal flexion using only proportional gain is insufficient for pitch stabilization. The addition of appropriately weighted active damping provides some stability, but does not provide the dexterous agility found in the insect. The emergent dynamics of the system, including flips and rapid spins, demonstrate that biologically−inspired active airframe deformation can provide control authority for unstable bi−rotors.

65.5 ROMERO, LM*; FEFFERMAN, NH; Tufts University, Rutgers University; *michael.romero@tufts.edu*

Using Allostasis as a Foundation for Modeling Studies

Physiological stress is increasingly used in conservation as an index for at−risk populations. However, it is unclear how to "scale up" from individual stress responses to population−level impacts. Traditional models of stress, based upon predictability and controllability of stressors, provides little guidance. Allostasis, with its emphasis on allostatic load (cumulative increase in the cost of coping with stressors), provides a potential foundation. We used principles from allostasis to create a set of theoretical models to predict how the ability of a stressed individual to survive and reproduce will impact population sizes. Surprisingly, our models predicted the following three non−intuitive results: (1) populations where the average individual was exposed to high levels of stress relied preferentially on the oldest and most physically fit individuals for reproduction; (2) reliance on the most physically fit individuals led to the average physical condition being highest in the populations where the average individual experienced the most stress; (3) any transient perturbation in the amount of average stress exposure led to a decrease in population size. These results suggest that the average physical condition of individuals in a population may be a poor measure of how much stress the population is experiencing, that any disturbance affecting the oldest and most physically fit individuals could have a disproportionate effect on the population, and that any change in the amount of stress experienced by the average individual is likely to have a short−term detrimental impact on the population size. In conclusion, allostasis provides the theoretical underpinnings to potentially connect individual physiological responses with population−level processes.

128.8 ROMNEY, A L*; PODRABSKY, J E; Portland State University; *arom2@pdx.edu*

Epigenetic regulation of alternative developmental trajectories in an annual killifish

The annual killifish, *Austrofundulus limnaeus*, is capable of entering into a state of metabolic and developmental dormancy during embryogenesis termed diapause. However, individuals may also follow an alternative phenotypic trajectory and instead "escape" entry into diapause and develop continuously until hatching. Early development along the two trajectories is indistinguishable, and gene regulatory mechanisms are currently unknown. Phenotype appears to be influenced by maternal provisioning based on the observation that young females produce predominately escape embryos and older females produce diapausing embryos. In addition, the incubation temperature of embryos can alter trajectory. Maternal provisioning is known in many vertebrates to direct early development prior to the initiation of embryonic gene transcription. I hypothesize that maternally packaged gene products coordinate the cellular events that determine developmental trajectory in *A. limnaeus*. In addition, I propose the expression of specific environmentally−responsive microRNAs during development that can override maternal provisioning. Using RNA−seq, we have generated complimentary transcriptomic profiles of messenger RNAs (mRNAs) and microRNAs during embryogenesis of *A. limnaeus*. Embryos that are destined for either the diapause or escape phenotypes have unique expression patterns starting at fertilization; well before they are morphologically distinct. Our findings suggest maternal programming of diapause through the packaging of specific mRNAs as well as temperature induced microRNAs that target maternal transcripts to alter developmental trajectory. These results will not only impact our understanding of genetic mechanisms that regulate entrance into diapause, but will also provide insight epigenetics and development.

67.2 ROSE, JA*; RUSSO, GA; YOUNG, JW; SMITH, GA; BUTCHER, MT; Youngstown State University, Youngstown, NEOMED, Rootstown, University of Akron, Akron; *jarose@student.ysu.edu*

Ontogeny of locomotor performance in Eastern cottontail rabbits: I. Hindlimb muscle architecture and fiber type.

Rabbits have powerful hindlimb muscles that allow them to accelerate rapidly during locomotion. Moreover, juveniles may have performance advantages relative to adults that could increase their survival to reproductive maturity. To investigate the ontogeny of power capacity in rabbit hindlimb extensors, muscle architectural properties and myosin heavy chain (MHC) isoform fiber type were quantified in six juvenile and four adult cottontail rabbits (*Sylvilagus floridanus*). It is hypothesized that musculoskeletal features of the hindlimb will be optimized in juveniles to promote increased locomotor performance. We measured architectural properties including muscle moment arm, mass, belly length, fascicle length, pennation angle, and physiological cross−sectional area (PSCA), known to provide functional estimates of maximum isometric force, joint torque, and power. MHC isoform distribution was determined by SDS−PAGE and immunohistochemistry techniques. Overall, the large proximal muscles of juvenile and adult rabbits have high fascicle length−to−muscle length ratios, suggesting similar muscle shortening abilities for high power generation. However, for each muscle studied, juveniles have larger PCSA−to−muscle mass ratios than the adults, suggesting higher force production capabilities, and this difference is most notable in the ankle extensors and digital flexors. Juvenile rabbits also have a relatively faster MHC isoform composition than the adults. These results support our hypothesis by indicating that the hindlimb muscles of juveniles are capable of performing greater amounts of mechanical work and power than those of adult rabbits. Supported by NSF IOS−1146916.

P1.159 ROSE, C.S.*; CAHILL, J.W.; James Madison Univ., Harrisonburg, Va; *rosecs@jmu.edu*

Isolating the effects of T4 and T3 on cartilage growth and cartilage shape change in Xenopus tadpoles

Experimental investigations of how thyroid hormone (TH) regulates metamorphic remodeling in *Xenopus* at the molecular and cellular levels commonly apply TH to induce metamorphic changes in tadpole−stage specimens. Studies in salamanders indicate that the precociously induced remodeling of skeletal tissues can vary in stage− and dose−dependent ways and does not always resemble skeletal remodeling in natural metamorphosis. This study aims to quantify the stage−dependency of size and shape changes induced in two pharyngeal arch cartilages (Meckels cartilage or MC and ceratohyal or CH) by the two different forms of TH (T4 and T3). We treated *Xenopus* tadpoles at early and late tadpole and early metamorphic stages (NF 46, 57 and 59/60) with 50 nM of either T4 or T3 and compared the effects on body size and size and shape of the two cartilages to the changes that occurred in controls and in natural metamorphosis. TH−treated and control specimens were first pretreated with methimazole to arrest them at the three starting stages, and methimazole and iopanoic acid were applied during the TH treatments to block endogenous TH production and prevent the conversion of T4 and T3 to other forms of TH. Animals were photographed before and after treatments, cleared and stained for cartilage and bone, and their MC and CH dissected and photographed. Body size and cartilage size and shape were quantified from landmarked photographs. The induced size and shape changes differed with stage of induction and type of TH and only those changes induced at NF 59/60 closely resembled natural remodeling. The discrepancy between T3 and T4 effects was most pronounced at NF 46 and resulted from T3 inducing cartilage shape change at the expense of cartilage growth

P1.202 ROSTON, RA; Duke University; *rachel.roston@duke.edu*

Blue Whale (Balaenoptera musculus) Anatomy at the Transition between the Embryonic and Fetal Periods

The morphological transformations associated with the secondary adaptation of cetaceans to aquatic life are well−documented in the fossil record. The ontogenies of extant cetaceans may clarify developmental origins of these macroevolutionary changes. Stages of odontocete (toothed whale) embryology have been defined, but the applicability of these stages to mysticete (baleen whale) development is largely unknown. In this study, the external and internal anatomy of a 130−mm blue whale fetus (*Balaenoptera musculus*), the largest mysticete, is described using microCT. Externally, the specimen resembles a late−stage odontocete embryo due to the lack of a fluke and dorsal fin, but resembles an early−stage odontocete fetus due to its elongated rostrum. Internally, the dermal cranial bones are partially ossified and do not yet overlap posteriorly as in an adult, much like odontocetes of a similar developmental stage, and the endochondral skeleton is cartilaginous. Within the larynx, the U−fold and laryngeal sac are approximately parallel to the body axis and airflow, much as in a balaenopterid adult. The gestational age is estimated to be 65 days by combining fetal morphological data with fetal length data from the International Whaling Statistics, historical accounts of blue whale migratory and reproductive habits, and published descriptions of fetuses of congeneric species. These data show that some but not all major balaenopterid characteristics are present before the onset of rapid growth during the fetal period.

89.1 ROSVALL, KA*; PETERSON, MP; BUECHLEIN, A; TANG, H; RUSCH, D; KETTERSON, ED; Indiana Univ.; *krosvall@indiana.edu*

Acute and persistent social challenges elicit widespread shifts in peripheral gene expression without a systemic rise in testosterone

The challenge hypothesis predicts that testosterone (T) rises following a social challenge to bring about changes in behavior and physiology that prepare animals for continued social instability. Evidence has been accumulating, however, that males of many songbird species do not socially modulate T, raising key questions about the nature of alternative physiological mechanisms related to social instability. We staged social challenges in free−living male dark−eyed juncos (*Junco hyemalis*), a species of songbird that under most circumstances does not elevate T in response to a simulated territorial intrusion. We hypothesized that tissue−specific changes in gene expression might prime individuals for continued social competition, at the expense of self−maintenance, even in the absence of a systemic rise in T. We used custom microarrays to assess these transcriptional responses in the liver, spleen, and pectoral muscle in males that were euthanized immediately after one 25−min playback (acute challenge), males that were euthanized on the day after a full day of repeated playbacks (persistent challenge), and unmanipulated controls. Both acute and persistent challenges led to many significant changes in gene expression in these three peripheral tissues, but T and corticosterone levels were unaffected. Consistent with our hypothesis, challenged males were characterized by transcriptional shifts away from self−maintenance, particularly in genes that function in DNA repair, cell death, muscle growth, and immune/inflammatory response. These results show that social challenges can cause rapid and lasting changes in gene expression in the periphery without a systemic change in the hormones that have been hypothesized to engender adaptive responses to social instability.

85.3 ROY, T*; SANE, S.P; National Centre for Biological Sciences, Bangalore, India; *tarunir@ncbs.res.in*

The antennal positioning response of flying honeybees

Antennal movements of insects are important for optimal acquisition of the sensory cues that they sample during specific behaviours. Although these behaviours are initiated by neural commands from higher centres, they are also influenced by inputs from multiple sensors. Here, we show that both mechanosensory and visual inputs modulate antennal positioning in flying honey bees. Freely flying honeybees control their antennal position relative to their air speed. As in most insects, the gross changes in antennal position are transduced by sets of mechanosensory hair fields on the basal segments of the antennae. In addition, experiments in which flying honeybees are presented with optic flow indicate that antennal position is also a function of bilateral visual input. Thus, the antennal positioning behaviour in honeybees uses multimodal cues.

12.1 RUIZ−JONES, GJ*; PALUMBI, SR; Stanford University, Hopkins Marine Station; *gjrj@stanford.edu*

Coral transcriptome−wide gene expression patterns at noon and midnight in a coral reef: insights into coral physiology

In coral reefs there are many environmental fluctuations from day to night. Circadian gene expression studies on corals have been done in controlled lab settings; however, little is known about day−night gene expression patterns in corals living on the reef. We sampled coral transcriptomes at six noon and five midnight time−points from a colony living in a back−reef on Ofu, American Samoa. We also measured temperature, oxygen, pH, and aragonite saturation at each time point. Vigorous wave action and water motion during the sampling period led to only small changes in temperature, pH, and aragonite saturation from day to night, which is atypical for this particular back−reef, but removes the potential influences of these three environmental variables on any observed daily gene expression fluctuations. By contrast, dissolved oxygen saturation increased during daylight and decreased at night. We measured gene expression at over 16,000 genes and found several hundred genes to be variable from day to night. As expected the expression of light−sensitive cryptochromes was higher at noon than midnight. We observed higher expression during the day of some known calcification genes, including the skeletal organic matrix protein galaxin. Interestingly, a hypoxia−inducible factor prolyl hydroxylase showed higher expression levels at midnight, a time when our data show low oxygen concentrations nearby the sampled colony. These examples show that our transcriptome−wide gene expression analysis of coral physiology at noon and midnight in a coral reef reveals the cellular processes that distinguish cellular activity at these two time points.

P3.103 RUMRILL, C.T.*; FLYNN, R.W.; SCOTT, D.E.; LANCE, S.L.; Savannah River Ecology Laboratory, University of Georgia, Aiken, SC; *rumrill@srel.uga.edu*

Latent effects of multiple stressors on southern toads, Anaxyrus terrestris

Anthropogenic stressors cause lethal and sublethal effects that contribute to population declines in amphibians; however, few studies examine effects after metamorphosis. In natural habitats individuals are exposed to multiple stressors, making it difficult to extrapolate results from single−stressor laboratory studies. We used 24, 1000−L pond mesocosms to investigate the combined effects of anthropogenic (copper) and environmental (pond hydroperiod) stressors on egg, larval, and early post−metamorphic stages of the southern toad (*Anaxyrus terrestris*). We exposed embryos (4 clutches, ~100/clutch) and larvae (25/clutch) to three concentrations (0, 20, and 50 µg/L) of Cu, a wide−spread heavy metal contaminant, crossed with two simulated pond drying regimes. We measured embryo/larval survival, time to/size at metamorphosis, and assessed performance (hopping speed and endurance) in toads at 5 and 35 days post−metamorphosis. There were no treatment effects on embryo survival but larval survival was affected by hydroperiod, with long averaging ~70% survival vs. 20% in short. Metamorphosis was delayed in the 50 µg/L−long treatment. Both factors affected body size at metamorphosis, with some effects persisting one month later, and hopping performance correlated with body size. At metamorphosis, the 50 µg/L treatment reduced hopping sprint and endurance speeds, as well as endurance distance; endurance remained depressed one month later. Additionally, there was a Cu*hydroperiod effect on hopping sprint and endurance speed, with endurance speed remaining depressed after one month. The persistent effects of Cu and the delayed onset of a Cu*hydroperiod interaction emphasizes the importance of extending studies involving stressors beyond the larval period.

93.8 RUPERT, JE*; BUTCHER, MT; Indiana University School of Medicine, Youngstown State University; *jerupert@iupui.edu*

Prehensile tail use in didelphid marsupials: functional modifications for terrestrial species

Locomotor behavior has largely been studied through analyses of limb kinematics, gait mechanics, and muscle architecture and fiber type. Evaluating these characteristics in extant mammals is helpful to determine ancestral form and provides insight into functional changes species have undergone. Families containing both arboreal and terrestrial species, such as didelphid marsupials, are particularly interesting because body size and gait mechanics have been modified to reflect use or disuse of rainforest vertical strata. Didelphids arose from a common arboreal ancestor, and yet all species retain prehensile digits, an opposable hallux, and a prehensile tail. Terrestrial opossums have overall larger body sizes and use lateral sequence gaits, but they do not require a prehensile tail for terrestrial locomotion. Our studies have analyzed the comparative structure and function of this specialized appendage between species of didelphids with opposing locomotor habits (i.e., arboreal vs. terrestrial). Using multiple muscle fiber typing techniques (e.g., SDS−PAGE, densitometry, immunohistochemistry) combined with anatomical measurements and behavioral observations, we find functionally different utilizations of the prehensile tail in didelphids associated with muscle physiology and locomotor habits. Species that have become habitually terrestrial use their tail for nest building and offspring manipulation, and have an overall slower fiber type distribution and reduced tail−to−body length ratio compared to arboreal species who use the tail extensively for balance, stability, and arboreal maneuvering. Our studies provide a foundation for future work relating tail function to locomotor behavior in other orders of mammals (e.g., non−human primates) that have either retained or lost tail prehensility.

7.4 RUPP, M.F.*; HULSEY, C.D.; University of Tennessee Knoxville; *mrupp@utk.edu*

Pectoral Fin and Feeding Kinematics in Rock Dwelling Malawi Cichlids

Adaptive radiations such as Malawi cichlids provide an excellent opportunity to elucidate the underlying forces behind evolution and how high amounts of species diversity are maintained in a largely shared environment. One group of particular interest is the rock−dwelling mbuna, which is one of the two major clades of Malawi cichlids. To try and better understand the factors behind their evolution into distinct niches and how such a large number of species coexist, we investigated differences in feeding kinematics of three rock−dwelling mbuna species via high speed video. All three species were filmed feeding from the top, side, and bottom of an experimental "rock" in order to explore how feeding orientation might influence trophic kinematics. Using this data we were able to make inferences about how the incredibly species rich group of mbuna in Lake Malawi could be partitioning their habitat to facilitate coexistence.

P3.15 RUPP, TM*; MARTIN III, AL; Saginaw Valley State University; *almarti2@svsu.edu*

The Effects of Shelter Availability on Aggression in the Rusty Crayfish

An important outcome of agonistic interactions is the allocation of resources. A higher dominance rank as a result of competition often affords an animal with greater access to resources. Shelters are an important resource and organisms will often escalate the intensity of an agonistic bout in order to obtain or sustain ownership. However, the distribution of shelters in a natural setting is often unknown, and in many animal systems it is not well understood how the availability of shelters may impact aggressive behavior. Crayfish are known to readily compete with conspecifics to gain access to shelters and other key resources. Crayfish have often served as a model organism for examining aggression and social relationships. In the present study populations of four size matched (within 10%) male crayfish, *Orconectes rusticus*, were presented with arrangements of two, four, or six shelters. Video analysis was used to quantify shelter use as well as fight frequencies, intensities, and outcomes over a 24 hour period. Shelter ownership, eviction rates, fight durations, and overall fight intensity were quantified and correlated between the three experimental designs. This study will provide information about the effects that the availability of resources may have on social dominance and aggressive behavior within a population.

102.6 RUSCH, T/W*; SEARS, M/W; RAY, G/F; MERLINO, T/L; ANGILLETTA, M/J; Arizona State University, Tempe, AZ, Clemson University, Clemson, SC, Franklin & Marshall College, Lancaster, PA; *trusch@asu.edu*

Beyond lethality use of thermal resources under the perceived risk of predation

When resources become concentrated in space, the perceived risk of predation can prevent prey from accessing those resources. We studied both the movement and thermoregulation of male lizards (*Sceloporus jarrovi*) under perceived risk in spatially explicit landscapes. In a previous study, male lizards thermoregulated more accurately in landscapes with patchy distributions of shade compared to landscapes with clumped distributions. But would this result hold in the presence of a predator? To test this idea, males were placed outdoor arenas (20 x 20 m) with either a clumped or patchy distribution of shade and exposed to an artificial aerial predator (*Buteo jamaicensis*). Predation risk was simulated by flying models on zip lines over the arenas. As a control, other lizards experienced the same landscapes with no artificial predation risk. We predicted that lizards would be more active and would thermoregulate best in patchy environments with no risk of predation. We will report the interactive effects between thermal landscapes and predation risk on the movements and accuracy of thermoregulation by lizards.

16.1 RUSSEY, WA*; FRANKINO, WA; Univ. of Houston; *warussey@gmail.com*

Do clines in Drosophila flight morphology result from adaptive environment−phenotype matching?

Drosophila exhibit convergent genetically−based clines and phenotypic plasticity in absolute and relative wing size; relative to warm environments, cooler environments produce large flies with disproportionately large wings. Although this pattern has been documented for many insect species on several continents, the reasons for the pattern remains unknown. The leading hypothesis is that selection on flight performance across thermal environments favors the observed patterns in morphology, although data addressing this hypothesis are scant and the importance of phenotypic plasticity in producing and maintaining these patterns remains unknown. Discussed here is a two−part study to (I) impose natural selection on flight performance in warm and cool environments to create experimentally derived populations of flies possessing morphology suited to flight at each temperature, and (II) assess the adaptive nature of the derived morphologies in ecologically relevant flight assays. Two experimental evolution studies were performed. In the first, warm and cool−selected populations were both reared at an intermediate temperature, removing effects of thermally−induced phenotypic plasticity. In the second experiment, warm and cool−flight selected lines were reared such that temperature of rearing was the same as the temperature of adult flight, providing a reliable cue during development. The experiments discussed here rigorously test the hypothesis that selection on ecological performance has produced a biogeographic morphological pattern frequently cited as one of the most compelling cases of adaptation known. In addition, the proposed work will offer general understanding into how developmentally and functionally integrated suites of traits might change rapidly under different thermal regimes, and quantify the importance of plasticity in this system.

26.2 RUSSO, G.A.; The University of Texas at Austin; Northeast Ohio Medical University; *grusso@neomed.edu*

Proximal caudal vertebral morphology in relation to tail length among primates and other mammals

Tail reduction/loss independently evolved in a number of mammalian lineages. One prerequisite to appropriately contextualizing and understanding its significance is the ability to confidently establish tail length from fossil material. This study examines how caudal vertebral anatomy varies among primates and other mammals (carnivores, diprotodonts, pilosans, rodents, and tree shrews; N=333) known to differ in relative tail length (RTL; =tail length/[head+body length] x 100). Linear and angular measurements with known biomechanical significance were collected on first, mid−proximal, and transition caudal vertebrae, and their relationship with RTL was assessed using phylogenetic generalized least−squares regression methods. Compared to shorter−tailed taxa, longer−tailed taxa possess a greater number of caudal vertebral features associated with enhanced proximal tail mobility (e.g., more circularly−shaped cranial articular surfaces), as well as greater surface area for attachment and improved leverage of basal tail musculature (e.g., more laterally expanded and caudally oriented transverse processes). Multivariate models constructed from the extant primate data were used to predict the RTLs of two extinct subfossil lemurs with associated caudal vertebrae. The predicted RTL of *Palaeopropithecus* was 36 (i.e., tail is shorter than ½ head and body length) and that of *Archaeolemur* was between 109 and 143 (i.e., tail longer than total head and body length). These results have implications for our ability to track evolutionary changes in tail length and also provide an anatomical basis for future studies of tail kinematics. Supported by NSF DDIG BCS−1156016 and The Leakey Foundation.

109.3 RYAN, J.F.; SCHNITZLER, C.E.; MAXWELL, E.K.; PANG, K.; FRANCIS, W.R.; SMITH, S.A.; WOLFSBERG, T.G.; MULLIKIN, J.C.; HADDOCK, S.H.D.; DUNN, C.W.; MARTINDALE, M.Q.; BAXEVANIS, A.D.*; NHGRI/NIH and Sars Intl. Centre for Marine Mol. Biol., Natl. Human Genome Res. Inst., NIH, Sars Intl. Centre for Marine Mol. Biol., Monterey Bay Aquarium Res. Inst., Brown Univ., Whitney Lab for Marine Bioscience, Univ. of Florida; *andy@mail.nih.gov*

The Genome of the Ctenophore Mnemiopsis leidyi: Bringing Resolution to the Phylogenetic Position of the Ctenophores

Until recently, Ctenophora (comb jellies) was the only non−bilaterian animal phylum without a sequenced genome, and its phylogenetic position has remained highly controversial. To understand the molecular innovations that drove the outbreak of diversity in the early evolution of animals, we have sequenced, assembled, annotated, and analyzed the 150 megabase genome of the ctenophore, *Mnemiopsis leidyi*. Our analyses of these data from both a gene content and a traditional concatenated phylogenomic perspective strongly suggest that ctenophores are sister to all other animals. The implications of these results are either that neural and mesodermal cell types were lost in Porifera and Placozoa, or that (to some extent) these cell types evolved independently in the ctenophore lineage. The inventory of genes associated with these cell types in both *Mnemiopsis* and the deeply sequenced transcriptomes of seven other ctenophores supports the possibility of some degree of independent evolution. We have also used these data to assess the role of these animals in furthering human disease research; using a comparative genomics approach, we find that non−bilaterian animals have the potential to serve as viable models for studying various important classes of human diseases.

P3.54 RYAN, LM*; BRANDER, SM; CHANG, ES; CHANG, SA; COVI, JA; University of North Carolina Wilmington, Bodega Bay Marine Laboratory, University of California Davis, Bodega Bay Marine Laboratory, University of California Davis; *lmr8506@uncw.edu*

The effects of toxicants on the production of ecdysteroids by the Y−organ in Callinectes sapidus

Over 80,000 chemicals are registered for use in the U. S., many of which remain in the marine environment. Because of their economic importance, the blue crab, *Callinectes sapidus*, is an important model organism in which to study the effects of endocrine disrupting chemicals on decapod growth. Blue crabs grow by undergoing a series of molts, which involve shedding of the exoskeleton, and growing into a new larger exoskeleton. Molting events are initiated by the synthesis and release of ecdysteroid hormones from the Y−organ (YO). Peptide hormones produced in the eyestalk ganglia (ESG), inhibit molting during intermolt periods. We are assessing the effect of toxicants on the release of ecdysteroids from the YO. Blue crabs were collected from four sites, with differing levels of polluted runoff, in North and South Carolina. Hemolymph was taken within 24 hours of capture for ecdysteroid analysis. YOs were then excised from the crabs and incubated in media with and without ESG for various incubation times. Ecdysteroid concentrations were measured in the culture media to determine basal secretion of by the organs and responsiveness to eyestalk ganglia extract. Preliminary results show that there is no significant difference in basal or ESG extract inhibited ecdysteroid secretion in crabs among the collection sites. In a separate study, we analyzed the secretion of ecdysteroids by YOs from crabs after controlled exposure to toxicants found in estuarine environments. Under the conditions used, Y−organs continued secreting ecdysteroids at a constant rate for at least 28 hours. Exposures to methoprene and bifenthrin within this time frame will be presented.

45.4 RYERSON, WG*; SCHWENK, K; University of Connecticut; *william.ryerson@uconn.edu*

The allometry of tongue−flicking mechanics in colubrid snakes

Oscillatory tongue−flicking in snakes enhances the rate of diffusion of odorant molecules onto the mucus covering the tongue, which is then delivered to the vomeronasal organ. The multiple oscillations of the tongue generate a unique airflow pattern, with two pairs of standing, counter−rotating vortices, one above the other. The vortices pull previously unsampled air in from the sides, jetting it vertically upward and downward into the path of the oscillating tongue, refreshing the supply of odorant molecules to be sampled. We have shown previously that this airflow pattern maximizes the rate of molecular transfer of volatile chemicals onto the tongue tips for vomeronasal sampling. Using high speed video and DPIV, we explored the mechanics of tongue−flicking in five species of colubrid snakes: northern black racer (*Coluber constrictor*); northern water snake (*Nerodia sipedon*); eastern garter snake (*Thamnophis sirtalis*); northern ringneck snake (*Diadophis punctatus*); and Dekay's brown snake (*Storeria dekayi*). All snakes generated the same pattern of vortices, but with different kinematic profiles. The largest snakes (*C. constrictor*) have a smaller tongue relative to body size, fewer oscillations per flick (3−4), and a lower tongue tip velocity (1 m/s). The smallest snakes (*S. dekayi*) have larger tongues relative to body size, more oscillations per flick (9−11), and a higher tongue tip velocity (3 m/s). Given the nearly identical fluid dynamic outcomes in all species, despite differences in tongue kinematics suggests that tongue size, velocity, and number of oscillations interact in a way to maintain the generation of vortices and optimization of molecular sampling. Tongue size and tongue tip velocity, and oscillation number all scale negatively with body size. It may be necessary to maintain a similar Reynolds number in order to generate the observed airflow pattern.

76.6 SAJUTHI, A.; CARRILLO−ZAZUETA, B.; BRONDANSKY, L.; WANG, A.; DUKE, E.; RIVERA, A.S.*; University of the Pacific; *arivera@pacific.edu*

Gene expression differences in the sexually dimorphic eyes of Euphilomedes carcharodonta (Ostracoda, Crustacea)

The difference between a simple light−sensing organ and a complex image−forming eye is largely one of cellular organization. An image forming eye requires intricate patterning of multiple cell types, directed by the expression of eye−development genes. Here we examine gene expression differences between these two eye types. In *Euphilomedes* ostracods (Crustacea), males (XO) have large complex eyes with standard ommatidial cellular structure, while females (XX) have simple eyes that do not exhibit these structures. We find that sex−specific gene expression differences are in place midway through juvenile development and that the earliest expression differences involve genes whose homologs are involved in various stages of Drosophila eye development. Namely, we observe that some genes involved in eye field specification, rhabdom organization, and lens development are expressed more highly in mid−juvenile males. We also see that mature male eyes express much higher levels of phototransduction gene homologs than female or developing eyes. Our findings suggest that activation of only a small subset of eye development genes is sufficient to pave the way for the growth and organization of this complex crustacean compound eye.

82.6 SALCEDO, M.K.*; IWASAKI, J.M.; RUNDLE, D.E.; COMBES, S.A.; Harvard, Univ. of Otago; *maryksalcedo@fas.harvard.edu*

Hunting with damaged wings: How does the location of dragonfly wing damage affect flight biomechanics and predation success?

Dragonflies perform a diverse array of complex aerial behaviors that entail a challenge for flight control, even under ideal circumstances. In the wild however, dragonflies often perform these maneuvers while suffering from natural wing damage. Wing damage negatively impacts survival in bees and predation success in dragonflies, but the link between specific morphological changes induced by wing damage and the resulting changes in flight biomechanics and performance remains unclear. We examined how symmetric damage to the hind wings of dragonflies (*Sympetrum rubicundulum*) affects dragonflies' ability to perform the complex maneuvers involved in aerial predation, by comparing capture success and flight biomechanics before and after inflicting artificial wing damage. We compared the effects of equal amounts of area loss (30% of hind wing area/18% of total area) in two commonly damaged areas of the wing, the tip and trailing edge, resulting in different morphological changes (reduced span vs. narrower wing chord). Predation trials conducted on 25 dragonflies before and after manipulation revealed that both wing damage treatments significantly reduced predation success, and that the two treatments reduced success by nearly identical amounts, regardless of the location of damage. Kinematic analysis showed that peak acceleration was reduced following both types of artificial wing damage, and that some aspects of maneuverability (e.g. turning rate, radial acceleration) may also be compromised. These results provide further evidence that wing damage can have severe ecological consequences, suggesting that insects may display morphological and/or behavioral adaptations to reduce the accumulation of irreversible wing damage.

57.3 SALEEM, S*; CARNEY, G.E.; Texas A&M University; *ssaleem@bio.tamu.edu*

Sexual experience enhances mating behavior and success of male Drosophila melanogaster

Competition for mates is a wide−spread phenomenon affecting individual reproductive success. The ability of animals to adjust their behaviors in response to changing social environment is important and well documented. *Drosophila melanogaster* males compete with one another for matings with females and modify their reproductive behaviors based on prior social interactions. However, it remains to be determined how male social experience that culminates in mating with a female impacts subsequent male reproductive behaviors and mating success. Here we show that sexual experience enhances future mating success. Previously mated *D. melanogaster* males adjust their component courtship behaviors and are able to out−compete sexually inexperienced males for copulations, when placed in the same mating arena. Interestingly, courtship experience alone was not sufficient in providing this competitive advantage, indicating that copulation plays a role in reinforcing this social learning. We also show that females use their sense of hearing to preferentially mate with experienced males when given a choice. Our results demonstrate the ability of previously mated males to learn from their positive sexual experiences and adjust their behaviors to gain a mating advantage. These experienced−based changes in behavior reveal strategies that animals likely use to increase their fecundity in natural competitive environments.

96.4 SALERNO, PE*; SEñARIS, JC; ROJAS−RUNJAIC, F.J.M.; CANNATELLA, D.C.; U.T. Austin, IVIC, Caracas, La Salle Nat. Hist. Museum, Caracas; *patriciasalerno@gmail.com*

Recent evolutionary history of a Lost World frog radiation

The Lost World of South America comprises hundreds of flattop mountains with walls up to 1000m high and hundreds of kilometers of lowlands separating them. These flattop mountains form a discontinuous ecosystem of islands in the sky, with enormous number of endemics unique to the highlands. However, many of these endemics seem to have arrived there recently, in spite of the drastic landscapes that suggest long−term isolation of highland species. We examine the evolutionary history of *Tepuihyla*, a genus of frogs endemic to these mountains. Although *Tepuihyla* is currently regarded as consisting of five species, species boundaries within the genus have been debated. We focus on three of the most recently diverged lineages, *T. edelcae*, *T. cf edelcae* (both summit restricted), and *T. rodriguezi* (midlands), to examine evidence of recent dispersals, demographic history, potential effects of Pleistocene climate shifts, and movements within the eastern flattop mountains and their surrounding lowlands. We also perform morphometric analyses to assess correspondence between genetic and morphological divergence. These analyses indicate the existence of a new cryptic species that lacks obvious diagnostic phenotypic characters.

P1.95 SALINAS−SAAVEDRA, M*; MARTINDALE, MQ; University of Florida, Florida; *mssaavedra@whitney.ufl.edu*
Understanding animal polarity: Functional studies during early embryogenesis of the sea anemone Nematostella vectensis.
How germinal layers are specified during early development of non−bilaterian animals is unclear. In bilaterian animals, rearrangements of the egg's cytoplasm and cortical domains polarize the embryo and direct proper partitioning of maternal determinants into distinct daughter cells often in relationship to a regular cleavage program. In some bilaterian animals, Lethal Giant Larvae (LGL) and PARtitioning−defective proteins (Par) are conserved components of cellular polarization during early embryogenesis. Par proteins and their role in establishing embryonic asymmetry have been widely studied in bilaterian development but not in more basally branching animals. Interestingly, the basally branching cnidarian sea anemone *Nematostella vectensis* shows a "random" cleavage pattern and it undergoes gastrulation at the animal (not vegetal) pole of the egg; begging the question of whether the same molecular mechanisms are conserved for specifying the site of gastrulation. We address this question by characterizing the localization and function of different components of the Par complex during early development of the sea anemone *N. vectensis*. The mRNAs of Par proteins are asymmetrically localized. However, Immunostaining using antibodies made against NvLGL and NvaPKC shows that these proteins distribute throughout the egg and embryo without any clear polarization confirming results obtained when we over expressed them using mRNA injections. In addition, the over expression of the full length and dominant negative version of some Par proteins affect cleavage divisions and gastrulation but do not have a clear effect on embryonic polarity. These data will provide a glimpse into the evolution of cell polarity and the organization of metazoan embryonic germ layer formation.

P3.174 SALOMON, R.*; MUSOLF, B.; Clayton State University; *rsalomon@student.clayton.edu*
Enhancing morphological studies of the bean beetle Callosobruchus maculatus with eigenshape analysis
Host effects on organisms that utilize them for food, shelter, and/or reproduction can be used to study the adaptive and evolutionary consequences of host choice. The bean beetle, *Callosobruchus maculatus*, is an ideal organism for host shift experiments because of its fast generation time, survival on a variety of bean hosts, and measurable changes in morphology. Previous research and observations of beetle survivorship and physical traits on non−native bean hosts has shown that there are phenotypic consequences incurred by a shift to a new bean host. We predicted that there are measureable changes in emergence, eggs laid and egg distribution, and weight of *C. maculatus* after a host shift. We quantified the phenotypic and behavioral modifications in *C. maculatus* after a shift to Cowpea (*Vigna unguiculata*), Mung (*Vigna radiata*), Adzuki (*Vigna angularis*), and Garbanzo (*Cicer arietinum*) beans. Additionally, we examined body shape modifications in host−shifted beetles using eigenshape analysis, focusing on the modifications of the beetle elytra and abdomen across populations. Using PAleontological STatistics (PAST) software, developed for evolutionary studies in paleontology by Hammer and Harper, we created a model shape for each beetle generation to elucidate modifications in shape among beetles reared on different hosts.

P3.63 SALVATORE, BP*; GERALD, GW; Nebraska Wesleyan University; *brittani_s@hotmail.com*
Thermal dependency of locomotor performance and anti−predator behaviors in boa constrictors (Boa constrictor)
Temperature is widely known to have a large influence on locomotor performance and behaviors of many animals, especially poikilotherms. In snakes, previous studies have quantified thermal dependencies of locomotor abilities during different locomotor modes in snakes of the family Colubridae. To our knowledge, no study has examined the influence of temperature on a species of snake in the family Boidae (boas and pythons). In addition to most species being found in tropical or sub−tropical environments, these large−bodied snakes might encounter more friction during movement compared to smaller snakes, thus exacerbating the influence of decreasing temperatures. This study examined both the thermal dependency of locomotor performance and anti−predator behaviors in the boa constrictor. Performance was tested on snakes moving via lateral undulation, swimming, concertina, and arboreal locomotion at three temperatures. We found that temperature dependencies were similar to those found in other colubrid snakes. Moreover, we found that anti−predator behavioral strategies exhibited were related to performance at different temperatures.

8.7 SAMPLE, C.S.*; XU, A.; SWARTZ, S.M.; GIBSON, L.J.; Massachusetts Institute of Technology, Brown University; *csample@mit.edu*
Nanomechanical properties of insect wing layers
Insect wings often change shape dynamically during the wingbeat cycle, and these deformations can confer energetic and aerodynamic benefits during flight. Due to the lack of musculature within the wing itself, the changing form of the wing is determined primarily by its passive response to inertial and aerodynamic forces. This response is in part controlled by the wing's mechanical properties, which vary across the membrane to produce regions of differing stiffness. Previous studies of wing mechanical properties have largely focused on surface or bulk measurements, but this ignores the layered nature of the wing. In our work, we investigated the mechanical properties of the wings of the house cricket (Acheta domesticus) with the aim of determining differences between the wing's three layers: the dorsal and ventral epicuticle layers and the internal epidermal layer. The thickness of the three layers was measured using scanning electron microscopy. The Young's modulus and hardness of the external epicuticle layers were measured via nanoindentation on the surface to shallow depths to avoid effects from the underlying layers. Nanoindentation was also performed at the center of cross−sectional samples of the wing to measure the mechanical properties of the epidermis. Measurements of both the surface and cross−section were repeated at several locations to investigate the variability of these properties. The results suggest that the epidermis is stiffer than the epicuticle, and the properties of both layers vary across the wing. Our findings lay the foundation for further investigation of the role played by this layered structure in wing deformation and insect flight.

P2.160 SANDERS, R.*; OXMAN, D.; TRUMBLE, S.; Baylor University, Waco, Texas, Alaska Department of Fish and Game, Juneau; *rebel_sanders@baylor.edu*

Stress Response Associated with Hatchery Conditions in Developing Chum Salmon (Oncorhynchus keta)

To assess the impact of hatchery techniques on the stress response of Chum Salmon *(Oncorhynchus keta)*, developing fish were subjected to treatments of formalin, low−medium−high densities, thermal shock, and mechanical distress. Mean cortisol levels for formalin treated eggs immediately increased ~350% and remained elevated for 60 minutes until returning to control treatment levels. Mean cortisol levels differed significantly between formalin and thermal treatments and control. Both mortality rate and mean cortisol differed significantly between low, medium, and high densities. Shock and pick, as well as transport of salmon fry, was mimicked with mechanical distress and cortisol levels did not increase until mechanical distress continued for 90 minutes whereby cortisol concentrations increased ~295% above control levels. These results should help identify stress responses during early life stages of chum salmon as well as identify potential sources of anthropogenic stress associated with hatcheries.

S4.1−4 SANDMEIER, F.C.*; TRACY, C.R.; Lindenwood University − Belleville, University of Nevada, Reno; *FSandmeier@lindenwood.edu*

Addition of relative metabolism in the "pace of life" hypothesis: incorporating ectothermic physiology

Incorporating metabolic rate as an additional axis in a theoretical model of the interspecific relationship between "pace−of−life" and the strength of an adaptive immune response (Lee 2006) makes the model more universally applicable. Using reptiles as an example, we hypothesize that animals with slow metabolic rates will invest more in innate versus adaptive immunity. This pattern logically derives from the concept that constant, high metabolism and body temperature should optimize the functioning of the adaptive (induced) immune response resulting in rapid, targeted cell division needed for T and B cell maturation and increasing the functions of antibodies via kinetics. Given the apparent importance of metabolism in the strength of adaptive immune responses, we suggest that increased immune function may have conferred a fitness advantage to ancestral vertebrates that led to the evolution of endothermy. Finally we show that general characteristics of the immune systems of host species, as shaped by both pace−of−life and metabolic rate (and body temperature), influence the ecology and evolution of host−pathogen systems in several, predictable ways.

P1.146 SANFORD, R S*; DABE, E C; KOHN, A B; MOROZ, L L; The Whitney Lab for Marine Bioscience, St Augustine, FL, Univ. of Florida, Gainesville, FL , The Whitney Lab. for Marine Bioscience, St Augustine, FL, The Whitney Lab for Marine Bioscience, St Augustine, FL, Univ. of Florida, Gainesville, FL, Univ. of Florida McKnight Brain Inst., Gainesville, FL; *rsanford@ufl.edu*

Evolution of neuronal genes in Aplysia californica: Interplay between development and memory of injury

Genome−wide transcriptional changes in development provide important information on mechanisms underlying neural fate specification, neural identity, neurogenesis and neural patterning and how these processes relate to neural recovery after injury. Here, we characterize transcriptomes of embryonic, larval, and metamorphic stages in the sea slug, *Aplysia californica*, and examine novel molecular components associated with the development of the nervous system and neuronal injury. To do this we first annotated the recently sequenced *Aplysia* genome (in conjunction with the Broad Institute) for the entire complement of the developmental genes. Second, we performed deep RNA−seq analysis of all key developmental stages starting from cleavage and gastrulation to post hatching veligers. Both Illumina and semiconductor sequencing were used with up to 50−60 million sequencing reads per sample. Finally, we compare these data to other molluscs including the limpet, *Lottia gigantea* and the oyster *Crassostrea gigas*. As a result we were able to identify a large subset of previously uncharacterized components of signal transduction pathways, transcription factors and non−coding RNAs potentially recruited from developmental programs to support neurogenesis and long−term plasticity in adult memory forming circuits. Interestingly, our initial comparative analysis suggests, with some molecular toolkits, the early origin of genes associated to injury−induced neuroplasticity was well−conserved across both basal metazoans and bilaterians.

P1.185 SANFORD, J.L.*; DICKENS, J.C. ; SHIELDS, V.D.C.; Department of Biological Sciences, Towson University, Towson, Invasive Insect Biocontrol and Behavior Laboratory, Plant Sciences Institute, Henry A. Wallace Beltsville, Agricultural Researcher Center, Agricultural Research Service, USDA, Beltsville; *jsanfo2@students.towson.edu*

Gustatory Receptor Neuron in Gypsy Moth Larvae Responds to Selected Insect Repellents

Gypsy moth larvae, *Lymantria dispar* (L.), have a medial styloconic sensillum that assist in food selection. The medial styloconic sensillum houses a gustatory receptor neuron (GRN) that responds to alkaloids (i.e., feeding deterrents). We stimulated the medial styloconic sensillum with three different insect repellent chemicals (i.e., DEET, IR3535, and picaridin) to determine if these compounds elicited electrophysiological responses from the deterrent−sensitive GRN housed within this sensillum. We found that all three repellent chemicals stimulated the same GRN within the medial styloconic sensillum. Additionally, we found the deterrent−sensitive GRN that responded to alkaloids was the same GRN activated by these repellents. The deterrent−sensitive GRN responded to the repellent chemicals in a dose−dependent manner. The repellents elicited a phasic−tonic temporal firing response. Similarities in the temporal firing response from the deterrent−sensitive GRN to alkaloids and repellents suggest both classes of chemicals are transmitted to the insect's central nervous system through the same transduction pathway. This study, in conjunction with a previous study on *Aedes aegypti*, suggests insect repellent chemicals mediate their effects through the olfactory and gustatory systems.

130.8 SANTAGATA, S.; Long Island University−Post; *scott.santagata@gmail.com*

Reconciling morphology, molecules, and species diversity with phoronid phylogenetic relationships.

Phoronids are tubiculous marine invertebrates closely related to brachiopods. Previous phylogenetic work by Santagata and Cohen (2009) found only weak congruence between the morphological and molecular based analyses. Here, I present an improved molecular phylogenetic analysis based on six genes and additional phoronid specimens that shows better concordance with adult morphology and reproductive traits. Combined with molecular sequences gathered from phoronid larval types, this dataset also sheds new light on phoronid species diversity as well as taxonomic status of some debated species. This ongoing work aims to better assess the validity of larval and adult morphological characters in phoronid systematics, identify several unclassified larval types, and detect cryptic species within adult phoronid morphotypes having seemingly cosmopolitan distributions.

8.3 SANTANA, SE; University of Washington; *ssantana@uw.edu*

Singing through the nose: cranial modularity in nasal−emitting bats

Changes in cranial modularity can evolve rapidly in response to selection, but mammals seem to have maintained a consistent pattern of cranial integration throughout their evolutionary history and across remarkable morphological and ecological diversity. Mammal skulls are composed by a rostral and braincase modules, and their evolution can be related to their primary roles in feeding, housing sensory organs and encasing the brain. However, a few lineages have evolved novel, fitness−relevant, cranial functions that could have resulted in evolutionary changes to this two−module scheme. I investigate if one of these functions, echolocation through nasal emission, is associated with a derived pattern of cranial modularity in a diverse lineage of bats (Rhinolophidae). I use phylogenetic, geometric morphometric and comparative analyses test if a third cranial module, the "nasal dome", has evolved in rhinolophids. I also examine trends in skull shape evolution across the wide geographic range occupied by rhinolophids. The results of this study indicate that, despite broad variation in the shape of the nasal dome, the integration of the rhinolophid skull is still highly consistent with conserved patterns of mammalian modularity. Across their geographic distribution, cranial shape in rhinolophids follows disparate trends in African versus South Asian species, which could reflect specializations to dietary and environmental factors. The results of this study highlight the potential of a relatively simple modular template for generating broad morphological and functional diversity in mammals.

111.5 SANTIAGO BASS, C.; Kaplan University, Ft. Lauderdale; *csantiagobass@kaplan.edu*

High Gill Parasite Abundance and its Effects on Behavior and Morphology of Fundulus heteroclitus

Parasites have been shown to affect various aspects of host functioning including behavior, morphology, growth, fecundity and survival. Although parasite−induced behavioral changes have been described for several parasite−host associations, none have been reported for fish harboring severe trematode infections in the gills. Nor have any studies been done linking morphological changes in the gills of fish to parasite infection. *Fundulus heteroclitus* from several areas of the Hackensack Meadowlands (a degraded brackish marsh system in northeastern NJ) were found to have gills that were highly infected with digenean trematode cysts (*Ascocotyle* sp.) compared to other sites. Significant differences in parasite density and species composition were observed among sites. It was also found that fish from highly infected populations spent significantly more time at the water's surface, exhibited significantly more conspicuous behaviors (e.g., scratching, jerking), and had significantly more gill morphological abnormalities than fish from less parasitized populations.

7.6 SANTINI, F.*; SORENSON, L.; CARNEVALE, G.; Univ. of Torino, Univ. of California, Los Angeles; *francesco.santini@alumni.utoronto.ca*

Origin and evolution of Oceanic pelagic communities

In order to investigate the origin and evolution of communities of large pelagic predators in today's Oceans we generated megaphylogenies for three major fish groups (Scombriformes, Istiophoriformes, Clupeiformes) and dated the molecular trees using the rich fossil record of each of these groups. Together with previously available time−calibrated trees of cetaceans, cephalopods and sharks, these new phylogenies reveal for the first time the pattern of origination and diversification of all the major groups of pelagic inhabitants of the world's major Oceans. Our result show two major bursts of origination and diversification: the first spanning the late Cretaceous/Early Paleogene, in some cases slightly predating the KPg extinction events, and a second one spanning the Late Miocene/Early Pliocene. The first burst of origination and diversification gave origin to many lineages that are currently assigned familial status, while the second episode saw the origin of most of the specific diversity of some of the largest pelagic predators, such as marlins and sailfishes, and tunas. We will discuss what factors may have been responsible for these two separate bursts of diversification in these clades, and how the radiation of these groups led to the present−day diversity of pelagic communities

P1.184 SARAF, S.R.*; KEMPLER, K.E.; DUGGER, D.R.; SPEISER, D.I.; OAKELY, T.H.; WILSON, R.K.; BATTELLE, B−A.; Whitney Lab., Univ. of Florida, Dept. of Ophthalmology, Univ. Florida, Univ. California, Santa Barbara, The Genome Institute, Washington Univ.; *battelle@whitney.ufl.edu*

Opsin expression in the Limulus visual system: Too many opsins?

The horseshoe crab *Limulus polyphemus* is a classic model for studies of vision. It has three types of eyes: lateral, median and larval. Much is known about *Limulus* photoreceptor structure and function; less is known about the opsins the photoreceptors express. Just two spectral types of photoreceptors have been detected in *Limulus* eyes: visible light−sensitive, all with a maximum sensitivity of about 520 nm, and UV−light sensitive. So it was surprising when a preliminary assembly of the *Limulus* genome revealed 12 rhabdomeral opsin sequences, many more opsin genes than there are identified photoreceptor types. The questions arise: Are all of these opsins expressed and where? The expression patterns of four of the opsins (LpOps1, 2, 5 and UVops) are known from previous work. Our current goal was to determine whether and where the newly identified opsins, all predicted visible light−sensitive opsins, are expressed. Several approaches were used: PCR amplification from cDNA confirmed by sequencing, *in situ* hybridization and immunocytochemistry. Two of the opsins, LpOps6 and 7 were detected in a median eye (ME) transcriptome. *In situ* hybridization and immunocytochemical assays confirmed that both are expressed in ME photoreceptors but not in the photoreceptors of lateral or larval eyes. With PCR and sequencing, LpOps8 and 11 were detected in MEs; LpOps11 was also detected in larval eyes, and the central nerve cord; LpOps6, 7, 8, 10 and 11 were detected in the tail. The tail is known to contain extraocular photoreceptors. LpOps9 was not detected in any of the tissues examined so far. Accumulating evidence suggests most *Limulus* photoreceptors express multiple opsins.

57.2 SASSON, DA*; MILLER, CW; University of Florida; *dsasson@ufl.edu*

The environmental and genetic effect on two sexually selected traits in a cactus bug

An organism's genetic make−up and natal environment can play a large role in its morphological, physiological, and behavioral development. However, work examining the role of both genes and the environment on sexually selected traits are rare. In this study, we have explored the effect of the environment, genes, and the gene by environment interactions (GEI) on body and testis size in a cactus bug, *Narnia femorata*. These two traits contribute to male pre and post copulatory reproductive success, respectively. We are interested in three questions: 1) How does the environment affect body and testis size and do males from different environments differentially allocate resources to body and testis size? 2) Are body and testis size heritable and does the environment affect heritability of each trait? 3) Are there GEIs on body and testis size so that families differ in their response to each environment? We investigated these questions using a half−sib split brood design across three ecologically relevant nutritional environments. Results suggest that natal environment greatly affects both testes and body size and that the environment may affect resource allocation decisions . Additionally, significant heritability was only found in the highest quality natal environment. Finally, we found no evidence for GxE interactions in either testes or body size, likely due to the little heritability and low genetic variation for these traits in the low quality environments.

85.4 SAXENA, N.*; NATESAN, D.; SANE, S.P.; National Centre for Biological Sciences, Bangalore, India; *niteshs@ncbs.res.in*

Odor tracking behavior of fruit flies in the presence of landmark cues

Flying insects rely heavily on visual cues for flight. For example, during pheromone tracking, moths are known to utilize surrounding visual patterns to maintain upwind heading. Similarly, fruit flies also require wide−field visual cues to reach the vicinity of the odor source location. Whereas odor cues in combination with far−field visual cues may serve to attract a fly towards the general area of odor source, landmark cues may be important to pinpoint the location of an odor source. Thus, we hypothesized that the presence of multiple landmarks or landmarks that are dissociated from odor sources will elicit a search behavior that is dependent on the distribution of visual objects. We studied the behavior of the fruit flies, *Drosophila melanogaster* as they honed in on the odor source within a wind tunnel. Our results show that in presence of multiple closely−spaced but identical visual cues, flies often make errors in identifying the exact location of the odor source. Moreover, in experiments where the odor cues are dissociated from visual cues, flies are often likely to be attracted to high−contrast visual cues in the vicinity of the odor cues. Thus, these experiments highlight the importance of landmark cues in the odor tracking behavior.

P2.29 SAYRE, JM*; BOYCHUK, EC; SINCLAIR, BJ; DAHLHOFF, EP; RANK, NE; Sonoma State University , University of Western Ontario , Santa Clara University ; *sayrej@seawolf.sonoma.edu*

The effects of thermal history on cold tolerance in a montane leaf beetle

Montane ectotherms are often confronted with dangerously low temperatures, even in summer when individuals are active and completing their cycle of reproduction and development to adulthood. These extremes in temperature may increase in frequency with increased climate variability predicted for the future. We investigated the effect of exposure to stressfully cold temperatures for adults and larvae of the montane beetle *Chrysomela aeneicollis* to test the hypothesis that exposure to cold enhances cold tolerance. These insects live in the Sierra Nevada mountains of eastern California, where they experience sudden cold snaps of subzero temperatures at night, or prolonged cool periods during daytime summer thunderstorms. We evaluated effects of long−term acclimation (LTA, 5 d at 4°C) and rapid cold hardening (RCH, 2 hr at −2°C) on subsequent tolerance to a 2−hr exposure to freezing temperatures (−6°C for adults, −8°C for larvae). Both LTA and RCH enhanced cold tolerance in adults and third−instar larvae. Larger individuals recovered better from cold exposure than smaller ones, and females, being larger, recovered better than males. LTA also lowered freezing temperatures of larvae, but we found no relationship between freezing temperature and cold tolerance. Ongoing studies will determine if genetic differences affect the relationship between thermal history and cold tolerance.

5.5 SCALES, JA; RIVERA, JA; BUTLER, MA*; University of Hawaii; *mbutler@hawaii.edu*

Vision and the adaptive radiation of Hawaii Megalagrion damselflies

Adaptive radiations are the result of exhuberant diversification to the exploitation of new resources, typically food or substrate. Diversification in response to light environment has been little explored, and only implicated in aquatic radiations. We used an adaptive radiation of Hawaiian *Megalagrion* damselflies which vary tremendously in ecology to demonstrate that (i) visual specialization to light can be important in the terrestrial habitat, (ii) regional variation in the eye can be used to fine−tune vision to environmental challenges, and (iii) that visual adaptation can be decoupled from size, giving species access to previously unaccessible "niches". Given that much of the world's biodiversity lives in complex light environments, this work suggests an important mechanism underlying the distribution and diversity of many animals in nature.

69.2 SCALES, J.A.*; BUTLER, M.A.; Univ. of Hawaii, Manoa; *jscales@hawaii.edu*

The relationship between muscle cross−sectional area and locomotor performance in lizards

Locomotor performance is essential to the fitness of many terrestrial vertebrates. Therefore, determining what defines locomotor performance is an integral part of understanding the evolution of morphology, physiology, and behavior of vertebrates. Recent work suggests that the amount of force and the rate at which force is applied to the ground may limit performance, indicating that force production is a key driver of performance abilities. The cross−sectional area (CSA) of a muscle is a significant determinant of peak force production capabilities, suggesting that CSA may influence performance abilities. However, few studies examine how muscle CSA actually impacts performance, especially in a comparative context. Here we examine how the CSA of muscles of the hindlimb are related to acceleration, sprint speed, and exertion in 21 species of lizards. We find that total muscle CSA scales isometrically in these lizards, with increases in both stance and swing phase musculature. Furthermore, speed and acceleration, but not exertion increase with CSA, and the CSA of stance phase muscles better predicts speed and acceleration abilities than swing phase muscles. Fast lizards show increased stance phase CSA, but the distribution of CSA across joints varies, suggesting that there is more than one way to achieve high speeds and acceleration. We conclude that muscle CSA plays an important role in defining some, but not all performance capabilities, and that there may be multiple muscle designs to achieve similar performances.

35.1 SCHACHNER, ER*; CIERI, RL; BUTLER, JP; FARMER, CG; University of Utah, Havard School of Public Health; Harvard Medical School; *eschachner@gmail.com*

Unidirectional airflow in varanids and the evolution of pulmonary airflow patterns in Diapsida

Historically the highly specialized avian lung has been considered unique due to the decoupling of the ventilatory pump and gas exchanging regions, as well as the presence of unidirectional flow through the bronchial tree. These traits are usually associated with their active, volant lifestyle and endothermic metabolism; however, the recent discovery of unidirectional airflow in the lungs of crocodilians suggests that these assumptions are false. Here we demonstrate region−specific patterns of unidirectional airflow in the lungs of three species of *Varanus*: *in vivo* data from *Varanus exanthematicus*, and *ex vivo* data from *V. albigularis* and *V. niloticus*. Pulmonary anatomy was studied using computed tomography of multiple individuals of each taxon, and 3D surface models of the bronchial tree were created in Avizo 7.1. Two distinct regions of unidirectional flow were identified within the varanid lung: intrabronchial flow in a cranial bronchus and interbronchial flow in the more caudal lateral bronchi. As in birds and crocodilians, flow patterns throughout the varanid lung appear to arise from aerodynamic valves as there are no anatomical structures (i.e., flaps or sphincters) maintaining or inducing flow. These data suggest that unidirectional flow is homologous in Archosauria and Varanoidea, and as a result the origin of unidirectional flow is likely far older than the Triassic split between crocodilians and birds. These results also indicate that this trait evolved completely independently from high aerobic activity metabolism or endothermy.

P2.3 SCHAPIRO, D.*; IYENGAR, V.K.; SUMMERS, A.P.; Kalamazoo College, Villanova University, University of Washington; *David.Schapiro10@kzoo.edu*

Goldilocks and the three shells: when the home is just right for the hermit crab Pagurus granosimanus

Hermit crabs rely on gastropod shells for temporary homes, as these shells protect their vulnerable, uncalcified abdomens from predators and competing crabs. Previous studies have shown that a lack of adequate housing significantly reduces growth, reproduction and feeding rates. It is known that hermit crabs use a combination of tactile, visual and chemosensory cues to examine new shells, and preferences are often species specific. Here we used a rapid prototyping technique to explore the morphological preferences of hermit crabs in the absence of any other cues. The hermit crab Pagurus granosimanus was given a binary choice of two shell sizes from one of three gastropod species of very different morphologies. Shells were scaled at 1% intervals and 3−D printed in plaster infiltrated with cyanoacrylate to mimic natural shell material. Live hermit crabs were de−shelled and given a choice between synthetic shells of different sizes. Hermit crabs were able to distinguish a 5% size increase and 9% size decrease in aperture in Oxystele shells when compared with their corresponding natural shells. With Turritella shells, crabs detected a 7% size increase and 10% size decrease, while in Haustellum shells, crabs detected a 6% size increase and 11% size decrease. With all observed preferences, hermit crabs chose their current shell size over enlarged or undersized shells with the exception of Turritella shells, where an oversized shell was preferred. Hermit crabs were capable of detecting a difference of just 789 microns in shell operculum size. There was no clear relationship between hermit crab mass and natural shell mass. This study suggests that tactile cues such as shell aperture size play a much more important role in shell selection than mass and that crabs are capable of very fine distinctions in morphology. Additionally, hermit crabs are more willing to select undersized shells than oversized ones.

77.4 SCHINDLER, AJ*; BAUGH, LR; SHERWOOD, DR; Duke University; *adam.schindler@duke.edu*

Identification of two novel insulin− and hormone−regulated nutritional checkpoints in C. elegans development

Developing organisms in the wild exist in complex environments in which the availability of food varies. When faced with nutritional scarcity, organisms slow or arrest development and undergo physiological adaptations. It is not well understood how organisms sense nutritional scarcity and systemically modify development. To address these questions, we examined the *C. elegans* starvation response during larval development and identify two previously uncharacterized nutritionally regulated checkpoints in the L3 and L4 larval stages. Tissue development arrests at precise times in each larval stage, remains arrested for several days, and resumes upon re−feeding. Two conserved pathways that mediate the L3 and L4 response to starvation are insulin−like signaling and steroid hormone signaling. A FoxO transcription factor, DAF−16, becomes nuclear−localized in response to reduced insulin signaling and is required for the timely response to nutrient withdrawal. It functions at least partly to inhibit steroid hormone secretion that systemically promotes developmental progression. In the absence of *daf−16* or when steroid hormones are overexpressed, animals continue development during starvation, leading to aberrant morphologies and shortened survival. These results demonstrate that *C. elegans* arrest development at precise times in response to starvation and highlight the genetic pathways that link nutritional status with developmental progression. The key pathways of nutritional response are conserved and may reflect an ancestral means of rapidly modifying growth and development in response to changing environmental conditions.

P3.197 SCHMESKI, S.M.*; KLIMA, B.M.; MONZON, R.; KROHMER, R.W.; Saint Xavier University, Chicago, IL; *stephsxudance@gmail.com*

Effect of Sex Steroid Hormones on Spinophilin Production in the Male Checkered Garter Snake Forebrain

Dendritic protrusions, known as dendritic spines, receive much of the incoming excitatory signals from associated contacts with surrounding neurons. Since the numbers of actual dendritic spines/synapses are immense, determining changes in spinophilin, a specific scaffold, cytoskeletal protein that is vital for the proliferation of novel spines, offers a method for quantifying regional changes. In a previous study, male red−sided garter snakes (*Thamnophis sirtalis parietalis*) exhibited neuronal plasticity in response to sex steroid hormones with dendritic spine formation greater under the influence of estrogen compared to testosterone. This study also revealed that red−sided garter snakes exhibited a seasonal/brain−region response in the concentration of dendritic spinophilin. In the current study we examined the role of sex steroid hormones on spinophilin production in the brain of male checkered garter snakes (*Thamnophis marcianus*). We hypothesize that, in the male checkered garter snake, like the red−sided garter snake, estrogens have a greater effect on the regulation of neuronal plasticity in regions critical for the control of reproductive behavior. Using unbiased western immunoblots, we examined regional variations in the concentration of dendritic spinophilin in the brains of male checkered garter snakes that had been implanted with either estrogen or testosterone. Our data indicate spinophilin levels were greater in animals implanted with estrogen compared to testosterone.

125.4 SCHMIDT, KL*; MACDOUGALL−SHACKLETON, EA; SOMA, KK; MACDOUGALL−SHACKLETON, SA; Univ. of Western Ontario, London, Univ. of British Columbia, Vancouver; *kschmi5@uwo.ca*

Programming of the HPA and HPG Axes by Developmental Stress in Song Sparrows

The hypothalamic−pituitary−adrenal (HPA) and hypothalamic−pituitary−gonadal (HPG) axes exhibit a large degree of developmental plasticity and can be permanently affected by early−life stressors. Although these effects have been well documented in mammals, less is known about how early−life stress affects regulation of these endocrine systems in non−mammalian species. We determined the long−term effects of early−life food restriction or corticosterone (CORT) treatment on the HPA axis of song sparrows (Melospiza melodia), including responses to restraint stress, dexamethasone challenge, and ACTH challenge. In addition, we assessed long−term effects on the HPG axis by measuring sex steroid levels (testosterone in males and 17^{2}−estradiol in females) before and after a gonadotropin−releasing hormone (GnRH) challenge. Both males and females treated with CORT during development had larger increases in CORT in response to ACTH challenge than food−restricted or control birds. Neither treatment affected the responses of CORT to restraint or dexamethasone. CORT−treated males also had higher initial testosterone levels, but neither treatment affected testosterone levels post−GnRH. Lastly, although GnRH challenge failed to increase circulating estradiol levels in females, females exposed to food restriction or CORT treatment had lower estradiol levels than control females. Therefore, exposure to early−life stress had opposite effects on gonadal sex steroid production in male and female song sparrows. These results show that exposure to stress can developmentally program the endocrine system of songbirds and illustrate the importance of considering developmental conditions when determining the factors responsible for inter−individual variation in endocrine regulation.

S4.3−3 SCHNEIDER, DS; Stanford University; *dschneider@stanford.edu*

Mapping infections in phase space

We would like predict how sick an individual will get when they suffer an infection. We study this problem using disease tolerance curves at a population level and using disease space to track individuals. Our recent work on measuring and modeling disease tolerance in a Drosophila infection shows that at least one of these curves is sigmoid shaped. This suggests that there is a rate limiting process for death and provides a route to defining physiologies that specifically control resistance and tolerance. To track the progress of individuals through infections, we have been plotting the routes they take through multi−dimensional disease space. This lets us map phase space and define areas of comfort, illness, recovery and danger. This works for situations in which we can follow the progress of an infected animal longitudinally and we will present work suggesting methods for preparing these curves from cross sectional data.

37.2 SCHNEIDER, SQ*; BASTIN, BR; PRUITT, MM; LETCHER, EJ; CHOU, H; Iowa State University; *sqs@iastate.edu*

The ins and outs of beta−catenin mediated binary cell fate specification

In the spiralian annelid *Platynereis dumerilii* each embryonic cell division oriented along the animal−vegetal axis is accompanied by higher nuclear accumulation of beta−catenin in the vegetal−pole daughter cell. As in the distantly related *C. elegans* where the Wnt/beta−catenin pathway is activated after every anterior−posterior oriented cell division, these observed reiterative asymmetries appear to convey lineage specific cell fate decisions. Ectopic activation of beta−catenin in animal−pole daughters causes the animal−pole daughter cell to adopt the fate of its vegetal−pole daughter cell. However, in contrast to the highly derived Wnt/beta−catenin activation mechanism in *C.elegans*, individual components of the Wnt/beta−catenin signal transduction pathways are highly conserved in *Platynereis*. To gain insights into mechanism and contribution of reiterative beta−catenin asymmetries to segregate cell fates in a spiral cleaving embryo and the formation of the annelid body plan, we (1) defined the stereotyped sister cell asymmetries (as observed by different cell sizes, cell cycle times, and beta−catenin activation patterns) in each cell division cycle until the 220 cell stage, (2) deployed a variety of RNA−seq based approaches to identify genes that comprise the reiterative Wnt/beta−catenin activation mechanisms and potential downstream targets in normal and compromised embryos, and (3) mapped the expression of Wnt pathway components (ligands, receptors, intracellular components, potential target genes) into distinct cell lineages. Our analysis provides the first comprehensive view of spatial and temporal inputs and outputs of Wnt signaling into embryos utilizing a spiral−mode of cell divisions to segregate cell fates.

109.4 SCHNITZLER, CE*; SANDERS, SM; PLICKERT, G; SEOIGHE, C; BUSS, L; WOLFSBERG, TG; NICOTRA, M; MULLIKIN, JC; CARTWRIGHT, P; FRANK, U; BAXEVANIS, AD; NHGRI, NIH, University of Kansas, University of Cologne, Germany, National University of Ireland, Galway, Yale University, University of Pittsburgh, NIH Intramural Sequencing Center; *christine.schnitzler@nih.gov*

A Tale of Two Hydractinia Genomes: Comparative Genomics of Two Sister Hydrozoan Species

Hydractinia is a hydrozoan cnidarian that has lost the medusa stage and produces gametes directly from polyps known as gonozooids. *Hydractinia* forms colonies of clonal polyps interconnected through a stolonal mat and, in nature, is typically found on shells inhabited by hermit crabs. Members of the genus *Hydractinia* can regenerate all tissues throughout their lives thanks to the constant turnover of pluripotent stem cells. These animals are also able to distinguish between themselves and other members of their species based on cell−cell contact, a phenomenon called allorecognition. *H. echinata* is amenable to transgenesis and gene knockdown studies. Thus, they show great promise as experimental models. We have sequenced and assembled the genomes of *H. echinata* and its sister species, *H. symbiolongicarpus*. The assemblies are based on a combination of Illumina and Roche 454 GS FLX+ sequencing data at high coverage. We have also assembled the transcriptomes of both species using Illumina sequencing data, as a first step towards comprehensive annotation of these genomes. We are using a comparative genomics approach to assess the gene content of these two genomes and have begun to characterize genes controlling development, the allorecognition complex, and the pluripotency gene regulatory network. With complete, high−quality genomic data, these organisms are now well−positioned for their use in functional studies targeting a wide variety of biological questions.

P2.43 SCHRAM, J.B.*; SCHOENROCK, K.M; AMSLER, M.O.; AMSLER, C.D.; MCCLINTOCK, J.B.; ANGUS, R.A.; Univ. of Alabama at Birmingham; *jbschram@uab.edu*

Testing the waters: Seasonal seawater carbonate chemistry baseline to inform biological ocean acidification experiments on the western Antarctic Peninsula

Marine organisms in the Southern Ocean are faced with comparatively rapid ocean acidification (OA) due to the high solubility of carbon dioxide at low temperature and regional ocean circulation patterns. Moreover, most Antarctic marine invertebrates are weakly calcified making them highly vulnerable to shell dissolution. To date, experimental OA research in Antarctica has relied on setting control and experimental pH levels based on models of global ocean averages. Assessments of ambient pH and other parameters of seawater chemistry in Antarctic seas are few and those studies conducted have been performed in seasonally ice free waters (Ross Sea & Prydz Bay) or over relatively short time periods, under sea−ice during the austral spring/summer (McMurdo Sound). Here we present data collected over a full year for nearshore benthic seawater (pH, total alkalinity, temperature, and calculated carbonate chemistry) along the coast of Anvers Island on the western Antarctic Peninsula (near−shore open water with brief, transient exceptions in winter months). Seawater samples were collected at three sampling frequencies: once daily, twice daily, and weekly. Median seawater pH over the year was 8.08 and relatively stable with the exception of an increase in the austral spring/summer (median 8.21 pH). This seasonal increase in pH is likely the result of both abiotic (melting sea ice) and biotic (phytoplankton bloom) factors. The seawater chemistry established in the present study is important in contextualizing and setting parameters for laboratory OA experiments for marine organisms of the Antarctic Peninsula. Supported by NSF grant ANT−1041022.

P3.73 SCHROEDER, RJ*; POWERS, DR; WETHINGTON, SM; George Fox Univ., Newberg, OR, Hummingbird Monitoring Network, Patagonia, AZ; *rschroeder11@georgefox.edu*

Is the Use of Torpor by Hummingbirds Limited in Landscapes with Warm Nighttime Temperatures?

Hummingbirds are found across landscapes that differ markedly in temperature extremes. If the temperature profile of a landscape requires hummingbirds to function well outside thermoneutral conditions increased thermoregulatory costs might make balancing their daily energy budget difficult. Hummingbirds can use nocturnal torpor to compensate for daily energy shortfalls, but it is unclear if a hypothermic strategy would be useful if landscape temperature profiles include warm nights. To study the use of torpor by hummingbirds in landscapes characterized by warm nighttime temperatures we examined torpor use in broad−billed hummingbirds (*Cynanthus latirostris*) from two landscapes where nocturnal temperatures differed by ~10 °C (Harshaw Creek; HC, ~4−27 °C vs. Sonoita Creek; SC, ~14−32 °C) in SE Arizona. Torpor use was tracked using open−flow respirometry on hummingbirds exposed to natural temperature cycles. Torpor was used by all birds ($n = 7$) at HC, but only 63% of birds ($n = 8$) at SC. SC birds entered torpor later and spent less time in torpor (4.75 h) than HC birds (5.3 h). Generally cooler temperatures at HC may increase daily thermoregulatory costs necessitating torpor use. Further, the HC temperature profile would allow birds to select roosting sites with temperature minimums near minimum tolerated body temperature (~12 °C). Reduced torpor use at SC could be due to lower daytime thermoregulatory costs making use of nocturnal torpor less necessary. Alternatively, higher nighttime temperatures at SC might reduce the energetic benefits of torpor. If the latter is true then predicted patterns of climate change that could raise both daytime and nighttime temperatures might limit the effectiveness of torpor use when energy shortfalls occur.

P1.78 SCHROEDER, R.T.*; LEE, D.V.; Univ. of Nevada, Las Vegas; *schroe95@unlv.nevada.edu*

Seeking muscle−tendon properties in robotic legs: Designing a piezoelectric series−elastic actuator

New actuation technologies are needed for the advancement of robotics and prosthetics. In fact, the disparity between the operating principles of electromagnetic motors (EMMs) and skeletal muscle is well known. For example, biological muscle (BM) functions at low frequencies while achieving peak forces. This behavior, characterized by the force−velocity curve of muscle, shows a direct contradiction to the nature of EMMs, which dictates that they must rotate at high speeds in conjunction with large gear reductions to produce any sizable torques. Because of this fundamental contradiction, as well as other inadequacies (e.g. torque fidelity, torque density), we predict that piezoelectric motors (PEMs) will mimic the functions of BM more effectively. It is known that PEMs exhibit a sort of locked−clutch behavior, which allows them to sustain static positions while wasting little to no energy. This ratcheting effect mimics the cross−bridge cycling, which occurs in a sliding filament. Also, the force−velocity curve of PEMs is similar to that of a BM. However, PEMs have not yet been tested in artificial muscles. Thus, our study investigates PEMs for a design capable of mimicking BM. An experimental prototype has been designed in order to verify the comparative operating principles of both motors. This design consists of an actuator system in which a load wheel is pulled by two artificial tendons (compliant cables) in order to mimic a flexor/extensor coupling in BM. The inherent characteristic of co−contraction allows for a control system capable of biomimetic operation. By comparing the performances of PEMs with EMMs in a biomimetic robotic system, we predict that a clear advantage will be exposed, in favor of the PEMs.

P3.129 SCHULTZHAUS, ZS*; SHAW, BD; JOHNSON, TB; Texas A&M University; *schultzz@neo.tamu.edu*

Evidence for Conserved Roles of Actin and Endocytosis in Filamentous Growth

Filamentous fungi grow chiefly as hyphae, cells characterized by their extreme polarity. In these cells, new membrane and cell wall material is deposited primarily at the cell tip. Members of some fungal phyla are marked by a collection of vesicles oriented at the tip called the Spitzenkörper that directs growth, but to date no subcellular structure or process has been identified that is required for the maintenance of this distinct type of cellular polarity across all tip−growing organisms. Here, we recount the evidence for the role of a subapical zone of endocytosis in hyphal growth. Additionally, we document the presence of endocytosis in three basal fungi,show that it is likely mediated by actin, providing evidence for an evolutionarily conserved relationship between endocytosis and filamentous growth.

P3.48 SCHULTZHAUS, JN*; MOEHLMAN, AT; CARNEY, GE; Texas A&M University; *jschultzhaus@bio.tamu.edu*

The role of fit in Drosophila melanogaster starvation response, eating behavior, and lipid storage

female specific independent of transformer (*fit*) expression increases in *D. melanogaster* courting males and in both sexes after mating. In contrast, *fit* expression decreases during starvation in males and females. *fit* expression is enriched in the fat body, an insect tissue that is analogous to vertebrate fat. The fat body stores excess nutrients that are mobilized during starvation. This information led us to investigate how *fit* mutants respond to starvation. We found that both *fit* mutant males and females are starvation resistant, a phenotype that is reversed in males by *fit* expression in the fat body. *fit* mutants may be starvation resistant because they consume more food than controls prior to starvation. To test this, we monitored the total amount of food consumed from eclosion until starvation using the CAFE assay. Another possible explanation for starvation resistance is either increased storage before or slower use of lipids in the fat body during starvation. We used Nile Red and Oil Red O to stain lipids in the fat bodies of fed *fit* mutants and controls to examine whether the absence of *fit* leads to altered lipid storage. We also examined the fat bodies of *fit* mutants and controls throughout starvation to determine when lipid stores are depleted.

P1.60 SCHULZ, H.M.*; PITTS, N.L.; MYKLES, D.L.; Colorado State University ; *hmschulz@rams.colostate.edu*

Understanding hormone release by analyzing gene expression in the eyestalk throughout the molt cycle of the green crab, Carcinus maenas

In decapod crustaceans, molting is regulated by the release of MIH from the X−organ/sinus gland (XO/SG) complex in the eyestalk ganglia (ESG). Neuropeptide synthesis occurs in the XO and includes the production of crustacean hyperglycemic hormone (CHH), as well as a molt−inhibiting hormone (MIH). CHH is a neuropeptide that is important in the regulation of various physiological functions including hyperglycemic action and other metabolic functions. MIH negatively regulates molting by inhibiting the Y−organ or molting gland. We hypothesize that the signaling molecule nitric oxide (NO) is involved in the secretion of neuropeptides from the SG. NO is synthesized by NO synthase (NOS) by catalyzing the conversion of L−arginine to L−citrulline. NO binds to a receptor guanylyl cyclase (GC−I²). Previous work showed that MIH and CHH mRNA levels are the same in the XO from intermolt (stage C_4) and premolt (stage D_2) animals. This suggests that control of neuropeptide release from the SG is posttransciptional. We hypothesize that NO acts as a neuromodulator by suppressing synaptic vesicle binding to the cell membrane, thus reducing neuropeptide release from the SG. The decrease in MIH stimulates molting. The purpose of this study is to examine whether NO is involved in the release of MIH and CHH from the SG. qPCR is utilized to quantify the expression of MIH, CHH, NOS, and GC−I² throughout the molt cycle in the ESG. Primers were designed to reduce dimerization and secondary structure formation. RNA was purified from ESG harvested from animals at intermolt, premolt, and postmolt stages. Cm−EF2 endpoint PCR was used to evaluate the cDNA. The experiments are currently in progress and the results will be reported. Supported by NSF (IOS−1257732).

P2.74 SCHUMACHER, MS; Illinois State University; *mkschum@ilstu.edu*
Fitness conflict between vector and parasite: an investigation of fecundity and survivorship in parasitized Aedes aegypti
Evolutionary considerations predict that vector−borne parasites have less effect on vector fitness than on the fitness of the vertebrate host, because reduced vector fitness would likely result in a reduction in the parasites' fitness. This prediction has led to the misconception that vector borne pathogens have no fitness effect on the vector. However, it is also true that parasites exploit their vectors, growing, developing, and sometimes replicating in the vector. Thus, the vector must remain healthy and live long enough to transmit the pathogen to a vertebrate host despite pathogen exploitation; however, vector fecundity is not essential for the parasite to survive or to be transmitted. If exploitation of the vector by the pathogen is energetically costly to the vector, vector fecundity may be reduced. Conversely, a parasite might manipulate vector fecundity by accelerating egg production to stimulate oviposition, which would in turn cause the vector to seek a blood−meal more frequently compared to non−infected females, thus enhancing probability of parasite transmission. *Brugia* spp. are blood−dwelling, filarial nematode parasites that are vectored by mosquitoes in the genera *Aedes* and *Culex*, and are the primary causes of lymphatic filariasis in mammals. Detrimental effects of *Brugia* on vector fitness, including fecundity and longevity of female mosquitoes were tested for a relationship to *Brugia* titer in the blood meal. The results illustrate the fitness conflict between vector and parasite, which arises because the parasite must exploit the vector to be transmitted successfully. The outcome of this conflict may be important to our understanding of vector−borne disease dynamics.

P3.187 SCHUMAN, B.*; DUCLOS, L.; LOVETT, J.; MCPHERSON, D.; SUNY Geneseo; *mcpherso@geneseo.edu*
Foot muscle of the sea slug Aplysia californica expresses a 5−HT2 serotonin receptor
Serotonin (5−HT) has strong modulatory effects on foot and body−wall muscle in the opisthobranch slug *Aplysia*. These effects include increased force of muscle contraction and increased rate of muscle relaxation. At the cellular level, 5−HT causes a dose−dependent increase in the cyclic adenosine monophosphate (cAMP) content of foot muscle. Our laboratory has previously isolated and cloned from *Aplysia* foot a 5−HT receptor belonging to the 5−HT_7 family, which stimulates adenylyl cyclase and could account for the increase in cAMP. More recently, a 5−HT_2 receptor has been cloned from sensory neurons in the CNS of *Aplysia* (Nagakura et al., 2010). Using the information from that receptor sequence, we have discovered that foot muscle in *Aplysia* also expresses a 5−HT_2 receptor. We are presently at work to clone the complete mRNA for this receptor, to determine whether it is identical to the one previously described. It is possible that 5−HT_2 and 5−HT_7 receptors act synergistically in the serotonergic modulation of muscle function.

118.2 SCHUMER, M; CUI, R*; POWELL, D; ROSENTHAL, G; ANDOLFATTO, P; Princeton University, Texas A&M University; *melop@tamu.edu*
The genetic architecture of reproductive isolation between naturally hybridizing species
Maintenance of species boundaries upon secondary contact is crucial to the speciation process. The Bateson−Dobzhansky−Muller model posits that epistatic effects between genomic loci inherited from different ancestries may prevent gene−flow by reducing hybrid fitness. Wild hybrid zones serve as good models for looking into BDM incompatibility. However, population genetic histories, such as bottlenecks and genetic drift, could confound the effect of selection and produce false positive linkage disequilibrium between unlinked loci. We identify genome−wide patterns of BDM incompatibility in two independent *Xiphophorus birchmanni* x *X. malinche* natural hybrid zones using a novel application of the Multiplexed Shotgun Genotyping (MSG) technique. Simulations show that using consensus LD information from two heterogeneous hybrid populations effectively reduces false−positive associations. We found numerous (~150), narrow unlinked genomic regions in LD. The majority of these LD pairs are enriched for conspecific ancestry, supporting the BDM model.

71.4 SCHUMER, ME*; WANG, S; CUMMINGS, ME; Princeton University, University of Texas at Austin; *schumer@princeton.edu*
Influences of mate preference behavior on patterns of brain gene expression in the sailfin molly Poecilia latipinna
Selection of a mate is one of the most important behavioral processes in an organism's lifecycle, however we understand little about the proximate mechanisms which underlie this process. In this experiment, we examine the molecular mechanisms associated with mate preference behavior in the sailfin molly Poecilia latipinna. Using an RNA−seq based approach we examine the effects of male exposure, social exposure, and preference behavior on brain gene expression. We analyze and discuss our findings in the context of research in other poeciliid fish which suggest that neural plasticity and learning play a major role in mate preference behavior, regardless of mating system.

104.1 SCHUNK, C.*; MICHAELSON, K.; PAINE, T.; SWARTZ, S. M.; BREUER, K. S.; Brown University; *cosima_schunk@brown.edu*
The effect of aspect ratio on the generation of lift and drag of bat−like flapping wings
Aspect ratio is frequently used to describe variation among the large diversity of bat wing shapes. Bats with high aspect ratio wings are expected to fly with high efficiency and to have superior lift−to−drag ratios. In contrast, bats with lower aspect ratio wings are thought to exhibit higher maneuverability. However, those assumptions often derive from theoretical models based on fixed wing aerodynamics. To examine the performance of highly compliant wings with different aspect ratios in flapping flight, we built several wings with different aspect ratios which, though simplified in shape, preserve many important features of bat wings such as a sharp leading edge of the propatagium, skeletal reinforcement of a compliant membrane and bat−relevant ratios of plagiopatagium to dactylopatagium. A two−degree−of−freedom shoulder joint allows for independent control of flapping amplitude and wing sweep to mimic the flapping motion of bats. We have measured the lift and drag forces generated by these bio−inspired mechanical wings flapping at frequencies that range from 2 to 10 Hz.

76.5 SCHWAGER, EE*; MENG, Y; EXTAVOUR, CG; Harvard University; *eschwager@oeb.harvard.edu*
vasa is required for mitotic integrity in early embryogenesis but not germ line specification in the spider Parasteatoda tepidariorum
Studies in vertebrate and invertebrate model organisms on the molecular basis of germ cell specification have revealed that metazoans can specify their germ line either early in development by maternally transmitted cytoplasmic factors (inheritance), or later in development by signaling factors from neighboring tissues (induction). The arthropods are the most speciose animal phylum, and are one of the phyla whose members appear to exhibit both induction and inheritance modes of germ line specification. However, to date there have been no functional studies of conserved germ line genes in species of the most basally branching arthropod clade, the chelicerates (which includes spiders, scorpions, and horseshoe crabs). Here we present the first such study by using molecular and functional tools to examine germ line development in the common house spider *Parasteatoda tepidariorum*. We used transcript and protein expression patterns of the conserved germ line marker genes *vasa* and *piwi* to show that primordial germ cells (PGCs) in the spider arise during late embryogenesis. Neither *Pt−vasa* nor *Pt−piwi* gene products are localized asymmetrically to any embryonic region before PGCs emerge as paired segmental clusters in opisthosomal segments 2−6 at late germ band stages. Functional studies of the role of *Pt−vasa* revealed that zygotic knockdowns of *Pt−vasa* did not prevent PGC formation. However, *Pt−vasa* is required maternally for egg laying, mitotic progression in early embryos, and embryonic survival. Our results thus provide evidence for a previously hypothesized conserved role for *Pt−vasa* in cell cycle progression.

P1.182 SCHWALBE, M.A.B*; SEVEY, B.J.; WEBB, J.F.; University of Rhode Island; *mbergstrom@my.uri.edu*
Conditioned behavioral responses to artificial water flows by the lateral line system in a cichlid fish
The peacock cichlid, *Aulonocara stuartgranti*, uses its lateral line system to detect hydrodynamic stimuli generated by benthic prey. A novel apparatus was designed to deliver artificial water flows emanating from tubes in the substrate, thus mimicking the flows generated by the benthic prey on which they feed in Lake Malawi. Fish did not demonstrate a clear unconditioned response to these flows, so a positive reinforcement protocol (food pellet reward) was used to train four adult fish to respond to two different types of flow (Type I − "pulsed," Type II − "dampened") at several flow rates, which were visualized and quantified using DPIV. Trained fish demonstrated a range of behaviors when responding to artificial flows. Responses of e3 s were defined and ranked by type (hover, shift, or search), and whether or not the fish bit at the tube (which was an unconditioned behavior). A hover with bite was considered to be the most intense behavior. *Aulonocara* learned to seek out artificial flows and detected both Type I and II flows at all rates presented (~1−47 mm/s); the behavioral threshold was below the minimum flow rate that could be generated with the apparatus. The types of behavioral responses varied with flow type − most fish responded to Type I flows by hovering with its lower jaw directly over the flow and bit at the tube, and most fish responded to Type II flows by hovering without bites. This study demonstrated for the first time that teleost fishes can be trained to respond to biologically relevant artificial water flows coming from the benthos, and can distinguish between flows with different hydrodynamic structures. Supported by NSF grant IOS−0843307 to JFW.

97.1 SCHWALBE, MAB*; WEBB, JF; University of Rhode Island; *mbergstrom@my.uri.edu*
Artificial vs. natural stimuli: How conditioned responses to artificial water flows reveal the sensory basis for prey detection in a cichlid fish
Using natural stimuli to investigate behaviors mediated by the lateral line system (LL) is ideal, but artificial water flows are repeatable and quantifiable and thus more amenable for analysis. Lab experiments demonstrated that the peacock cichlid, *Aulonocara stuartgranti*, uses its LL to detect flows generated by benthic invertebrates, but behavioral studies have been confounded by visual cues generated by live prey. Thus, a novel apparatus was designed to generate flows emanating from the substrate, thus mimicking natural benthic prey, so that LL−mediated prey detection behavior could be analyzed in the absence of other sensory stimuli. Five fish were trained to respond to an artificial flow (Type I −"pulsed"; ~3 mm/s) and then fish were treated with cobalt chloride to temporarily ablate the LL. Fish participated in behavioral trials, in which tubes with and without flow were presented in pairs, in the two days before, the day of, and daily up to 21 days post−treatment to track the loss and subsequent recovery of flow sensing behavior. Fish lost the ability to identify flows on the day of treatment, the number of positive responses to flow returned to pre−treatment levels by Day 3, and the intensity of responses recovered by Day 7. Other fishes similarly treated with cobalt chloride were stained with 4−Di−2−ASP either on day of treatment or later, up to 9 days post−treatment, demonstrated dramatic changes in fluorescence indicating the loss and return of functional hair cells, which followed the same time course as the recovery of flow sensing behavior. This is the first study to use an artificial water flow stimulus to investigate the role of the LL in a benthic feeding teleost. Supported by NSF grant IOS−0843307 to JFW.

90.2 SCHWARTZ, TS*; MCGAUGH, S; BRONIKOWSKI, AM; University of Alabama at Birmingham, Washington University, Iowa State University; *tschwartz@uab.edu*

Gene expression and genetic variation in the heat stress response of garter snake life−history ecotypes

The emerging field of conservation physiology requires experimental data to address critical questions on the mechanistic basis for an organism's ability to persist in a habitat. For example, what molecular networks are activated under physiological stress and what traits are affected by those networks? Also, to what extent does plasticity in these molecular networks allow for physiological acclimation to a changing environment? To what extent is there genetic variation in the genes involved in the response? Because both the mean and variance of environmental temperature are predicted to change across large landscapes, and because temperature has a strong influence on molecular reactions thereby modulating the degree to which organisms can respond to changing thermal conditions, the focus of our experimental work is on transcriptomic responses to temperature. Here, we present a large−scale transcriptome study of heat stress in a poikilothermic reptile − the garter snake, *Thamnophis elegans*. Our study populations have been models of ecological and evolutionary genetics for the past quarter century. We bring this long−term understanding of a natural ecological system to bear on the questions of how animals respond to physiological stress. We characterize the plastic responses of liver transcriptomes to heat stress using Illumina RNAseq, and identify molecular networks or pathways that are affected. We investigate those pathways further for genetic variation within and across populations.

P1.86 SCHWARTZ, TS*; ALLISON, DB; GOHLKE, J; University of Alabama at Birmingham; *tschwartz@uab.edu*

Preliminary assessment of fluctuating temperature on epigenetic modification and life history traits in Daphnia

Most animals have evolved in fluctuating environments, such as daily thermal fluctuations or seasonal food availability. These fluctuations are expected to activate molecular networks differently compared to constant environments. One component of these molecular networks is epigenetic modifications of the genome, which may regulate gene expression and ultimately have an effect on physiological processes. These modifications can be transient, life−long, and/or transgenerational such that they persist into subsequent generations. Depending upon the persistence of these modifications, pleiotropic traits dependent on the same molecular networks may also be affected, such as lifespan and reproduction. The evolution of a trait can vary dramatically if its variation is due to variation in the DNA sequence − as assumed in population genetic models − or due to transient, transgenerational, or inherited epigenetic modifications. Here we present preliminary data on the effect of thermal fluctuations on life history traits, metabolic rate, and epigenetic modifications using the water flea, *Daphnia pulex*. Furthermore, we describe ongoing tests for transgenerational affects of the gestational and the pre−gestational thermal environment on these traits. We discuss the implications of these findings in an evolutionary and life history context.

116.1 SCHWEITZER, A.M.*; PERKINS, S.L.; CARNAVAL, A.C.; The Graduate Center, CUNY, The American Museum of Natural History, The City College of New York; *amandaschweitzer5@gmail.com*

Host−symbiont dynamics in the Atlantic Forest hotspot

To better understand the effects of long−term climatic changes on spatial patterns of biodiversity, we examine the host−symbiont dynamics of skin bacteria from widely distributed frogs in the Brazilian Atlantic Forest, targeting species used in phylogeographic studies such as *Hypsiboas faber*, *H. semilineatus*, and *H. albomarginatus*. Studies indicate the northern forest lowlands served as large biodiversity refugia to populations of these species during the Last Glacial Maximum while the mostly unsuitable southern lowlands have only been recently recolonized. Phylogeographic data suggests the targeted host species have tracked these changes. We aim to determine if the same historical climatic events have significantly impacted an individual host's ectosymbiont composition and evaluate whether historical climatic stability can shape contemporary diversity patterns by mediating biotic interactions. To achieve this, we have collected and analyzed bacterial swabs and host DNA samples from breeding ponds across multiple elevations and latitudes in the Atlantic Forest. Collected hosts were swabbed, washed with distilled water to remove transient bacteria, and swabbed again to determine which bacteria have colonized the skin. Swabs were used in DNA cloning and next−generation sequencing to sufficiently sample the microbiome. Symbiont DNA sequence data, generated through conserved 16S primers, are used to test the following hypotheses: i) bacterial alpha diversity is higher in the climatically stable areas and lower in the historically unstable areas; ii) host specificity is higher in areas of stability and lower in areas of instability; iii) symbiont beta diversity is higher in the climatically stable areas and lower in the unstable areas.

P1.79 SCIBELLI, A.E.*; MULCAHY, S.L.; KRANS, J.L.; Western New England University; *scibelli.a@gmail.com*

Development and implementation of a nano−Newton ergometer for examining fight or flight modulation of power output in D. melanogaster

The biogenic amines octopamine and tyramine are an established model for investigating fight or flight physiology amongst arthropods (Roeder, 2005). The augmentation of force by octopamine in the small longitudinal muscle fibers of *D. melanogaster* larvae was recently demonstrated (Ormerod et al., 2013). The action of tyramine, although statistically attenuating contractile forces at high dose, was much smaller than octopamine's contribution. Here we set out to examine the physiological relevance of modulation by these two biogenic amines via oscillation of muscle length comparable to that observed during larval locomotion. We describe the change in work loops achieved during amine modulation. A custom, highly sensitive ergometer and force transducer were created specifically for this project and their development is also considered. We report here the profound action of these amines upon potential contractile power using two main experimental manipulations: (a) amine dose / concentration, (b) stimulus frequency. Based upon Nishikawa's recent hypothesis of the "winding filament theory", we believe that higher rates of stimulation or the presence of octopamine will increase the winding of the titin−like, giant sarcomere associated proteins (Nishikawa et al., 2012)(gSAPs). We have engaged this characterization of wildtype tissue in order to compare it to tissue with knocked down titin / gSAP expression (via novel mutations of the *D. melanogaster* genome).

P1.35 SCRIBER, KE; MCCLINTOCK, JB*; AMSLER, CD; Univ. of Alabama at Birmingham; *mcclinto@uab.edu*

Feeding preferences of a freshwater amphipod for aquatic vascular plants and macroalgae

Many factors influence the palatability and feeding preferences of predators for their prey. The present study tested the null hypothesis that the common freshwater amphipod *Hyallela azteca* presented three species of vascular plants and two species of filamentous algae displayed feeding rates indicative of no differences in prey palatability. Differences in prey palatability were found and pairwise−choice feeding assays were conducted and preferences for particular foods established. Subsequent feeding bioassays using standard techniques demonstrated that tissues of the vascular plant *Vallisneria americana* were chemically defended against amphipod grazing, and that extracts from this vascular plant could inhibit feeding by amphipods on other species of vascular plants and algae. Tissue toughness, measured by penetrometry, indicated all three vascular plants likely rely on structural defense. There was no correlation between nutritional value (protein content) and prey palatability or preference for a given prey. The findings of this study emphasize the importance of the direct contribution of vascular plants and algae to freshwater food chains, an important topic in freshwater benthic ecology that has been largely overlooked.

102.4 SEARS, MW*; LEVY, O; ANGILLETTA, MJ; Clemson Univ., Arizona St. Univ.; *sears3@clemson.edu*

Fractal dimension of landscape features drives activity of terrestrial ectotherms

Understanding the ecological responses to global climate change represents one of the greatest challenges of the 21st century. To forecast these responses, we must develop computer−intensive models that leverage detailed climatic and biological data to predict the future distributions of species. Current approaches to ecological forecasting have focused on driving factors of geographic distributions such as climate, topography, and land use. In particular, mechanistic models have successfully integrated principles of biophysical ecology with GIS. While this approach is quite powerful, integrating behavior and physiology to predict the potential for organismal activities a central component of many mechanistic models remains challenging. The problem is worsened by the mismatch between the scales on which these models consider climate and geography versus the scale at which organisms experience environmental heterogeneity. Here, we extend a framework that explicitly incorporates fine−scale processes to predict the activity, dispersal, and energetics of animals. Initial findings suggest that either increased elevational relief or increased fractal dimension of a landscape will increase the potential duration of activity. To examine the robustness of this result, we generated randomly configured landscapes that differ in elevational range, percent vegetation, and the fractal dimensions of elevation and vegetation. With these artificial landscapes, we will use an individual−based model to predict spatial and temporal patterns of activity, not just the potential for activity. We will then examine whether these factors can be used to correct estimates of activity on a flat surface that can then be applied to mechanistic models of species' distributions.

95.6 SEDDON, R. J.*; HEWS, D. K.; Indiana State University; *rseddon@sycamores.indstate.edu*

Behavioral and hematological changes in relation to melanization in western fence lizard, Sceloporus occidentalis

A growing area of behavioral ecology examines how mechanisms underlying production of animal coloration can affect traits other than body coloration. Melanin, and molecules that regulate melanin, can directly and indirectly affect other phenotypic traits such as aggression or the immune system. Such associations have been studied mainly in birds and mammals, and potential correlates of differences in melanization in reptiles are less well studied. As a first step in examining an elevational gradient in melanization in a lizard, we studied adult males in one high− and one low−elevation population of the western fence lizard, *Sceloporus occidentalis*. This previously−characterized elevational gradient exhibits increasingly darker−bodied and larger adults at higher elevations. To compare the two populations, we measured agonistic behaviors of males in response to standardized staged territorial intrusions (STIs) during the breeding season (early June 2013, low elevation population; later June 2013, high elevation population) along the Merced River and in Yosemite National Park. We also asked whether there were morphological, hematological, and hormonal differences associated with elevation. Principle−components analysis on behavioral responses to the STIs revealed that darker (higher−elevation) males were more aggressive than males in the lighter population. Males of the darker population had higher mite loads, but did not differ significantly in the white blood cell measures (e.g., heterophil: lymphocyte ratio). We currently are assaying plasma testosterone and corticosterone, and will determine if population differences in the traits examined are associated with difference in plasma levels of these steroid hormones.

P3.138 SEDLAK, KA*; GERALD, GW; Nebraska Wesleyan University; *ksedlak@nebrwesleyan.edu*

Limb mechanics and locomotor performance during different modes of locomotion in long−limbed and short−limbed lizards

Limb reduction exhibited by many species of lizards is a relatively common phenomenon found in a number of lizard lineages. This trend seems contradictory because limbs are, intuitively, necessary for efficient locomotion in most terrestrial vertebrates. However, it has been hypothesized that smaller limbs, along with more elongated bodies, might be more advantageous for movement in some locomotor situations (such as moving underground and in water). Despite this, no study, to our knowledge, has closely examined the influence of limb length on locomotor performance and kinematics during different modes of locomotion. We quantified the relationship between limb length and various performance and kinematic variables in a short−limbed lizard (*Riopa fernandi*) and a long−limbed lizard (*Leiolepis belliana*) species during running, burrowing, and swimming. We found no influence of limb length on running speed or running kinematic variables. However, limb length was significantly related to burrowing with lizards with relatively smaller limbs exhibiting faster speeds and less interrupted stride cycles and reduced stride frequencies. Owing to the observation that the species used in this study swim very differently, limb length was positively related to swim speed in the long−limbed species only. This study provides important data on how limb length during movement in certain locomotor situations could influence selection for smaller limbs in the lineages that led to the evolution of limb−reduced lizards and snakes.

P1.181 SEEN, C/M*; ADENUGA, E/T; SHIELDS, V/D/C; Baltimore City Community College, Towson University; *cseen1@students.towson.edu*

Olfactory Repellents Acting As Aversive Feeding Deterrents in Gypsy Moth Larvae

Repellents are widely used to limit interactions between arthropod disease vectors and their animal hosts. Olfactory repellents, such as DEET, an effective repellent against mosquitoes, are thought to exert their effects by modulating the responses of olfactory receptor neurons (ORNs). DEET may act by directly stimulating the responses of the ORNs or by modifying their responses resulting in behavioral disruption. Recent studies in our laboratory have demonstrated that DEET elicited responses from gustatory receptor neurons (GRNs) sensitive to feeding deterrents in gypsy moth larvae, *Lymantria dispar*. Here, we show that DEET, as well as some other known olfactory repellents suppress feeding behavioral responses in gypsy moth larvae. This indicates that the gustatory system of these larvae, in addition to possibly the olfactory system, is capable of responding to these compounds. This research provides a basis for studies aimed at the discovery of additional novel compounds with repellent activity and a better understanding of the gustatory system of these larvae.

P1.110 SELLERS, K.C.*; MILLER−PHILLIPS, C.M.; SCHMIEGELOW, A.B.; DAVIS, J.L.; HOLLIDAY, C.M.; Univ. of Missouri, Xavier Univ., Univ. of Massachusetts Amherst; *kcsty5@mail.missouri.edu*

A Three−Dimensional Model of Bite Force in Alligator mississippiensis.

Bite force is an important character in analyses of the ecology of an organism. Higher bite forces allow organisms to process more resistant food items, giving them access to a wider variety of foods and niches. Although researchers can experimentally measure bite forces of living animals, the bite forces of extinct ones must be estimated. Despite a variety of different methods available for estimating bite forces, few models are validated with *in vivo* data. Validated modeling methods are particularly important for investigations of bite force and feeding function in fossil taxa as a means of increasing inferential accuracy. Here we test the accuracy of modeled bite forces of an ontogenetic series of American alligators (*Alligator mississippiensis*). Jaw muscles were digitally mapped using Strand7 software, and muscle resultants and bite forces were calculated using the Boneload program. Using areas of muscle attachment, muscle length, and modeled physiological parameters, we calculated the force exerted by each individual muscle, then used geometric relationships to sum each muscle force to yield total bite force at particular bite points. We then compared our calculated bite force values to measured values from animals of comparable sizes reported in the literature. Modeled bite forces were found to underestimate *in vivo* recordings from individuals of similar sizes. Likely reasons for this underestimation include anatomical details lost in the modeling process and current challenges with accurately wrapping muscles around bones. Increasingly accurate modeling techniques will enrich investigations into the role of bite force in ecology.

9.2 SENNER, N.R.*; VERHOEVEN, M; ZWART, L; TIBBITTS, T.L.; GUTIéRREZ, J; ABAD, J.M.; PIERSMA, T; University of Groningen, USGS−Alaska Science Center, NIOZ, Universidad de Extremadura; *n.r.senner@rug.nl*

When Siberia Comes to The Netherlands: The Response of Continental Black−tailed Godwits to Extreme Spring Weather

Many migratory bird species are able to anticipate weather conditions along their migration routes and adjust their progress and behavior accordingly, but there are numerous instances of extreme weather events surprising birds mid−migration. These occurrences can act as strong selection events and even affect population dynamics. Global climate change is predicted to increase the frequency of extreme weather events and lower the predictability of longer−term conditions. As such, migratory birds may increasingly face adverse conditions during inherently stressful periods of their annual cycle. In March 2013, Western Europe experienced a severe snowstorm that preceded a prolonged period of record low temperatures, coinciding with the northward migration and pre−breeding period of Continental Black−tailed Godwits, *Limosa limosa limosa*. We documented the response of Continental godwits breeding in The Netherlands to these conditions using a combination of tracking devices, foraging observations, measurements of food availability, resighting color−marked individuals, and quantifying godwit aggregations in the region and compared these measures with data from our long−term study of this population. We found that different individuals used different response mechanisms including stalling migration, reversing migration, using novel habitats and sites, and increasing foraging effort to survive the period. Despite these energetically costly responses, we subsequently found that both breeding propensity and success were high, suggesting that godwits have significant behavioral plasticity to respond to environmental stochasticity.

31.1 SERB, J.M.*; KRAUSE−PORATH, A.J.; PAIRETT, A.N.; Iowa State Univ.; *serb@iastate.edu*

Uncovering patterns underlying the molecular evolution of non−visual photoreception in molluscs

Photosensitivity of the dermis or extraocular photoreception (EOP) is widespread in animals. It has been suggested that this non−visual photoreception is the first step towards differentiated photoreceptive elements and, in some lineages, lead to the organization of these units into eyes capable of spatial vision. However, the data to support this evolutionary hypothesis is lacking. Often, the phototransduction pathway differs between dermal and ocular organs or the EOP mechanism varies between closely related taxa. This suggests that EOP does not result from a single ancestral condition, but may have polyphyletic origins. To examine this hypothesis, we compared photoreceptive systems from molluscan lineages and new phototransduction genes sequences from tissue−specific transcriptomes of the bivalve scallop (Pectinidae). We identified 10 opsin−like genes from these transcriptomes. We confirmed that a novel opsin is involved in scallop EOP by in situ hybridization. Amino acid comparison of EOP− and eye−specific opsins finds only 55% sequence identity despite being the same opsin type. These opsins also differ in secondary structure, ligand−binding site predictions, and tertiary structure models. To test the hypothesis that a gene duplication event resulted in tissue−specific functional divergence of scallop opsins, we compared all available molluscan opsins under a phylogenetic framework, which identified a gene duplication event leading to separate non−visual and spatial vision function in bivalves. From these data, we conclude that EOP has evolved multiple times across Mollusca. We hypothesize that EOP, like the eye, is an evolutionarily flexible system and has evolved though various molecular processes including co−option, gene sharing, and subfunctionalization of phototransduction pathway members.

6.5 SERRANO, MM*; SHARPE, SS; KUCKUK, R; GOLDMAN, DI; VELA, PA; Georgia Institute of Technology; *mserrano6@gatech.edu*

High Performance Tracker for Subsurface Locomotive Studies

Studying the sub−surface locomotive strategies of burrowing animals through x−ray imaging presents several challenges to automated imaging−based tracking systems. These include a low signal−to−noise ratio, spatially variable imaging statistics arising from heterogeneity in the granular media, and imaging sensor noise. Markers are typically used to compensate for the first issue, however the benefits of markers are often nullified through the latter two issues. Additionally, as it is desirable to impede the subjects as little as possible, the markers are purposefully set flush to the subject's tissue; thus the marker will vanish when aligned normal to the imaging device. Unlike existing methods that require unique correspondences between markers in subsequent images, the method described here can handle false positive marker detections arising from the noise inherent to x−ray imaging. A Bayesian approach to trajectory estimation using linear models with Gaussian noise leads to a combined Kuhn−Munkres algorithm and Kalman filtering formulation. Coupled with a b−spline model for the subject, the system is able to handle image artifacts and unobservable markers while still capturing a wide range of motions. To validate our system's robustness, a simulated sandfish (*Scincus scincus*) is tracked in an environment where the noise levels and the relative contrast are varied. We find that the tracker is able to perform under the majority of these conditions and also present challenging cases. Additional performance evaluations are made on pre−annotated videos of subsurface undulating sandfish and shovel−nose snakes (*Chionactis occipitalis*) and of the slow−intermittent burying ocellated skinks (*Chalcides ocellatus*) in granular media.

S8.1−2 SERRATO−CAPUCHINA, G.A.; PFENNIG, D.W.*; Univ. of North Carolina, Chapel Hill; *dpfennig@unc.edu*

The role of pre−existing plasticity in adaptive evolution

In order for adaptive evolution to occur, phenotypic variation must be present on which selection can act. Yet, relatively little is known about the source(s) of phenotypic variation or whether different sources affect adaptive evolution's tempo and mode. Here, we review cases studies of natural populations to infer whether adaptive evolution came about strictly through genetically canalized change (i.e., change that reflects allelic or genotype frequency changes and that is relatively insensitive to the environment) or whether, alternatively, it may have arisen through phenotypic plasticity. Although the former is generally presumed to be the sole mediator of adaptive evolution, increasing evidence suggests that plasticity can promote adaptive evolution under certain circumstances, such as when reaction norms become a target of selection. We also consider how these two mechanisms can impact adaptive evolution's speed. As we describe, phenotypic plasticity can promote rapid evolution, thereby increasing the chances that a population will adapt to changing environmental circumstances and persist. Finally, we consider how these two proximate mechanisms interact and affect adaptive evolution's mode. In particular, because environmentally contingent phenotypes can lose their plasticity over evolutionary time, new traits that initially arise through phenotypic plasticity may eventually become genetically canalized. Indeed, adaptive evolution may proceed through an initial phase in which new traits are environmentally induced to a later phase in which these traits are expressed constitutively. In our review, we draw on cases studies of the proximate causes and evolutionary consequences of phenotypic plasticity, especially in the context of competitor− and predator−mediated selection, where rapid responses are often vital.

80.7 SETH, D; TANGORRA, J*; FLAMMANG, B.E.; LAUDER, G.V.; Drexel University, Philadelphia, PA, Harvard University, Cambridge, MA, Harvard University, Cambridge, MA; *tangorra@coe.drexel.edu*

Active modulation of bluegill sunfish tail compliance

The goal of the study is to understand the active changes in the mechanical compliance of the bluegill sunfish (*Lepomis macrochirus*) tail during natural swimming. Several previous studies have investigated the relationship between body stiffness and swimming speed using dead fish and model fish. However no studies have been conducted on live fish in which the tail may be actively stiffened during swimming. The tails of bluegill sunfish (N=2, 45 trials total) were perturbed with a fluidic pulse as the fish swam at speeds of 0, 0.5, 0.65, 1.1, 1.25, and 1.5 body lengths per second (BL/s). A vortex generator was developed in−house to produce vortex pulses of controllable properties to perturb the tail. High speed video and particle image velocimetry were used to measure deflection of the fish tail and to quantify the strength of the vortex. The compliance analysis was conducted within 20ms of the perturbation's impact to minimize the effect of active or reflexive motions. Relative compliance was calculated by comparing passive deflections in the tail at different swimming speeds. A parallel study was conducted on flapping foils of different known flexibilities to help characterize the impact of the vortex and to compare the response of the biological tail to that of a purely passive material. The results suggest a decrease in compliance of the tail as swimming speed increases. Deflections in the tail at swimming speeds below 0.65BL/s were much larger than the deflections at swimming speeds above 1.1BL/s. The results suggest that fish tune the tail's compliance during swimming. These studies are the first conducted on live fish and support those conducted on dead and model fish.

107.5 SEWALL, KB*; SOHA, JA; PETERS, S; NOWICKI, S; Virginia Tech, Duke University; *ksewall@vt.edu*

A possible trade−off between song and a cognitive metric in song sparrows

Sexual ornaments can be honest signals of male quality if they are linked to traits that enhance female reproductive success. Males might be expected to invest maximally in traits important to females and thus in sexual ornaments. However, mechanisms that link sexual ornaments with other character traits also may be the basis for trade−offs between traits. Bird song is a sexual ornament that depends principally upon brain structure and function, making it reflective of at least some measures of neural capacity and cognition. We explored the possibility that constraints on brain growth could lead to a trade−off between song and cognition in song sparrows (*Melospiza melodia*). Specifically, we examined the relationship between song repertoire size and performance on a spatial task. We found an inverse relationship between repertoire size and speed of spatial learning and suggest that a developmental trade−off between the hippocampus and song control nuclei could be responsible for this relationship. Differences in how males resolve this trade−off between brain−dependent traits could contribute to the spectrum of variation in song and cognition. Such a trade−off suggests that song can inform females about a suite of male traits rather than a single metric of condition.

P1.67 SHAIKH, H*; STEFFENSON, M; MANN, W; BEACH, J; MYDLARZ, L; University of Texas, Arlington; *humera.shaikh@mavs.uta.edu*

Environmental variation and the evolution of immune function in wolf spiders

Temperatures are expected to rise with climate change, with drier, hotter summers expected in subtropical regions. It is important to understand how species will respond to increased temperatures, especially in arthropods, as they cannot regulate their own body temperature. As a result, ectotherms must allocate a higher proportion of energy toward managing temperature stress than endotherms. The goal of this study was to identify whether changing environmental conditions (e.g. temperature) over the course of the growing season influences basal immunity among wolf spiders (*Tigrosa helluo*) in North Texas. Sixteen male *T. helluo* were collected every two weeks from May to November. Spiders were brought back to the laboratory and had their running speed recorded by chasing them down a track with a wooden dowel. The following day, spiders were weighed and hemolymph was extracted, homogenized, and frozen for immunological assessment (protein concentration, antioxidant and antimicrobial activity). Carapace length of each specimen using digital microscopy was also recorded. Preliminary results indicate that body mass, running speed, and carapace length did not significantly change over the growing season. However, protein concentration and immune response activity significantly increased from late spring to mid−summer. As temperatures increased through mid−summer, the number of prey items may have as well, resulting in an increase in protein concentrations. This in turn could increase the amount of energy individuals had to invest in a temperature stress response, thus also increasing constitutive immune activity. However, spiders may not have had enough energy to invest in all physiological responses and thus trade−offs between running speed and immune response are expected.

51.2 SHARMA, P.P.*; SCHWAGER, E.E.; GUPTA, T.; WHEELER, W.C.; EXTAVOUR, C.G.; American Museum of Natural History, Harvard University; *psharma@amnh.org*

Homology of deutocerebral appendages revealed by functional interrogation of homothorax in the harvestman Phalangium opilio

The segmental architecture of the arthropod head is one of the most controversial topics in the evolutionary developmental biology of arthropods. The deutocerebral (second) segment of the head is putatively homologous across euarthropods, owing to the segmental distribution of the tripartite brain and the absence of Hox gene expression of this appendage−bearing segment. Mandibulates (insects, crustaceans, and myriapods) bear a characteristic pair of antennae on this segment, whereas chelicerates (e.g., spiders, scorpions, harvestmen) bear the eponymous chelicerae. In such insects as the fruitfly *Drosophila melanogaster* and the cricket *Gryllus bimaculatus*, the head appendages are differentiated from the thoracic appendages (legs) by the activity of the appendage patterning gene homothorax (*hth*). Here we show that zygotic RNAinterference of *hth* in the harvestman *Phalangium opilio* results in homeotic transformation of chelicerae and pedipalps to legs. In homeotically transformed chelicerae, expression of the hth cofactor extradenticle (*exd*) resembles expression in wildtype legs, corroborating the observed transformation. These data suggest a deep homology across euarthropods with respect to the mechanism whereby gnathal appendages are differentiated from locomotory appendages, and support the homology of the antenna and the chelicera. In contrast to this conserved function of *hth* in mandibulates and chelicerates, other genes involved in insect antennal specification and/or segmentation (e.g., *spineless, spalt*) are either not expressed in the chelicera of *P. opilio* or are not associated with segmentation in the chelicera of this species, suggesting that activity of these genes in the antenna constitutes a mandibulate synapomorphy.

P2.104 SHARMA, P.P.*; SCHWAGER, E.E.; EXTAVOUR, C.G.; WHEELER, W.C.; American Museum of Natural History, Harvard University; *psharma@amnh.org*

Hox cluster duplication overcomes barriers to tagmosis in scorpions

The evolutionary success of the largest animal phylum, Arthropoda, has been attributed to tagmatization, the concerted evolution of adjacent metameres to form morphologically and functionally distinct segmental regions called tagmata. Specification of segmental identity is regulated by the Hox genes, of which ten are inferred to be present in the ancestor of arthropods. Due to spatial and temporal collinearity of Hox gene activity, the number of Hox genes present in a genome imposes an upper limit on the number of segmental identities that can be conferred during development. The bauplan of scorpions has long defied explanation, given that the expression domains of the anterior eight Hox genes are conserved across chelicerates, yet scorpions bear four different segmental identities in the posterior two tagmata an architecture theoretically unfeasible in any arthropod with only ten Hox genes. Here we show that the scorpion *Centruroides sculpturatus* has two paralogs of almost all ten Hox genes, suggesting a duplication of the Hox cluster (or alternatively, a whole genome duplication) in this arachnid order. Embryonic anterior expression domains boundaries of the last four pairs of Hox genes (two paralogs each of *Antp, Ubx, abdA*, and *AbdB*) are unique and correspond to distinct segmental groups, such as pectines, book lungs, and the characteristic metasoma (tail). These distinct expression domains are indicative neofunctionalization of all opisthosomal Hox gene paralogs subsequent to duplication and overcome the limit to the number of segmental identities possible with only ten Hox genes. Our data reconcile previous understanding of Hox gene function across arthropods with the extreme heteronomy of scorpions.

41.7 SHARPE, S.S.; KUCKUK, R.M.; KOEHLER, S.A.; GOLDMAN, D.I.*; Georgia Tech, Harvard; *ssharpe@gatech.edu*

The effect of body length and slenderness on sand−swimming: comparing the performance of the sandfish lizard and the shovel−nosed snake

A few desert dwelling animals possess the ability to swim subsurface in sand and move by propagating anterior−to−posterior waves down their body. To investigate how body morphology affects swimming performance, we compare the movement strategies of two desert dwelling sand−swimmers exhibiting disparate body forms: the long−slender limbless shovel−nosed snake (*Chionactis occipitalis*) and the relatively shorter limbed sandfish lizard (*Scincus scincus*). The snake has an average body radius to length ratio (r/L) of 0.02 compared to the sandfish which has a r/L of 0.05. We hypothesize that a long slender body improves swimming performance. X−ray imaging of subsurface kinematics revealed that the snake operated with a lower slip factor ($S = 6.0 \pm 1.6°$, defined as the average angle between velocity and tangent vectors along the body) compared to the sandfish ($S = 21.6 \pm 3.7°$, $P < 0.01$); this implies that both animals caused local flow of the surrounding media but that the snake yielded the material less. The snake also used a higher number of waves along the body ($\xi = 3.5 \pm 0.7$) compared to the sandfish ($\xi = 1 \pm 0.1$, $P < 0.01$). We use a previously developed frictional fluid model (granular resistive force theory) to predict how r/L, ξ, and the curvature ($\kappa\lambda$, local curvature at a bend multiplied by the arc length of the wave averaged over all visible undulations) affect S for the two animals. The model predicts that r/L affects S differently depending on $\kappa\lambda$ and ξ, but for the range that the sandfish and snake operate, surprisingly, r/L alone has little effect. The model shows that having a larger $\kappa\lambda$ or ξ results in a lower S. Therefore, the snake's long body may offer a functional advantage for low slip locomotion by allowing the snake to use a large ξ while maintaining a swimming waveform with higher $\kappa\lambda$.

33.1 SHAWKEY, MD*; D'ALBA, L; XIAO, M; BUCHHOLZ, R; University of Akron, University of Mississippi; *shawkey@uakron.edu*

The ontogeny of an iridescent nanostructure composed of hollow melanosomes

Iridescent feathers are among the most colorful objects in nature and are model systems for the evolution of sexually selected traits. Their colors are produced by coherent light scattering from linear or crystalline arrangements of melanosomes (melanin−containing organelles). Hollow melanosomes, an evolutionary innovation largely restricted to birds, contain an optically powerful combination of high and low refractive indices (from the melanin and air, respectively) that enables production of brighter and more saturated colors than solid melanosomes. However, despite their significance to avian color evolution and potential utility as optical biomaterials, little is known about the ontogeny of either the melanosomes themselves or the nanostructures they comprise. We used light and electron microscopy to characterize nanostructural development in regenerating feathers of wild turkeys, a species with iridescent color produced by a hexagonally close−packed array of hollow melanosomes. We found that melanosomes form as solid bodies in melanocytes. Later in development, largely after placement in developing barbules, their interiors dissolve and leave hollow cores. These now hollow melanosomes are initially disorganized in the barbule, but become close−packed as they are trapped between two layers of polymerizing keratin. These data thus provide further evidence that structurally colored tissues are self−assembled and represent novel pathways of development that could provide inspiration for new materials.

23.8 SHIELDS, V.D.C.*; CHARLES, C.D.; ARNOLD, N.S.; Towson University; *vshields@towson.edu*

Functional Morphology of Antennal Sensory Organs of the House Cricket, Acheta domesticus (L.)

House crickets, Acheta domesticus (L.), have paired antennae that bear many sensory organs (sensilla). These sensilla allow them to gain information about olfactory, gustatory, and mechanosensory cues pertaining to their environment. Both antennae of male and female crickets bear, on average, more than 200 segments. Scanning and transmission electron microscopy studies revealed seven antennal sensillum types. Four types bear external morphological features suggestive of olfactory sensilla. Two of these types resemble short to medium−sized pegs with their cuticular shafts perforated by conspicuous pores, while another resembles a short peg with longitudinal ridges or "fingers". Another type resembles a short peg recessed in a deep pit. The antennae also bear two sensillum types suggestive of a mechanosensory function. One of these types resembles a long hair−like sensillum with conspicuous ridges and an aporous cuticular shaft, while the other resembles a small circular depression on the antennal surface. We found one medium−sized sensillum type bearing diagonal circular ridges and a single terminal pore suggestive of a gustatory function. This study complements our behavioral and electroantennographic bioassays to screen a large panel of ecologically−relevant volatiles.

119.3 SHINE, C*; ROBBINS, C; KEEN, H; NELSON, O L; MCGOWAN, C P; University of Idaho, Washington State University; *shin0453@vandals.uidaho.edu*

Basic Biomechanics of Grizzly Bears: Gaits, speeds and forces.

Bears are the only group of large, plantigrade, quadrupedal mammals in the world. However, they are relatively understudied in the areas of biomechanics and locomotion. This study represents one of the first to investigate the gaits mechanics used by grizzly bears (*Ursus arctos horribilis*). We used three high speed cameras and a custom built forceplate to record four captive female grizzly bears travelling across a runway across a range of speeds. Video data were analysed to determine the average speed and the gait pattern. The footfall patterns were combined to create an average gait pattern for the bears at each speed. The forceplate data were analysed to determine peak forces and impulses in order to determine fore−hind limb force distribution in each gait. Initial analysis of the video data shows that bears walk with an average speed of 1.7 m/s, use a running walk with an average speed of 2.6 m/s and canter with an average speed of 2.9 m/s. There was no aerial phase for these gaits at any speed recorded. Preliminary results suggest that bears do not appear to trot like other quadrupeds studied, such as dogs and horses, but use a running walk instead. The running walk is the same order of footfalls as a walk but the pattern is changed so that there is a maximum of two feet on the ground at the same time, rather than three. A canter is the preceding gait to a gallop; the stride is extended in the gallop to produce a four beat gait rather than a three beat gait. It is likely that the bears were not achieving a fast enough speed along the runway to break into a full gallop.

P2.109 SHINKAWA, N*; MEKDARA, PJ; WONG, TF; IQBAL, F; LENT, DD; MULLER, UK; California State Univ. Fresno; *Shinkawa13@mail.fresnostate.edu*

Glutamate in the locomotory behaviors of Drosophila navigating around an obstacle

Drosophila melanogaster use vision to orient towards or avoid objects during walking and flight. To this end, visual input is transformed into new motor programs. In this study, we explore the underlying neural mechanisms by looking at the role of neurotransmitter systems in motor control. In insects, glutamate is a major excitatory neurotransmitter at the neuromuscular junction. There are also many glutamate receptors in the central nervous system, in particular in the central complex, a neuropil implicated in motor control. It has been shown that glutamate agonists have a significant effect on the fruit flies walking behavior and it's control by the central complex. To examine the role of glutamate in the visual guidance of locomotory behavior, we have developed an arena in which we can observe and track individual wild−type and mutant flies as they perform normal vertical walking following a tap down protocol. As flies perform their vertical walking, they encounter an obstacle with high visual contrast, which requires them to maneuver around. We quantified the behaviors by investigating the distance from the barrier where the fly first initiates the turn, the time it takes to initiate to turn, and the radius at which it turns in order to explore how glutamate and the central complex function in mediating visually guided locomotion in *Drosophila*. We found that over expression of glutamate in the peripheral nervous system decreases the flies' climbing ability and lowers the success rate in negotiating obstacles. Over expression of glutamate in the central complex is likely to cause an increase in walking speed without impairing the flies' ability to maneuver around the obstacle

P2.81 SHORT, K.E.*; DERRICKSON, E.M.; Loyola University Maryland, Baltimore; *keshort@loyola.edu*
Compensatory Changes in the Small Intestine Morphology in Response to Lactation and Dietary Protein
Digestive systems exhibit morphological flexibility in response to different dietary demands and constraints. Previous research in our lab indicated that mice may have morphological adaptations that allow them to accommodate a lower level of protein in their diet. Our hypothesis is that mice modify their gut to increase assimilation efficiency in response to low dietary protein. Our prediction is that villus height, crypt depth, and cell size will increase on low protein diets. Mice (*Mus musculus*, ICR strain) were randomly placed on isocaloric diets containing either 11.5% protein (low) or 23.0% protein (control). Mice were divided into reproductive and non−reproductive groups, and were maintained on their diets for six weeks. Mice were dissected and intestinal segments from the proximal, mid, and distal areas were excised, fixed, embedded, sectioned, and stained. Measurements of villus height, apex width, base width, crypt depth, intestinal perimeter and enterocyte size were taken. All measurements differed by intestinal location. Lactating mice exhibited greater perimeters, villus height, crypt depth and apex width. Diet had no effect on villus measurements at the tissue level which was partially attributable to small sample size and variation in tissue shrinkage by location and diet. Decreased dietary protein, however, was associated with increased enterocyte width at the proximal location, especially in lactating mice, and increased enterocyte width at the distal location, especially in lactating mice. The results for enterocytes give support to our hypothesis that mice modify their intestine in response to dietary deficiency of protein.

115.7 SHRIVASTAVA, R; SEIDEL, R; REPP, F; KOLLMANSBERGER, P; ZASLANSKY, P; DEAN, MN*; VIT University, India, MPI−Potsdam, Germany, ETH−Zürich, Switzerland, Charité−Universitätsmedizin, Germany; *mason.dean@mpikg.mpg.de*
Morphology and distribution of interlacunar canals in elasmobranch mineralized cartilage
Connectivity among tetrapod bone cells is integral to tissue health and mechanosensing: osteocytes connect via tendril−like cell processes, passing through the mineralized matrix in long, narrow channels (canaliculi). Similar networks are lacking in tetrapod mineralized cartilage, as chondrocytes die during matrix mineralization. In shark and ray skeletons, however, chondrocytes remain alive despite encasement in mineralized tissue, their lacunae connected via short interlacunar canals. We examine this cellular network by monochromatic, high−resolution absorption synchrotron microCT tomography of stingray tesserae (mineralized tiles that comprise the calcified layer of the skeleton), using quantitative 3D image analysis to characterize orientation, density and morphology of the lacunae−canal system. Tesserae are as cell−dense as the underlying unmineralized cartilage, with a range of morphologically and locationally distinct lacunar types suggesting cells with different functional roles. Most prominent are long uni−directional "lacunar strings" formed from consecutive lacunar spaces linked by interlacunar canals. These radiate outward from the center of each tessera, with non−radial (i.e. vertical or circumferential) canals nearly non−existent. Lacunar strings are concentrated between wedge−shaped zones of higher mineral density, resulting in alternating cell−rich and mineral−dense zones. Although we have seen no cell processes physically linking chondrocytes, the high cell density, rich interlacunar network and lack of cell death in this tissue suggests cell communication is important and points to a level of parallelism in early chondrocyte and osteocyte evolution.

128.3 SIEBERT, S*; GOETZ, FE; CHURCH, SH; BHATTACHARYYA, P; ZAPATA, F; HADDOCK, SHD; DUNN, CW; Brown University, Providence, Monterey Bay Aquarium Research Institute, Moss Landing; *stefan_siebert@brown.edu*
Stem cells in a colonial animal with localized growth zones
Siphonophores are planktonic marine Cnidarians with complex colonial organization. The different bodies, or zooids, of a colony show functional specialization and are arranged in a highly organized manner. Cellular dynamics of siphonophore growth are, however, not understood. We identified interstitial stem cells that express five canonical stem cell and germ line markers at distinct, well−defined locations in colonies of Nanomia bijuga. These locations are the tips of the two localized growth zones, young zooid buds, and particular locations within the maturing and the mature zooids. The expression of these stem cell genes is strongest early in zooid formation and development, and becomes more restricted as zooids mature until it disappears from most zooid regions. Germ cells are segregated early in one of the growth zones. Expression persists the longest in gametogenic and cnidogenic regions and in regions where cell proliferation and differentiation is known to continuously occur such as tentacle bases. No cells expressing these stem cell markers were identified in the stem to which zooids are attached, or at locations within zooids that would suggest that stem cells migrate within or between zooids. Maintenance of self−renewing multipotent cells in the growth zone and deposition of populations of stem cells in particular places within zooids allow for a highly organized and an almost meristem−like growth pattern in siphonophores.

P2.92 SIEVE, J*; AVILES, J; HARRISON, JF; SOCHA, JJ; Virginia Tech, Arizona State University; *sjake5@vt.edu*
A volumetric analysis of the tracheal system of the grasshopper Schistocerca americana using μCT
Although insects possess an open coelom, recent work suggests that grasshoppers are able to create functional compartments within the body. These compartments appear to reduce the movement of hemolymph, which baths all tissues and organs including the respiratory tracheal tubes and air sacs. Anaesthetized grasshoppers exhibit less control of hemolymph distribution: when the animal is experimentally held in a vertical position, air sacs at the bottom end collapse regardless of orientation (head up or head down). In this study, our aim is to characterize the three−dimensional geometry of the tracheal system to determine the volumetric effects of body orientation on hemolymph distribution and tracheal configuration. We used micro−computed tomography (μCT) to visualize the exoskeleton and tracheal system of the grasshopper in two orientations: head up and head down. In addition, we included a treatment with the spiracles sealed to begin investigation of the role of intra−tracheal pressures in tracheal system compression. Sacrificed grasshoppers were scanned using a SkyScan 1172 high−resolution μCT scanner using x−ray energy, amperage, and power settings of 70kV, 140μA, and 10W, respectively. Our preliminary results demonstrate that tracheal tubes with diameters as small as 10 micrometers are able to be visualized, providing the first three−dimensional representation of the major structures of the tracheal system in a grasshopper. Quantification of tracheal volumes using Amira software will enable us to determine the specific effects of orientation on the respiratory capacity. Supported by NSF 0938047.

55.3 SIGWART, JD; Queen's University Belfast;
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Responses (or not) to environmental change in a "living fossil" (Mollusca, Polyplacophora)

Chitons (Polyplacophora) are benthic grazing molluscs with an eight−part aragonitic shell. Their morphology has remained extremely conserved over more than 300 million years, yet almost 1000 living species show niche−specific adaptations and differential responses to environmental change. The radula, a serial tooth ribbon that extends internally over more than half the body, is mineralised with iron magnetite apparently as an adaptation to constant grazing on rocky substrates. As the anterior feeding teeth are eroded they are shed and replaced with a new row. The efficient mineralisation and function of the radula could be affected by changing oceans in two ways: changes in seawater chemistry (pH) may impact the biomineralisation pathway, potentially weakening the feeding teeth; rising temperatures could increase activity levels and feeding rates with greater wear on the teeth beyond the animals' ability to synthesise, mineralise, and replace radular rows. The effects of pH and temperature on growth and mineralisation in the radula were examined using *Leptochiton asellus*, a sensitive member of the most plesiomorphic living clade of chitons. The experiment implemented three temperature (12C, 16C, 20C) and two pCO_2 (pH 8.0, 7.5) treatments. Animals (n=50) were acclimated in the six treatment conditions for a period of 3 weeks. This is sufficient time for growth of ca. 7 new tooth rows or 20% turnover of the mineralised portion. There was no significant difference in the number of new (non−mineralised) teeth or total tooth row count in any treatment (Ç^2=5.543, df=5, p=0.35). Examination of the radulae via SEM revealed no differences in microwear or breakage on the feeding cusps correlating to treatment groups. The shell valves also showed no sings of dissolution. As a lineage, chitons have survived repeated shifts in Earth's climate in deep time, and at least their radulae may be robust to future perturbations.

P1.198 SILVERTHORN, D.U.; Univ of Texas, Austin;
silverthorn@utexas.edu

Group peer evaluations using Blackboard

Peer evaluation is an important component of group work in both lecture classrooms and student laboratories because it helps alleviate the complaint that some students slack off and allow others to do all the work. In our experimental physiology laboratory class we initially used paper−based peer evaluations but the size of the class (60 students in groups of 4), biweekly reassignment of students to different groups, and 5 ratings per partner with written comments generated such a volume of information that we decided to develop an online peer evaluation tool. Our goal was to create a method that would allow timely and honest feedback while protecting the privacy of the student evaluator. After several aborted attempts, we created an evaluation system within Blackboard, the university's course management system. The peer evaluation questionnaire uses the test manager template, so it can be easily copied from semester to semester or modified for other classes. Students log into Blackboard to evaluate their lab partners. The scores they give their partners are visible only to the instructors, and the evaluators may type extensive comments to explain their scoring. The results download as Excel spreadsheets, which makes compilation of data much easier than with paper forms. Students like the online system because of its ease of use and anonymity. After several rounds of evaluations, the instructors can identify those students whose performance has been poor in several different teams and provide counseling.

76.3 SIMAKOV, O.*; ROKHSAR, D.S.; ARENDT, D.; EMBL Heidelberg, Germany, UC Berkeley; *simakov@embl.de*

Combining developmental, population, and comparative genomics analyses to study long term evolution of cell types

While most of the inferences about the ancestral metazoan or bilaterian cell type complements are based primarily on gene expression and morphological comparisons, they usually lack information about their dynamics, i.e.: micro− (intra−species environmental and population) and macro−evolutionary (e.g, inter−species genomic) variation. Here I discuss a new integrative eco−evo−devo' approach that combines comparative genomics studies of bilaterian genomes (including the first broad sampling of the lophotrochozoans), eco−transcriptomics of the natural populations and a molecular study of cell−type development of a cosmopolitan polychaete *Platynereis dumerilii*. In particular, using genomic and population data and taking advantage of a detailed cellular−level characterization of the foregut development in *Platynereis* and few other phylogenetically important species, we are in the process of mapping micro− and macro−evolutionary variation onto cell types or tissues. This allows us to identify correlates of evolutionary stable' (slow−evolving) and 'unstable' (fast−evolving) cell types or tissues and provides us with the first glimpse into how micro− and micro−evolutionary processes might have interacted and shaped animal evolution over the past 600 million years at the cell type level. In my presentation, I will summarize the data from the different time scales including the genomic (gene family, repeat, and linkage evolution), population (transcriptomics and metabolomics), and development (expression profiling) and describe an integrative framework for cell type evolution in a context of a comparative study of the foregut development. Such framework can be readily extended to other model systems.

19.6 SIMON, R.V.*; ROWE, T.B.; The University of Texas at Austin; *rvsimon@utexas.edu*

Olfactory Evidence on the Terrestrial Origins of Monotremata

Whether Monotremata originated as a terrestrial or aquatic clade is a hot debate that so far has revolved around the interpretation of fragmentary Early Cretaceous fossils from Australia. To test these diametrically opposed hypotheses, we used high resolution x−ray computed tomography (CT) to generate new phylogenetic characters that were added to a morphological character matrix and run in a parsimony analysis. The dataset included living and extinct monotremes, plus outgroups comprising select therian mammals and extinct mammaliaforms. Most significant was the addition of CT data on the skull of the rare and poorly studied long−beaked echidna, *Zaglossus*. We also included the extinct long−beaked echidna *Megalibgwilia*, which we scored from the literature. Our results suggest that the ancestral monotreme had a well−developed Main Olfactory System (MOS) that was designed for analyzing air−borne odorant molecules, much like the system present in mammals ancestrally and that persists in many living mammals. From this condition, the platypus clade shows progressive reduction of its MOS, including reduction of the ethmoturbinals and olfactory bulb. However its vomeronasal organ (VNO), which is sensitive to soluble odorant molecules, underwent a genomic expansion unmatched by any other known mammal. In contrast, the echidna clade shows a unique degree of hypertrophy of its ethmoid skeleton and a large olfactory bulb and pyriform cortex, with no elaboration of its VNO genome. These results suggest that the ancestral monotreme was terrestrial, that the platypus lineage is secondarily aquatic, and they contradict the controversial proposition that echidnas are secondarily terrestrial.

132.2 SIMPSON, A.M.*; BELDEN, J.B.; JEYASINGH, P.D.; Oklahoma State University; *adam.simpson@okstate.edu*

Toxicity of a Current−Use Insecticide to Daphnia pulicaria: Impact of 500 Years of Evolution

This study examined how the natural evolutionary progression in a resurrected *Daphnia pulicaria* population indirectly affected its sensitivity to new anthropogenic stressors, specifically pesticides. Toxicity of the organophosphate insecticide chlorpyrifos was determined through a series of acute toxicity tests quantified by the median lethal concentration (LC50). After comparing LC50 values across clone genotypes, a trend can be seen demonstrating an increased sensitivity to chlorpyrifos in the ancient clones. This could be explained by a pre−evolved decrease in metabolism in the more contemporary clones. Ultimately, these results provide preliminary insight into preexisting mechanisms that confer developed resistance to new environmental stressors.

83.3 SIMPSON, RK*; MCGRAW, KJ; Arizona State University; *rksimps1@asu.edu*

The role of a fluctuating environment on multiple signals

Many animals communicate using more than one modality (e.g. acoustic, visual), and several hypotheses have arisen to explain the evolution of multiple signals. These hypotheses typically assume static selection pressures and fail to acknowledge how environmental fluctuations over time or space can shape variation in signaling systems. Environmental variability, such as food availability and ambient lighting, may affect the costs and benefits of trait development and information content in signalers as well as signal perception and value in receivers. We are studying how the form and function of multiple signals in a tropical songbird change due to spatiotemporal environmental fluctuations. We tested how intra− and inter−annual variation in light environment and ambient noise influences the transmission, perception, and reliability of song and coloration in the red−throated ant−tanager in Panama. During the spring of 2013, we recorded songs of male ant−tanagers and plucked feathers to measure their plumage coloration. For our environmental variables, we measured canopy cover (light environment) and recorded ambient noise. We found that both canopy cover and ambient noise varied across territories, and we will present how song and color relate to this environmental variation. Our preliminary results demonstrate how male ant−tanagers on louder territories sing at higher minimum frequencies and have shorter song bandwidths. This type of study is important in understanding how the environment affects essential behaviors, such as communication, which affect the reproductive success of an individual.

66.5 SINCLAIR, B.J.*; GRAETHER, S.P.; UDAKA, H.; Univ Western Ontario, Univ Guelph; *bsincla7@uwo.ca*

FROST: The red herring gene of insect cold tolerance?

The gene *FROST* (*Fst*) is one of the most compelling candidates for a cold tolerance−related gene in *Drosophila*. *Fst* is upregulated in response to a brief cold exposure in all life stages and most species of *Drosophila*, and is the only gene that has been consistently associated with cold exposure in microarray, RNA−seq, and QTL studies. However, *Fst* polymorphisms are not associated with cold tolerance in a gradient in Australia, and knockdown of *Fst* does not appear to affect several different measures of cold tolerance in *Drosophila*. We will discuss the temporal, spatial, and phylogenetic expression of *Fst* in *Drosophila*, as well as the putative structure of the protein. We will then consider the potential roles of the Frost protein, and what this tells us about our approach to identifying candidate genes and about the biology of insect cold tolerance in general.

S9.3−3 SINGER, M.S.*; MASON, P.A.; SMILANICH, A.M.; Wesleyan University, U. Colorado, Boulder, U. Nevada, Reno; *msinger@wesleyan.edu*

Ecological Immunology of Woolly Bear Caterpillars

The emerging field of ecological immunology recognizes the role of an organism's environment in its ability to defend itself against parasites. One important mechanism of ecological immunology is medication behavior, the acquisition of substances that resist or improve tolerance to disease. In the broad sense, medicinal substances can include nutrients as well as pharmacological agents. In this paper, we use adaptive plasticity theory to frame nutritional and non−nutritional aspects of medication behavior of the woolly bear caterpillar, *Grammia incorrupta* (Lepidoptera; Erebidae; Arctiinae). As grazing herbivores, individual caterpillars can consume many chemically diverse plant species. The most phagostimulatory plants contain pyrrolizidine alkaloids (PAs) and diets including such plants confer resistance against tachinid parasitoids at the cost of reduced nutritive value. As theory predicts, parasitism by tachinids causes caterpillars to exhibit therapeutic self−medication by increasing their ingestion PAs. PA−medication manifests approximately 48 hours after caterpillars become infected with tachinid parasitoids, whereas the caterpillars reduce total food intake during the first 48 hours following infection. Because protein intake is reduced more sharply than carbohydrate intake, we suggest this feeding change is adaptive with respect to immune function. Manipulation of dietary PAs and nutrients exerted no detectable effect on the caterpillar's immunological melanization response. We conclude that PA−medication is a secondary line of defense contingent on habitat quality and the failure of immunological defenses; and immunological melanization may be robust to variation in dietary nutrients, thus enhancing immune function when reduced protein intake limits parasitoid growth.

P2.38 SINGLETON, E.M.*; SUTHERLAND, K.P.; GOODMAN, K.M.; LIPP, E.K.; Rollins College, UGA; *emn7070@uncw.edu*

Survival of the coral pathogen Serratia marcescens and the development of a model organism for studying coral disease

Populations of elkhorn coral (*Acropora palmata*) in the Florida Keys are facing a precipitous decline due to white pox disease, or acroporid serratiosis (APS). Untreated wastewater has been identified as a definitive source of the human enteric bacterium *Serratia marcescens*, the causative agent of APS. To better understand the etiology of APS, this study characterized the persistence of *S. marcescens* strain PDR60 isolates and strain PDL100 in seawater microcosms amended with glucose. The isolates with the shortest and longest survival times in glucose microcosms were isolate 2 and isolate 3, respectively (both PDR60 from APS−affected *A. palmata*). Isolate 2 lived for 21 days while isolate 3 lived for 127 days and was still alive at the end of this study. We also observed extended survival time of 156 days for isolate 8 (from wastewater in the Florida Keys) in seawater alone. In addition to survivability studies, we conducted experiments to determine if *Aiptasia pallida*, a sea anemone, can be used as a model organism to study the effects of APS. We inoculated *A. pallida* polyps with 10^6 cfu/ml of the most virulent *S. marcescens* isolate, isolate 6 (from wastewater in the Florida Keys), which killed *A. palmata* corals in ~4 days (Sutherland et al. 2011). After 4 days, *A. pallida* did not display any visual signs of stress, indicating that isolate 6 was not lethally virulent under the conditions of this study. The survivorship curves of *A. pallida* (non−clonal and clonal lines) inoculated with *S. marcescens* were no different from controls (p = 0.124 and p = 1.0, respectively). These results indicate that *S. marcescens* can persist in the environment for longer than expected and represent a starting point for further research on using *A. pallida* as a model organism.

3.5 SINGLETON, J. M.*; GARLAND, T.; University of California, Riverside; *jsing014@ucr.edu*

Influence of corticosterone on growth, home−cage activity, wheel running, and maximal oxygen consumption in replicate lines of house mice selectively bred for high voluntary wheel−running behavior

Corticosterone, chiefly referred to as a "stress hormone," impacts a surprising variety of organismal traits, including skeletal growth, cognition, and motivation. Hence, changes in corticosterone levels may impact multiple aspects of locomotor behavior, including both motivation and physical abilities. Previous rodent studies have found that altering circulating corticosterone levels can affect activity levels or induce a depressive state, depending on dosage and other factors. We have used a long−term artificial selection experiment to examine the evolution of high levels of voluntary wheel−running behavior in laboratory house mice. As compared with four non−selected control (C) lines, the four replicate High Runner (HR) lines are smaller in body size, run ~3−fold more on wheels on a daily basis, have higher home−cage activity when deprived of wheels, and have higher maximal oxygen consumption (VO_2max) and basal circulating corticosterone levels. To examine further the role of corticosterone in locomotion, we administered 50 µg/ml in the drinking water of HR and C male mice from weaning to seven weeks of age. Mice were then tested for wheel running and maximal oxygen consumption. Corticosterone administration reduced growth rate and body mass−adjusted VO_2max of both HR and C mice. It did not affect wheel running of C mice, but decreased that of the HR lines. Previous studies show that HR but not C mice sometimes run voluntarily at or near their maximal aerobic speed, so the present results suggest that corticosterone can impact wheel running via changes in VO_2max when animals are motivated to run voluntarily near their aerobic limits. Supported by NSF IOS−11212732.

P3.193 SINKIEWICZ, DM*; WILCZYNSKI, W; Georgia State University; *dsinkiewicz1@gsu.edu*

Regional Expression of Foxp2 in response to testosterone in the brain of Hyla cinerea

Vocalization is a conspicuous form of communication that is observed across most of the vertebrate taxa. Foxp2 is a gene that is implicated in the learning of vocalizations in humans and songbirds. There is little known about the role this gene plays in the production of unlearned vocalizations, however, it is present in the brains of such animals. In the green tree frog (Hyla cinerea), unlearned vocalizations are produced only during the breeding season. The breeding season coincides with an increase in gonadal hormonal levels. In this experiment we addressed how changes in testosterone effect Foxp2 expression in the brain of adult male green tree frogs. Animals were gonadectomized and implanted with either a testosterone or empty silastic implant. Fourteen days following surgery brains were collected and trisected into forebrain, midbrain, and hindbrain. RNA was extracted from the samples using Trizol (Invitrogen) and measured for Foxp2 transcription levels using quantitative PCR. There was an observed effect of brain region on Foxp2 expression (p <0.001) with highest expression in the midbrain. Within this there is significantly greater Foxp2 expression in the midbrain than in the hindbrain regardless of treatment (p<0.01). However, we only observed a significant difference in forebrain expression in the sham animals (p=0.02), but not in testosterone implanted animals (P=0.12). Examination of the data suggests this loss of significance is due to an increase in Foxp2 expression in the forebrain of T implanted animals. This suggests that increased T levels result in increased expression of Foxp2 in the forebrain of the green tree frog.

P3.39 SIRMAN, A.E*; DEVRIES, Z.C; DONOVIEL, Z.S; HOOD, W.R; Auburn University, NC State University, Raleigh; *aubrey.sirman@gmail.com*

The effects of early nutrition on metabolic rate and fitness in the house mouse (Mus musculus)

Effects of diet on individuals can be far−reaching, particularly during the period of rapid growth during early development. Plastic responses of genotype to environmental conditions experienced during development can have lasting effects on physiological variables that impact metabolism. Although individual differences in life history are often attributed to differences in energy utilization, few studies have found a relationship between BMR and reproductive performance. Due to impacts on physiological processes, it is feasible that the early diet has formative effects on an individual's fitness. Our goal was to determine if an individual's diet during development has persistent effects on whole animal metabolic rate. We manipulated dietary protein levels of wild house mice (*Mus musculus*) maintained in semi−natural enclosures, allowed the parental generation to breed, and monitored F_1 individuals into adulthood. Parents were maintained on a 20% or 10% protein diet, and their offspring were maintained on the same diet or switched to the alternative diet around the time of weaning. We measured resting metabolic rate of each F_1 mouse at 30 days (just prior to the dietary shift where applicable) and at 75 days (adulthood). Diet did not impact F_1 body mass at 30 days or 75 days. Dietary treatment had a significant impact on pup metabolic rate at 30 days but not at 75 days. This suggests that the whole animal metabolic rate responds to the diet an individual's parent consumes during gestation and lactation, and is sufficiently labile that this effect may not persist into adulthood. The relationship between dietary treatment, metabolic rate, and F_1 fitness variables will be discussed.

P3.76 SIRSAT, T.S.*; GOY SIRSAT, S.K.; DZIALOWSKI, E.M.; University of North Texas, Denton; *tusharsirsat@gmail.com*

Development of Endothermy in the Bobwhite Quail (Colinus virginianus)

Development of endothermy is associated with the maturation of aerobic capacity in avian species. In precocial species such as the Bobwhite quail (*Colinus virginianus*), aerobic capacity increases and they become endothermic rapidly after hatching. Development of endothermy involves maturation of multiple organs and systems involved in oxygen delivery to tissues and increased mitochondria function. We quantified the changes in Bobwhite endothermic capacity by measuring oxygen consumption, ventilation, and mitochondrial respiration of permeabilized skeletal muscle (thigh and breast). Heart−ventricle mass, hemoglobin, and hematocrit were examined as parameters of oxygen delivery capacity. Animals were tested on embryonic day 20 (85% development), externally pipped (EP) stage, and through 6 days post hatching (dph). Oxygen consumption of day 20 embryos through 24 hours post hatch (hph) and ventilation rate of 1dph decreased when ambient temperature was lowered. During cold temperature exposure, 3 dph hatchlings increased oxygen consumption and ventilation rate until 25°C, after which they declined, while 6 dph hatchlings were able to increase oxygen consumption and ventilation rate when exposed to 15°C, exhibiting a stronger endothermic response. Among the tissues, thigh mitochondria showed higher oxidative phosphorylation (OXPHOS) than breast and increased significantly through development. Heart ventricle mass increased significantly upon hatching and was the greatest fraction of body mass by 3 dph. The metabolic capacity necessary to attain endothermy was associated with increased tissue metabolic capacity and oxygen delivery capacity and was obtained after hatching. Supported by NSF IOS 1146758 (EMD).

P3.171 SKANDALIS, D.A.*; STILES, F.G.; MCGUIRE, J.A.; ALTSHULER, D.L.; University of British Columbia, Vancouver, BC, Canada, Universidad Nacional de Colombia, Bogotá, Colombia, University of California, Berkeley; *skandalis@zoology.ubc.ca*

Evolutionary and biomechanical correlates of hummingbird body size

Body shape and size are under multiple selective pressures, with major sources of variation including evolutionary history and intraspecific variation. We investigated correlates of sexual and biomechanical selective pressures in hummingbirds using a newly developed phylogeny and recent analytic tools that account for measurement error in interspecific studies. Rensch's rule is the observation that in small species females are larger while in large species males are larger, and is often taken to reflect sexual selection, especially on males. We tested this hypothesis for body size and for several measurements of wing size and shape, and observed some trends consistent with the predicted pattern, but with wide confidence intervals. Any change in body and wing morphology due to sexual selection should also influence biomechanical performance. For example, moments of wing area, which are frequently used to describe wing shape, are hypothesized to relate to specific components of mechanical power output that could be advantageous for territorial males. We applied a multivariate approach, principal components analysis, to a suite of morphological and physiological parameters. Three components dominated: the first corresponds to wing shape parameters, the second to body mass, wing length and area, as well as wingbeat frequency, and the third to wing stroke amplitude. This suggests that wing shape parameters are not strongly linked to either flight performance or body size across species, and that stroke amplitude is behaviorally, not morphologically, determined. We suggest that in contrast to extravagant tail and bill sexual dimorphism, sexual selection on body and wing size in hummingbirds is limited.

19.3 SLATER, GJ; Smithsonian Institution; *SlaterG@si.edu*

Macroevolutionary dynamics of scapula shape and locomotor behavior in Carnivora

The mammalian scapula is a large, flat bone, forming the proximal end of the forelimb. Because the scapula has no bony articulation with the axial skeleton, the forelimb attaches to and supports the trunk through muscular action only. As a result, the shape of the scapula should be strongly influenced by the mechanics of locomotion and forelimb use, making it an ideal predictor of ecology in species whose habits are unknown. Unfortunately, there have been few quantitative comparative studies of scapula shape in mammalian clades. I used a geometric morphometric approach to quantify shape variation among the scapulae of ~160 species of fissiped (i.e., non−pinniped) carnivorans, a clade with tremendous variation in locomotor behavior and forelimb use. Ordinations qualitatively demonstrate strong differentiation of scapula shape along both functional and phylogenetic axes. These observations are confirmed quantitatively by univariate and multivariate macroevolutionary models fitted to a phylogenetic comparative dataset. Taken together, these results suggest that carnivorans rapidly diversified to fill locomotor niches early in their evolutionary history. The gross morphology of the scapula, where preserved, should be a strong predictor of ecology in fossil carnivorans, and renewed focus on this understudied element would benefit future paleocological work.

P2.142 SLAY, C.E.*; HICKS, J.W.; University of California, Irvine; *cslay@uci.edu*

Cardioventilatory responses to digestion in anemic American alligators (Alligator mississippiensis)

American alligators (*Alligator mississippiensis*), like other intermittent "sit−and−wait" predators, are capable of enduring long fasts and thereafter consuming remarkably large meals. Among the intermittent feeders, the Burmese python (*Python molurus*) is renowned for its scope of postprandial oxygen consumption (SDA) and pronounced postprandial organ plasticity, including doubling of small intestinal mass and up to 40% increase in heart mass. Recent work has suggested that the trigger for this cardiac enlargement is increased cardiac work stimulated by a postprandially elevated oxygen supply−demand mismatch. In this study, we hypothesize that given the alligator's feeding strategy and natural history, this species may also be capable of rapid and pronounced tissue hypertrophy. Furthermore, we predict that if cardiac hypertrophy does not occur under "normal" conditions in alligators, it can be stimulated by manipulating the oxygen supply−demand dynamic. To test this hypothesis, we rendered gators anemic before feeding them large meals. For each group of animals, we recorded SDA, heart rate, mean arterial pressure, adrenergic and cholinergic tones, heart mass, and visceral organ mass. While differences in SDA values were subtle, fed anemic animals exhibited heart rates 72% higher than fasted controls (attributable primarily to significantly reduced cholinergic tone). Nevertheless, we found no cardiac hypertrophy in fed anemic alligators, nor any gut hypertrophy among fed animals (regardless of hematocrit). These data suggest that either the meal size was not large enough to elicit postprandial plasticity or, more likely, that alligators have sufficient oxygen delivery capacity to meet the metabolic demands of digestion, even when the magnitude of oxygen supply−demand mismatch is artificially increased.

82.2 SLOAN, T.J.*; TURINGAN, R.G.; Florida Institute of Technology; *tsloan2009@my.fit.edu*

Thermal response of prey−capture kinematics in teleost fishes departs from physiological expectations

As poikilotherms, the physiological performance of fishes is expected to reach optimum levels at a narrow temperature range. As a consequence of the direct effects of environmental temperature on the contractile properties of skeletal muscle, it is expected that the rate of motion in muscle−driven mechanisms doubles for every 10°C change in ambient temperature (i.e., Q_{10}=2.0). This study examined the variation in Q_{10}s of prey−capture kinematic velocities among cyprinodontiform, scorpaeniform and perciform species, as well as among a size series of cyprinodontiform and scorpaeniform fishes, in an attempt to address the question, "How does temperature affect whole−organism performance in teleost fishes?" Size−corrected Q_{10}s for gape, hyoid, lower−jaw displacement, and cranial rotation velocities in fish feeding at 20°C and 30°C ranged from 0.56 to 1.44 in all three species. Intraspecific analyses revealed that the Q_{10}s for the same kinematic variables were 1.0−1.50 in pike killifish (17−101mm SL) and 1.02−1.40 in lionfish (36−107mm SL). These results indicate that prey−capture performance remains largely unaffected by temperature at both interspecific and intraspecific levels of investigation. In the light of the climate−change phenomenon, it is imperative that we advance our understanding of the mechanisms that underlie whole−organism performance in different temperature regimes.

120.6 SMELKER, K.*; SMITH, L.; ARENDT, M.; SCHWENTER, J; ROSTAL, D; SELCER, K; VALVERDE, R; Southeastern Louisiana University, South Carolina Department of Natural Resources, South Carolina Department of Natural Resources, Georgia Southern University, Duquesne University; *kimberly.smelker@ttu.edu*

Plasma vitellogenin in free−ranging loggerhead sea turtles (Caretta caretta) of the northwest Atlantic Ocean

Until presently, innate production of vitellogenin has not been described in reproductively active free−ranging sea turtles. Our study describes circulating concentrations of vitellogenin in nesting and non−nesting females, juvenile and male loggerhead sea turtles (*Caretta caretta*) from the Northwest Atlantic distinct population segment. We hypothesized that vitellogenin concentration would parallel estrogen concentration, therefore vitellogenin would only be detectable in reproductively active females and plasma concentration would decrease as the nesting season progressed. Blood samples from juveniles, males, and non− reproductive females were collected in 2008 and 2009 via in−water captures off the coast of the Southeast US, and blood samples from nesting females were collected in 2008 at Hutchinson Island, Florida. All samples were analyzed using an in−house ELISA developed specifically for *Caretta caretta* vitellogenin. As expected, plasma vitellogenin declined in nesting turtles as the nesting season progressed, although it still remained relatively elevated at the end of the season. In addition, mean vitellogenin concentration in nesting turtles was 1,000 times greater than that measured in samples from in−water captures. Our results suggest that vitellogenesis may continue throughout the nesting season, albeit at a decreasing rate. Further, vitellogenin detected in turtles captured in−water may have resulted from exposure to endocrine disrupting chemicals.

113.2 SMITH, E.K.*; O'NEILL, J.; WOLF, B.O.; University of New Mexico; *ericksmith2@yahoo.com*

Climate change impacts for desert birds: High temperature and thermoregulation in non−passerine desert granivores

During the summers of 2012 and 2013 we captured White−winged Doves (WWDO) and Gambel's Quail (GAQU) near Tucson, AZ, USA. Using flow−through respirometry we measured the effects of air temperature on evaporative water loss, resting metabolic rate, body temperature, and evaporative efficiency. Both species are obligate drinkers and our goals were to establish values for critical thermal max and estimate performance in a hotter climate. We found that WWDO maintained very low resting metabolic rates and relatively low body temperatures over a wide range of air temperatures (40 − 64°C). GAQU, in contrast, were much more sensitive to increasing air temperature, experiencing spikes in resting metabolism and rapid hyperthermia as air temperatures approached 52°C. Both species are common breeders in the Sonoran desert during the hot summer, however, WWDO evaporate water at a 40% higher rate at 50°C than GAQU. Their higher rates of evaporation and lower resting metabolism makes WWDO more efficient at heat dissipation, enabling them to tolerate temperatures as high as 64°C (147°F) while maintaining body temperatures at or below 45°C.

S6.1−3 SMITH, J.*; COSENTINO, C.; Marine Biological Laboratory, Woods Hole; *joelsmith@mbl.edu*

Reliability and Modularity in the Sea Urchin Gene Regulatory Network for Endomesoderm Specification

Development from egg to embryo is a reliable, reproducible (if not invariant) process. On the other hand, we know or at least suspect that developmental programs evolutionary flexibility built in. Studying developmental gene regulatory networks therefore allows us insight into this "tightrope between stability and change", and the sea urchin network controlling endomesoderm which is particularly well characterized provides a foremost example. In this talk, we describe how robustness is "programmed" into the network. We also show data suggesting a layered or modular structure to the network, cosnsitent with the principle of evolution by the accretion and indicating a network feature supporting adaptability. We compare sea urchin development with that other echinoderms. Lastly, we look at how principles from the control of dynamic systems engineering can inform gene network studies, and how our biological studies might in turn contribute to concepts in control theory.

61.4 SMITH, H.K.*; WALLINGFORD, J.B.; RYAN, M.J.; Univeristy of Texas, Austin; *hksmith@utexas.edu*

Development of laryngeal structure for call generation in the Túngara frog

The relationship between genes, development and behavior remains poorly understood. In frogs, evolutionary modifications in larynx development produce diverse larynx morphologies that influence call structure and behavior. The Túngara frog (*Physalaemus pustulosus*) represents a model system of sexual selection and mate choice. In this species, the adult male larynx is more than seven times the size of that of the female. The structure of male larynx allows them to produce a downsweep frequency note, the "whine", and facultatively add 1 to 7 "chucks". Distinct structures within the larynx produce specific sounds: the vocal cords produce the whine, whereas fibrous masses produce the chucks. The embryonic origins of these different laryngeal features are unknown, as are the signals that govern their growth and development. As a crucial step to understanding larynx development, we present data from the Túngara frog that pinpoints its embryonic origin and provides a basis to explore subsequent phenomena controlling its development.

112.2 SMITH, BJH*; CULLINGFORD, C; USHERWOOD, JR; Royal Veterinary College, London; *bsmith@rvc.ac.uk*

Kinematics of mice running in exercise wheels

In many fields, mouse locomotion is used as a model for studying the effects of age, stress and genetic disorders. Often these experiments are carried out using exercise wheels, since mice will voluntarily run long distances in wheels, and wheels are compact enough to fit in standard mouse cages. The sample rate of these measurements is typically low; both speed and distance covered are calculated based on number of revolutions per minute, under the assumption that the mouse is running at a constant or near constant speed. While this is sufficient for long term measurements such as daily activity level, it provides little information on kinematic variables such as stride length and duty factor which can be used as indicators of psychological state and to detect neurological conditions. Conversely, most biomechanical studies of mouse locomotion have measured kinematics of a mouse running on a treadmill or over flat ground. It is likely there are significant differences between the kinematics of a mouse running on a wheel and a mouse running on a treadmill or flat ground, due to the shape of the running surface. Additionally, it has been found that mice have preferences for particular wheel designs, and that variations in wheel size can affect running speed and duration. These factors could also have an effect on running kinematics. The research presented here addresses these two issues: firstly by comparing the kinematics of mice running on exercise wheels to those of mice running on treadmills and over flat ground, and secondly by investigating the effect of wheel design on the kinematics of mouse locomotion. A number of factors are considered, including wheel type (upright vs. angled disc), wheel radius, and wheel angle.

P1.179 SMITH, C.A.*; HAEHNEL−TAGUCHI, M.; LIAO, J.C.; The Whitney Lab for Marine Bioscience/Department of Biology, University of Florida, St. Augustine, FL 32080; *cat.smith@whitney.ufl.edu*

Regional specialization of posterior lateral line efferent neurons in the hindbrain of larval zebrafish

The hair cells contained in the neuromasts of the flow−receptive lateral line system in fishes are directly innervated by two populations of efferent neurons. It has been proposed that the efferent system protects neuromasts from desensitization during motion−induced self stimulation and improves signal to noise levels. Efferent cell bodies are located in the octavolateralis efferent nucleus (OEN) and are subdivided into rostral and caudal efferent neurons (REN and CEN, respectively) without knowledge of their post−synaptic targets. To investigate to which posterior lateral line neuromasts the RENs and CENs are connected, we electroporated fluorescent dyes into efferent terminals at specific neuromasts. First, we labeled each neuromast in the trunk posterior lateral line (n = 5 fish), and found that only one REN and two CEN innervate about a dozen neuromasts. We next labeled pairs of neuromasts with two fluorescent dyes of different wavelengths to look at their position relative to each other in the hindbrain. We found that 57.7% of the most rostrally located neuromasts (L1, n = 26 neuromasts) are connected to the REN, while 80.8% were connected to a single CEN. In contrast, L2 (n = 10) and L5 (n = 13) neuromasts were not innervated by the REN but always connected to one or both CENs. By showing that the REN exclusively innervates one rostral trunk neuromast, while one of the CENs specifically innervates more caudal neuromasts, we demonstrate a regional hindbrain specialization of the efferent lateral line system based on peripheral neuromast location in larval zebrafish.

10.4 SMITH, G.D.*; NEUMAN−LEE, L.; DURSO, A.M.; ZANI, P.A.; FRENCH, S.S.; Utah State University, University of Wisconsin−−Stevens Point; *gdssmith57@yahoo.com*

Investment between reproductive and immune systems varies with latitude and time in Uta stansburiana

Environmental variation is known to elicit different physiological responses from animals living in those environments. In response to limited resources, animals must allocate energy reserves into competing systems. In some instances, increased reproductive output can maximize fitness in the short term, but increased immunological investment could increase lifetime fitness by allowing the animal to survive to subsequent breeding seasons. In our model, side−blotched lizards (*Uta stansburiana*), there is a wide gradient of lifespan across their large range. Northern individuals sometimes live seven or more years while southern individuals rarely live more than one or two breeding seasons. By using bacterial killing assays, *in situ* sonagraphy, radioimmunoassay, and oxidative−stress assays we are beginning to understand more clearly the relationships between the reproductive and immune systems, and how animals allocate resources among these systems. We have sampled populations from Oregon to Arizona for the last two years. When comparing populations at the same time of year we found that northern populations were allocating more energy into their immune systems than the southern populations, and less into reproduction, which corresponds logically with their longer potential lives and future reproductive opportunities. However, when comparing investment across emergence time and relative clutch number (i.e., first, second, third of the season) the relative investment pattern changes, suggesting that investment varies across years and the breeding season.

P1.170 SMITH, C.L.*; HAGUE, M.T.J.; ROUTMAN, E.J.; San Francisco State University, University of Virginia; *camillesfsu@gmail.com*

The Effect of Microgeographic Barriers on Gene Flow and Population Differentiation

Gene flow is considered to be an important homogenizing force holding a species together. (Jackson and Pounds, 1981; Morjan and Rieseberg, 2004). However, some authors have suggested that gene flow is a weak and therefore evolutionarily irrelevant homogenizing force, and that selection is more likely to be the main reason for species cohesion. (Ehrlich & Raven 1969). To accurately determine the effectiveness of gene flow as a homogenizing force, studies of gene flow must be conducted over a variety of geographic distances. In the present study, we compare the genetic differentiation among populations of two small insectivorous lizards, side−blotched lizard (*Uta stansburiana*) and zebra−tailed lizard (*Callisaurus draconoides*). The Cima Lava Field in the Mojave National Preserve provides a good opportunity to study gene flow patterns across a variable landscape. The lava field region consists of light granite sands infiltrated by large patches of dark lava, overall about 20 km long. Previous research on *U. stansburiana* in the same region directly observed the lizard on both lava and granite sands and documented dark and light color polymorphisms (Micheletti et al. 2012). Field observations by our lab suggest that although *C. draconoides* resides on the sandy washes that surround and sometimes wind through the lava field, it is not able to use the lava rock as habitat. Thus the lava acts as a semi−permeable barrier to *Callisaurus* but not to *Uta*. Both species at this site were discovered to have an unusually high levels of both mitochondrial and autosomal genetic diversity (Micheletti et al. 2012, Hague unpublished data).The high amount of diversity provides sufficient genetic variation to enable exploration of the effects of microgeographic barriers on genetic differentiation.

101.2 SMITH, A.J.*; BERTHAUME, M.A.; ANDERSON, P.S.L.; University of Massachusetts at Amherst, Duke University, Durham, NC, University of Hull, UK; *ajsmi1@cns.umass.edu*

Effects of Food Item Shape and Size on Optimal Notch Angle During Ductile Food Item Fracture

It is common to assume that teeth are optimal for their function, but few studies evaluate the impact of the size and shape of food items on tooth function. Here we test the hypothesis that the size and shape of food items does impact the performance of one specific tooth morphology; notch angle, the angle between two cusps or teeth. Many animals have prominent notches including the carnassial teeth of carnivorous mammals, some sharks, and the beaks of edentate animals such as turtles and birds. We used four different blades with known notch angles (60°, 90°, 120°, 180°) to fracture "food items" made of soft clay. The clay was molded into three different shapes (flat, cylinder, and hemisphere) and a variety of sizes. We measured maximum reaction force and energy to fracture, and identified the notch angle that minimized reaction force or energy to fracture as the optimal notch angle for each food item shape. We discovered that optimal notch angle changed radically as food item shape and size changed, and concluded that variation in food item shape and size should be taken into account when inferring function from tooth shape. We found that, in general, the optimal notch angle is smallest for flat food items and largest for hemispherical food items. No such pattern emerged concerning optimal notch angle and food item size, even though optimal notch angle varied with size. Finally, these data suggest that at least some teeth are optimal for their function, as members of the order Carnivora which consume flatter food items tend to have lower notch angles (i.e., hypercarniverous lions and tigers) while members of the same order that consume more cylindrical food items (i.e., durophagous hyenas) tend to have larger notch angles.

81.6 SMOOT, SC*; PLANTE, CJ; PODOLSKY, RD; College of Charleston; *scsmoot@gmail.com*

Within−species variation and phylogenetic patterns in anti−bacterial activity in egg masses of 16 mollusc species

Gelatinous egg masses are used by several species of marine invertebrates to encapsulate embryos until hatching. The high protein and mucopolysaccharide content of these egg masses make them particularly hospitable to microbial growth and therefore susceptible to infection. Previous studies have isolated chemical compounds from egg masses that deter bacterial infection, but have not examined quantitative differences among species or the effects of environmental variation on these defenses. We compared the anti−bacterial activity of egg masses from 16 sympatric molluscan species or species groups that varied in ecological habitat and deposition substrate. Egg masses were extracted with non−polar ethyl acetate (EtOAc) and polar methanol (MeOH) solvents and then tested for anti−bacterial activity against the Gram−negative bacterium *Vibrio harveyi* and Gram−positive *Bacillus subtilis* in a 96−well plate growth assay. In addition to large differences among species in anti−bacterial activity we also found within−species variation tied to habitat type and deposition substrate. Furthermore, we detected a phylogenetic signal at higher taxonomic levels, with cephalaspids showing the highest level of anti−bacterial activity and nudibranchs showing surprisingly low levels. A randomization test found a significant difference between the cephalaspids and nudibranchs in the activity both extracts against *V. harveyi* but not against *B. subtilis*. These results suggest wide interspecific and intraspecific variation in the degree of anti−bacterial protection in embryo encapsulating structures. Levels of anti−bacterial protection appear to depend both on phylogeny and on environmental conditions at small and large spatial scales.

P2.36 SMYTH, K*; DREA, C; Duke University, Durham, NC; *kendra.smyth@duke.edu*

Dominance status and gastrointestinal parasites in meerkats (Suricata suricatta)

In many species, testosterone influences the development of male secondary sexual characteristics, as well as the expression of territorial and sexual behavior. The well−documented benefits of elevated testosterone in males, including enhanced aggressiveness and high−quality sexual ornaments, ultimately act to increase reproductive success. Although less studied in this regard, females may also benefit from testosterone. In the meerkat (*Suricata suricatta*), a cooperatively breeding mongoose characterized by female social dominance and marked female reproductive skew, dominant females benefit from elevated testosterone through increased competitive abilities, enabling them to monopolize preferred food resources and control reproduction via eviction of subordinate females or infanticide. Such benefits may not be without costs, however, as in various species testosterone has been associated with increased mortality owing partly to reduced immune function and increased parasitism. In this study, which represents the first comprehensive immunological assessment of free−ranging meerkats, we applied the techniques of ecological immunology to evaluate health−related costs of dominance. Specifically, we quantified the gastrointestinal parasites infecting dominant and subordinate individuals and found the composition of parasite communities to differ based on host social status.

12.5 SNELLING, J; MEYER, E*; Oregon State University;
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A genetic linkage map of the coral Orbicella faveolata produced by 2bRAD genotyping of single larvae
Scleractinian corals are acutely sensitive to elevated temperatures, prompting widespread concern over their fate during global climate change. Genetic variation in corals' responses to temperature may in principle support an adaptive response to warming temperatures, but the lack of a complete genome assembly has hampered efforts to identify genomic regions underlying such variation in corals. To help develop resources for genomic analysis of thermal tolerance in corals, we focused on *Orbicella (Montastraea) faveolata*, a dominant and widely studied component of Caribbean reefs. To evaluate the suitability of 2bRAD for genome−wide genotyping in corals, we first characterized genetic diversity among parental colonies. This analysis genotyped 1.4 Mb per sample, revealing 1 SNP every 228 bp on average, many of which (42%) were suitable for linkage analysis. To demonstrate the reproducibility of 2bRAD genotyping in the small amounts of DNA obtained from individual larvae, we compared genotypes determined from replicate preparations of the same DNA, revealing acceptably low error rates (1 disagreement per 10,727 bp). A population of 100 full−sibling larvae obtained by crossing the most diverse pair of parents was then genotyped using 2bRAD, and linkage groups inferred using JoinMap software. We present the consensus linkage map, along with a bulk−segregant analysis of mortality during development to demonstrate the utility of this map for genomic analysis. We also discuss the potential for linkage analysis to organize scaffolds from shotgun genome assemblies, highlighting an efficient route to chromosome−scale genome assemblies that we expect to be widely applicable in many non−model species.

115.5 SODA, KJ*; SLICE, DE; Florida State University, Tallahassee; *kjs11w@my.fsu.edu*
The Use of Geometric Morphometrics to Characterize Morphology and Movement in Bipalium cf. vagum
Over the past few decades, geometric morphometric methods (GMM) have revolutionized how morphometric studies are conducted. Because GMMs are able to maintain all geometric information present in a set of landmarks, semilandmarks, or outlines throughout an analysis, these methods have allowed researchers to maximize the information available to characterize structures, to draw comparisons, and to reveal covariation between structures and additional variables. However, these methods have usually been restricted to hard structures, while morphometricians working on soft−bodied organisms have continued to rely on qualitative descriptions and linear measurements. Perhaps the largest reason that GMMs have thus far been restricted to hard structures is the dynamic nature of soft−bodied organisms' shapes. Here we discuss a new method to characterize the morphology and locomotion of a soft−bodied planarian, *Bipalium* cf. *vagum*, via GMMs and geometric motion analysis. How this information can be interpreted and future applications to other systems are discussed.

S1.1−2 SOLIMAN, Karam F; Florida A&M University;
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Epigenetic Mechanisms and Environmental Signals
Exposure to specific environmental conditions can alter the epigenome, as the control mechanism of genomic DNA expression, and can lead to long−term phenotypic consequences as certain chronic diseases. These epigenetic changes are plastic and can be altered at different points of development, which can have varying impact on disease incidence. Epigenetic alterations such as DNA methylation or histone modifications patterns are associated with each unique maladaptive phenotype. This is further complicated by a limitless combination of environmental cues that could alter the epigenome. DNA methylation is initiated by DNMTs that methylate CpGs, which are tagged by MBD proteins attached to potent repression complexes. The repression complexes, in turn, control modifications to histones H3 and H4 tails, which perpetuate constriction and make stable modifications to the histone cores H2A and H2B to prevent histone unit ejection/nucleosomal displacement. These collective events are associated with stabilized tension of the histone H1 linker. HP1± and HP1² proteins tether silencing elements from methylated CpGs to ATPase remodeling machinery−together, in order to tightly crowd methylated DNA close to the nucleosomes, thereby blocking transcription elements. The positioning of silenced heterochromatin along the nuclear envelope is carried on by lamins. Within euchromatin, unmethylated CpG islands remain open to transcription initiation complexes by opposing processes such as hyperacetylation of histone tails, H2A core variant exchange, HMG proteins binding. In summary, research in this area indicates that the more we learn about epigenetic mechanisms of gene regulation, the more complex it seems. However, more understanding of the environmental role in the epigenetic basis of diseases will help in providing more effective means in disease prevention and to develop new improved therapies.(Supported by NIH grants G12 MD007582and P20 MD006738)

106.6 SOLOMON−LANE, T.K.*; WILLIAMS, M.M.; MARTINELLI, A.C.; THOMAS, A.; ROGERS, L.; GROBER, M.S.; Georgia State Univ., Atlanta, Agnes Scott College, Atlanta, Colombia Univ., New York; *tsolomonlane1@student.gsu.edu*
Reproductive choices, hormones, and behavior in bluebanded goby (Lythrypnus dalli) social groups
Reproductive choices are complex and influenced by internal and external factors including social status, group behavioral dynamics, and steroid hormones. Bluebanded gobies (*Lythrypnus dalli*) form hierarchies of one dominant male and multiple subordinate females, and reproduction in these groups is related to patterns of agonistic interaction and individual reproductive state/behavior. To examine the causes and consequences of reproductive choices, we formed social groups with females of specific reproductive states: the highest (alpha) and middle−ranking females (beta) were either very gravid or not gravid (gamma was never gravid). Within 48 hours, eggs were laid in 45% of groups with at least one gravid female, and 73% of the layers were alphas, indicating an advantage for social dominance. The presence of multiple gravid females was a strong motivator to reproduce: eggs were laid in 78% of groups with a gravid alpha and beta compared to 42% of groups with only a gravid alpha or 25% of groups with only a gravid beta. Despite these dramatic reproductive differences, behavioral variation among groups was nuanced. Male− and gamma−initiated behaviors, particularly directed at beta, varied among treatments, as did beta agonistic efficiency. In addition, although neither alpha gravidity nor the presence of eggs affected behavior, beta gravidity may be a salient signal. Finally, we examined associations between steroid hormones (systemic, brain) and individual behavior and reproduction. These data provide critical insights into the proximate regulation of reproductive success in social species.

65.3 SOMA, K.K.; University of British Columbia; *ksoma@psych.ubc.ca*

Steroid Synthesis in the Brain

Endocrinologists have traditionally focused on circulating hormone levels. In the case of steroid hormones, circulating steroids can be locally metabolized within the brain to either more active or less active signaling molecules. Furthermore, the brain can synthesize sex steroids, such as androgens and estrogens, de novo from cholesterol or from inactive precursors in the blood ("neurosteroids"). For such reasons, steroid levels in the blood and brain can differ dramatically. In birds, local steroid synthesis has been implicated in the control of territorial behavior, auditory communication, and neural plasticity. In particular, recent data suggest that aggressive interactions rapidly increase androgen synthesis in the brain of male song sparrows (Melospiza melodia) during the non−breeding season. In contrast, aggressive interactions do not affect circulating androgen levels in the non−breeding season. These data suggest that the Challenge Hypothesis stated by John Wingfield operates at a highly local level in the brain of non−breeding song sparrows.

P2.132 SONG, S.M.*; BURNETT, L.E.; BURNETT, K.G.; College of Charleston; *song.sarah@gmail.com*

Effects of hypoxia and sub−lethal bacterial injection on critical oxygen pressures of penaeid shrimp

Estuarine organisms such as juvenile penaeid shrimp experience fluctuating O_2 pressures on a daily basis. In coastal waters of the southeastern US, severe hypoxia (4−6 kPa) is common in the summer, also a time during which bacterial concentrations in seawater are high. In response to invading bacteria, crustaceans mount an immune defense resulting in aggregation of circulating hemocytes. These aggregates can be trapped in and obstruct hemolymph flow through the gills, inhibiting O_2 uptake. Hypoxia itself is also known to inhibit immune function. In this study we compare overall O_2 uptake in two commercially important shrimp species following acute exposure to environmental hypoxia, and injection with a sublethal dose of bacteria. Wild−caught *Litopenaeus setiferus* (Atlantic white shrimp) and aquacultured *L. vannamei* (Pacific whiteleg shrimp) were held in normoxia (>16 kPa) or hypoxia (~10 kPa) and injected with saline or bacteria (*Vibrio campbellii* 90−69B3). The rate of O_2 uptake and critical O_2 pressure (Pcrit), the pressure below which O_2 uptake depends on available O_2, were measured. Trials with bacterial injections are ongoing; preliminary results of LD_{50} tests suggest that virulence of *V. campbellii* in *L. setiferus* (LD_{50} = approx. 7.61×10^5 CFU g^{-1} shrimp) is similar to that previously determined in *L. vannamei* (LD_{50} = 3.06×10^5 CFU g^{-1} shrimp). In normoxia, the Pcrit of *L. vannamei* (3.5 kPa) is lower than that of *L. setiferus* (6.3 kPa). This is consistent with previous findings in our lab, that hemocyanin in *L. vannamei* has a higher O_2 affinity than that in *L. setiferus*. These data suggest that *L. vannamei* is better adapted to hypoxia than *L. setiferus*. (NSF IOS−1147008)

120.4 SONNEFELD, M.J.*; TURINGAN, R.G.; Florida Institute of Technology; *msonnefeld2008@my.fit.edu*

The Drivers of Feeding Mode in Marine Teleost Fishes

It is well known that the feeding mode of fish falls within a continuum of prey−capture techniques and behaviors; fish could use suction, ram, or manipulation (bite) to feed on a subset of a diverse prey−resource base. The main goal of ecomorphological research is to model the relationship between form and function, and in the case of fish feeding, one of the key questions is, "How does the functional design of the feeding mechanism constrain fish to a particular feeding mode?" This study initially addresses this question by conducting a multivariate analysis to determine which of the key functional components of the feeding mechanism predicts the feeding mode of teleost fishes along the Atlantic coast of Florida. Sixteen feeding−relevant traits from each of 22 species were subjected to a Principle Component Analysis to generate a morphospace for the assemblage. The first two dimensions contributed 99% of the variation in functional morphology among members of this assemblage; the physiological cross−sectional area of the epaxialis muscle loaded heavily in these axes. A Discriminant Function Analysis revealed that the drivers that discriminate the assemblage among suction, ram, and manipulation feeding modes are Suction Index, mechanical advantage of the jaws, and mechanical advantage of neurocranial rotation. The model revealed that 91% of the species' feeding modes were correctly predicted by properties of the feeding mechanism. Appropriately establishing the link between morphology and ecology remains a valuable tool in our continuing search for information that advances our understanding of the underlying mechanisms that drive the diversity and evolution of feeding systems.

86.6 SOTO, W*; TRAVISANO, M; NISHIGUCHI, M.K.; University of Minnesota, Twin Cities, New Mexico State University; *nish@nmsu.edu*

Ecological Diversification of Vibrio fischeri During the Planktonic Phase & Subsequent Consequences for Squid Host Colonization

Stable microcosm experiments with bacteria have become model systems for studying microbial ecological diversification, whereby standing liquid cultures founded by planktonic, water−column inhabiting cells that form smooth colonies (smooth morphs) on agar plates differentiate into alternative types due to resource competition as a result of mutations. These variant cell types can either establish pellicle and/or benthic populations in structured, undisturbed, and heterogeneous microcosms. When grown on agar plates, the derived cell types can form wrinkled and fuzzy colonies (wrinkly−spreaders and fuzzy spreaders). Bacteria in the family Vibrionaceae are gram−negative bacteria living in marine and brackish waters as planktonic cells and biofilms attached to abiotic surfaces or eukaryotic host cells. In particular, *Vibrio fischeri* is a marine bioluminescent microbe that exists mutualistically with sepiolid squids and monocentrid fishes. Although *V. fischeri* has been well studied as a beneficial bacterium during host colonization, adaptive radiation during the free−living phase due to mutations and the accompanying effects on animal host colonization are poorly understood. *V. fischeri* wrinkly−spreaders that evolve in stable microcosms as free−living cells are competitively superior during squid colonization relative to their smooth morph ancestors, indicating that simple *de novo* mutations can significantly affect symbiosis. Understanding how bacteria are capable of adapting to fluctuating conditions in the environment may provide insight to how organisms accommodate these changes to their dual life history between planktonic and symbiotic states.

P1.73 SPAINHOWER, K.B.*; MILLIGAN, C.A.; CHRISTENSEN, L.A.; GOLLER, F.; MEYERS, R.A.; Weber State University, Ogden, UT, University of Utah; *rmeyers@weber.edu*

Species Differences in the Restructuring of Syringeal Muscles After Denervation

The muscles of the avian vocal organ, the syrinx, are composed of fast and superfast muscle fibers, which enables them to rapidly control song features. Unilateral denervation of the syrinx results in the reduction of cross−sectional area and a shift to slower fiber types. Our previous denervation experiments on male Zebra Finches (*Taeniopygia guttata*) showed a 10% reduction of total muscle cross−sectional area and a 30% reduction of superfast fibers seven days after unilateral denervation of the syrinx. Decrease in cross−sectional area and superfast fiber percentage reached a maximum at eleven days at 72% and 70% of their original values. By 40 days, the cross−sectional area and fiber percentage of the denervated side had almost returned to their original values. Because this post−denervation recovery is unusually rapid in Zebra Finches, we repeated the experiment on male Yellow−headed Blackbirds (*X. xanthocephalus*) for comparison. Four birds were unilaterally denervated between three and 35 days. We quantified the cross−sectional area and the average fiber diameter for each bird, and the results differed greatly from those of the Zebra Finch experiments. By day seven, blackbird cross−sectional area was reduced to 85% of its original value, average diameter of both fiber types decreased, and each continued to decrease post−denervation. In contrast to the finches, cross−sectional area of the blackbird denervated syrinx was reduced to 40% of control by day 17. Results from the Yellow−headed Blackbirds are consistent with the results from work done on mammals and suggest that innervation of the syrinx in Zebra Finches may be unusual. Further studies will repeat the experiment at additional time intervals and increased sample size.

48.1 SPEISER, D.I.*; DEMARTINI, D.G.; OAKLEY, T.H.; Univ. of California, Santa Barbara; *dispeiser@gmail.com*

The origin of screening pigments in the evolution of the shell' eyes of chitons (Mollusca: Polyplacophora)

Image−forming eyes have evolved multiple times in Mollusca. We are studying these eyes to learn: 1) the functional consequences associated with the separate steps of eye evolution and 2) the changes in genotype associated with the transitions between these steps. We are working on chitons because they have unique sensory structures embedded in their shell plates ("aesthetes") that vary from the ancestral condition of non−pigmented, light−sensitive cells ("photoreceptors"), to bundles of pigmented cells ("eyespots"), to what may be the most recently evolved eyes with lenses ("eyes"). The eyes and eyespots of animals use a variety of pigments − *i.e.* melanins, pterins, and ommochromes − to screen off−axis light from reaching photoreceptors. To study the evolution of the eyes of chitons, we are characterizing the screening pigments used by their eyes and eyespots, as well as the genes associated with the production of these pigments. Our findings − based on evidence from spectral analysis, high−performance liquid chromatography (HPLC), and mass spectroscopy − indicate that several chitons with eyes (*Acanthopleura granulata* and *Squamopleura araucariana*) and eyespots (*Chiton virgilatus*) use pheomelanin, a red−brown pigment that is soluble in NaOH, as their screening pigment. Chitons are thus the first mollusks known to use pheomelanin as a screening pigment. From transcriptome sequencing, we find that pigmented and non−pigmented aesthetes from chitons express a homolog of *tyrosinase*, the gene responsible for the production of melanin in other mollusks, as well as many other organisms. We hypothesize that changes in the expression level or enzymatic activity of *tyrosinase* may have contributed to the origin of screening pigments in chitons.

P1.62 SPENCE, AS*; SMITH, GD; FRENCH, SS; Utah State University; *austin.r.spence@gmail.com*

Effect and prevalence of the endoparasite Plasmodium across the range of Uta stansburiana

Parasitic infections can be costly for organisms, with consequences such as loss of nutrition, decreased body condition, or impaired immunocompetence. In this study, blood slides from side−blotched lizards, *Uta stansburiana*, were created from populations in Arizona, Utah, and Oregon to assess the prevalence of the endoparasite *Plasmodium* across the lizard's range and to investigate possible effects on hormone levels and immune function. The blood slides were stained and examined using a standardized screening procedure through a microscope to determine the presence of *Plasmodium*. Infected and uninfected individuals were then compared in their capacity to produce corticosterone in response to a uniform stressor, their body size, and their bacterial killing capability. Averages between populations and states were also compared. There was a significant difference between populations in Utah and Oregon, suggesting that *Plasmodium* infection rates are lower in the northern parts of the *U. stansburiana* range. While bacterial killing ability at individual and population level had no significant correlation with infection, infected animals were smaller and had lower baseline corticosterone that uninfected animals. Further research will improve our understanding of what effects *Plasmodium* has on free living individuals and populations throughout the western United States.

15.6 SPERLING, E.A.*; FRIEDER, C.A.; RAMAN, A.V.; GIRGUIS, P.R.; LEVIN, L.A.; KNOLL, A.H.; Harvard University, Scripps Institution of Oceanography, Andhra University; *sperling@fas.harvard.edu*

Oxygen, ecology, and the Cambrian radiation of animals

The Proterozoic−Cambrian transition records the appearance of essentially all animal body plans (phyla), yet to date no single hypothesis adequately explains both the timing of the event and the evident increase in diversity and disparity. Ecological triggers focused on escalatory predator−prey arms races' can explain the evolutionary pattern but not its timing, whereas environmental triggers, particularly ocean/atmosphere oxygenation, do the reverse. Using modern oxygen minimum zones as an analogue for Proterozoic oceans, we explore the effect of low oxygen levels on the feeding ecology of polychaetes, the dominant macrofaunal animals in deep−sea sediments. Here we show that low oxygen is clearly linked to low proportions of carnivores in a community and low diversity of carnivorous taxa, while higher oxygen levels support more complex food webs. The recognition of a physiological control on carnivory therefore links environmental triggers and ecological drivers, providing an integrated explanation for both the pattern and timing of Cambrian animal radiation.

P3.95 SPICA, E.; DAVIS, G.K.*; Bryn Mawr College; *gdavis@brynmawr.edu*

Induction of reproductive fate in the Pea Aphid

The pea aphid, *Acyrthosiphon pisum*, exhibits several environmentally cued, discrete, alternate phenotypes (polyphenisms) during its life cycle. In the case of the reproductive polyphenism, differences in day length determine whether mothers will produce daughters that reproduce either sexually by laying fertilized eggs (oviparous sexual reproduction), or asexually by allowing oocytes to complete embryogenesis within the mother without fertilization (viviparous parthenogenesis). Among other aspects of the polyphenism, we are interested in the process that specifies sexual versus asexual fate during embryonic development. Several lines of evidence implicate juvenile hormone (JH) in this process, namely that titers of JH correlate with day length (1) and that topical application of JH can alter reproductive fate (2). Together these observations suggest that high titers of JH are responsible for specifying asexual fate. We are exploring this JH hypothesis further by testing whether JH is also *required* for the specification of asexual fate during embryonic development. So far we have confirmed the requirement for JH and hope to extend this result by additionally discriminating among competing models for the role JH plays in the process. (1) Corbit TS, Hardie J. 1985. Juvenile hormone effects on polymorphism in the pea aphid, *Acyrthosiphon pisum*. *Entomologia Experimentalis et Applicata* 38: 131−135. (2) Ishikawa A, Ogawa K, Gotoh H, Walsh TK, Tagu D, Brisson JA, Rispe C, Jaubert−Possamai S, Kanbe T, Tsubota T, Shiotsuki T, Miura T. 2012. Juvenile hormone titre and related gene expression during the change of reproductive modes in the pea aphid. *Insect Mol Biol* 21: 49−60.

73.6 SPONBERG, S*; HALL, RW; DANIEL, TL; Univ. of Washington; *bergs@uw.edu*

Sensory and motor determinants of tracking performance in free flight and low light

In sensory deprived environments such as the low luminance conditions of dusk and night, visual processing limitations can be the primary constraints on performance. Yet the mechanics of how the body responds to neuromuscular commands could still express considerable influence on locomotor performance. We explored these two determinants of performance flight at very low light levels where the hawkmoth, *Manduca sexta*, visually tracks and forages from flowers subject to continuous perturbations in unsteady air currents. Vertical and horizontal motion detection circuits are separate, but have comparable processing properties. In looming, tracking performance may be poorer due to limitations of detecting visual expansion. If sensing limits performance, then tracking should equivalent in vertical and horizontal directions, while reduced in looming. To test these predictions, we allowed naïve, freely flying moths to feed from a robotically actuated flower, which we oscillated with multiple sinusoids from 0.2 to 20 Hz in any of the three directions. After converting moth and flower movement to the frequency domain, we calculated the ratio of their motion amplitudes (the gain), their relative timing (phase) and extracted a combined tracking error metric. Vertical tracking varied more in gain and showed worse performance at low frequencies. However it did not fall off in phase as quickly as horizontal tracking and performance only degraded above 2 Hz compared to 1 Hz for horizontal. Surprisingly, looming performance was significantly better at low frequencies than either of the other modes due to a more favorable combination of gains and phase lags. We reject the sensory limitation hypothesis. The dynamics of movement are critical determinants of tracking performance even when sensory information is highly constrained.

97.4 SPRAYBERRY, JDH; Muhlenberg College; *jsprayberry@muhlenberg.edu*

Effects of Manzate odor on processing of floral scent in bumblebees

Bumblebees, along with honeybees, have experienced alarming declines in recent decades. There are numerous factors known to contribute to declines in bumblebee colony fitness. One potential factor is a reduction in foraging efficiency. Recent work in our lab has shown that olfactory pollution of a learned floral scent modifies foraging behavior. The most pronounced effects were observed with Manzate, a commercial fungicide. While behavior experiments exposed *Bombus impatiens* to the headspace of Manzate alone (a sulfurous scent), the effects of this agrochemical on the olfactory pathway is unclear. To investigate potential modulation of olfactory processing by Manzate odor, we performed electroantenograms (EAG) on *B. impatiens* antennae and multi−unit recordings on antennal lobes in response to lavender odor, Manzate odor, and lavender + Manzate. The EAG data unsurprisingly show a robust response to lavender odor. Likewise, they clearly demonstrate that the antennae do indeed tranduce Manzate odor. However the response to lavendar + Manzate does not appear summative − rather the addition of Manzate can result in a lower peak response than to lavender alone. Ongoing analysis of multi−unit recordings will elucidate the effects of Manzate on the neural representation of lavender odor in the antennal lobe.

93.4 SPRINGTHORPE, D*; NG, P; FULL, R.J.; Univ. of California, Berkeley; *dspringthorpe@berkeley.edu*

Effect of moisture content on burrowing performance of ghost crabs

Prior work demonstrated that ghost crabs (*Ocypode quadrata*) build semi−permanent burrows in a relatively uniform substrate using a complex behavioral suite that includes specialized postures, locomotion in confined environments and goal−directed manipulation of the substrate. However, ghost crabs burrowing in nature must contend with highly variable environments where physical characteristics can quickly be substantially altered. Here, we examine burrowing performance in our artificial beach environment in response to changes in gravimetric moisture content (GMC). We measured burrow extension rate and burrow architecture for crabs ranging in body size from 26−45mm in carapace width. Crabs were unable to burrow in dried sand and in sand with a GMC above 21%. For GMCs ranging from 3−12%, which represents a 9% increase in substrate density and an estimated 30% increase in elastic shear modulus, crabs dug J− or U−shaped burrows, consistent with both prior laboratory and field observations. Crabs burrowed between 50 and 75 cm in depth. Smaller crabs burrowed significantly faster than larger crabs. Crabs with a carapace width of 26 mm extended their burrows (0.9±0.5 cm/min) approximately three times faster than crabs with a carapace width of 45 mm (0.3±0.2 cm/min). Normalized burrow extension rate (body lengths per minute) demonstrated a significant negative correlation with carapace width. Varying GMC from 3% to 12% produced no significant changes in burrow extension rate. Ghost crab burrowing is a flexible behavior capable of accommodating a range of environmental conditions. Further experiments to identify the compensatory mechanisms will offer new insight into mobile manipulation with simple appendages and inspire a new generation of robots capable of transforming their terrain.

P2.9 SPRINGTHORPE, S.K.*; STONE, W.E.; Salem College, Winston−Salem, NC, Alabama Agricultural and Mechanical University, Huntsville; *sarah.springthorpe@salem.edu*

Foraging Ecology of Bats in Developed and Forested Areas in Nanjing, Jiangsu, China

Bats play key roles in many ecosystems, but the rapid urbanization that is occurring in China may have detrimental effects on their species composition and foraging activity. To determine if there has been an impact, this study was conducted to examine what the bat species are eating in Nanjing and if there is a difference in their diets and the foraging activity in developed and forested habitats. Bat foraging activity was assessed at 9 sites on 13 nights by measuring the number of echolocation calls with an Anabat II bat detector per one minute intervals every five minutes for an hour. Nine bats were captured using mist nets while recording calls at these same sites. Guano was collected from these bats and analyzed for diet composition using a nine point grid overlay on eleven magnified photos of the guano for each bat. Three species were caught: three *Pipistrellus abramus*, which had a generalist foraging strategy, five *Eptesicus serotinus*, which consumed 64% Coleoptera, and one *Rhinolophus pearsonii*, which consumed 68% Lepidoptera. The results of a t−test revealed that bat foraging activity was significantly higher in developed sites($n=7$) than in forested sites ($n=6$, $p=0.02$). Results reveal that there were no significant differences between the diets of *P. abramus* in forested habitats ($n=1$) and developed habitats ($n=2$, $p>0.05$). Evidence of ground gleaning on a springtail was found in one *P. abramus*. Future work needs to examine the foraging strategies of the *P. abramus* and to focus on obtaining a larger sample size.

40.2 SQUIRE, M S*; ROSENTHAL, G G; Texas A&M University; *squiremk@gmail.com*

Mate Choice in a Hybrid Zone: Chemical and Visual Preferences of Male Swordtails,

Species recognition via various cues, including chemical and visual cues, is extremely important when it comes to animals' mating preferences and subsequently, mate choice and reproductive fitness. Multivariate cues may be especially important; an animal may rely on multiple cues presented simultaneously when choosing whom to mate with. Hybrid zones represent a breakdown in species recognition; heterospecifics may mate if certain cues are missing. In the *Xiphophorus malinche/X. birchmanni* hybrid zone of the Sierra Madre Oriental of central Mexico, anthropogenic disturbance has led to species recognition breakdown: chemical pollutants in the water have been found to block the olfactory receptors of these fish, leaving them to chose mates based mostly on visual cues. Past research in the lab has found that females of both species tend to favor the visual cues of male *X. birchmanni*. In addition, another study found that *X. birchmanni* males also tend to choose the chemical cues of *X. malinche* females over those of conspecifics. This complex array of preferences highlight the need to understand both male and female multivariate preferences in order to determine the fate of these species and the hybrid zones they form. In this study, we set out to determine both the chemical and visual preferences of *X. malinche* males, so that we may complete the preference picture. Using this information, we can make more informed hypotheses about the interactions within the hybrid zone and the future of these two species.

P3.164 SQUYRES, N.S.; Johns Hopkins University; *nsquyre1@jhmi.edu*

Limb Joint Surface Area Ratios in Living and Extinct Carnivorans

Differences in relative humeral and femoral head size are thought to be related to locomotor capabilities in carnivorans. Measures of humeral and femoral articular surface size, shaft robusticity, and relative femoral neck size were collected in 148 individuals of 21 carnivoran taxa to test this hypothesis. The ratio of humeral/femoral head size appears to differ between more and less arboreal taxa, with more arboreal taxa generally having relatively large femoral heads. Taxa that emphasize forelimb use in activities such as digging and large prey capture have relatively large humeral heads. Species with relatively large femoral heads do not necessarily have relatively robust femoral shafts, but do have relatively small femoral necks. This suggests that increases in femoral head size are driven by the need for greater hip excursions rather than by greater hind limb loading during arboreal movement. Application of these data to extinct carnivorans *Miacis*, *Didymictis*, and *Vulpavus* confirms previous conclusions about locomotor behavior in these genera based on other aspects of postcranial morphology.

47.5 SRIVASTAVA, M*; MAZZA−CURLL, KM; REDDIEN, P; Whitehead Institute/MIT; *mansi@wi.mit.edu*

Molecular mechanisms for whole−body regeneration in acoels

Whole−body regeneration is widespread in the Metazoa, yet little is known about how underlying molecular processes compare across distantly related phyla. Acoels are an enigmatic phylum of invertebrate worms that can be highly informative about many questions in bilaterian evolution, including regeneration. We developed the three−banded panther worm, *Hofstenia miamia*, as a new acoelomorph model system for molecular studies of regeneration. *Hofstenia* were readily cultured, with accessible embryos, juveniles, and adults for experimentation. We developed molecular tools and resources for study of gene function in *Hofstenia* regeneration, including a complete transcriptome and robust systemic RNAi. We report the identification of molecular mechanisms that promote regeneration of the two major body axes in *Hofstenia*. Phylogenetic analyses using the *Hofstenia* transcriptome support an early branching position for acoels among bilaterians. Based on the striking similarity of regeneration in *Hofstenia* and a protostome lineage, the Platyhelminthes, we propose that regenerative mechanisms have been well conserved over 500 million years of bilaterian evolution.

77.1 SRYGLEY, R.B.; USDA−Agricultural Research Service; *robert.srygley@ars.usda.gov*
Nutrient intake of nymphal and adult Mormon crickets and its effects on immunity
For insects, two of the most important dietary macronutrients are carbohydrates and protein, and many organisms regulate dietary intake of both. In the field, carbohydrate (C) to protein (P) intake of Mormon crickets is indicative of nutritional imbalance that had major effects on immunity to pathogens. Here we used a set of dietary choice experiments in the lab to investigate the preferences of Mormon cricket nymphs and adults for C and P. Diet pairs were selected that would allow Mormon crickets to reach a single intake target of C:P from four unique starting points. After the last pair of diets was removed on day 7, we assayed phenoloxidase and anti−bacterial activity. Both males and females at both the adult and nymphal stages showed a strong preference for the diet that was richest in macronutrients with equal preference for C or P. When given a choice of a high carbohydrate diet and a high protein diet, the Mormon crickets selected both at random, balancing their daily intake of C and P. Weight gained was highly dependent on the mass of protein consumed, with a conversion factor greater than four times that of the carbohydrates consumed. Those Mormon cricket nymphs that consumed more protein had higher titers of total phenoloxidase, but there was not a significant effect of diet on other measures of immunity. In nature, omnivores might consume an excess of one of the macronutrients because they can often find the other through active searching of their local habitat. However environmental change and interspecific or intraspecific competition can challenge an organism's ability to encounter required nutrients on a local scale, which contributes to the Mormon crickets' migratory behaviors. A preference for the richest diet suggests that only the concentration of one macronutrient needs to vary in the environment for Mormon crickets to be highly variable in their nutritional deficiencies.

P1.103 STAAB, KL*; REISER, PJ; HERNANDEZ, LP; McDaniel College, Ohio State, George Washington; *kstaab@mcdaniel.edu*
Interspecific and intermuscular differences in myosin heavy chain isoform expression: a case study using teleost jaw adductors
When asking questions about physiological properties of muscles, functional morphologists typically use electromyography or measurements of muscle mass or cross sectional area to derive meaningful metrics. Protein content of muscle is left for biochemists who often focus on model organisms, particularly mammals. Yet differences in sarcomeric protein isoforms could help explain functional diversity that characterizes teleost fishes. Specifically, disparities in myosin heavy chain (MyHC) isoforms largely determine contractile speed and force; thus differential expression of MyHCs underlies properties of whole muscles. We present a technique that has been ignored by functional morphologists with which large amounts of information can be obtained quickly without major investment in equipment. Using dot blots of extracted myosin and antibodies for different MyHC isoforms, we tested the hypothesis that divisions of jaw adductors in nine teleosts display patterns of MyHC expression correlated with functional diversity. The adductor mandibula is comprised of three divisions (A1, A2, & A3) and concomitant functions (A1−explosive upper jaw protrusion, A2−scraping and/or biting, A3−cyclic respiratory movements). This case study provides a framework for testing hypotheses of correlated MyHC expression and muscular function. We find that A1 shows a general correspondence between feeding mode and MyHC expression. While A3 contains the greatest proportion of slow MyHC, as expected given its function, there is greater diversity in predominant MyHC isoform among the examined species than predicted. We propose that this method can improve comparative studies of muscle function by addressing form−function from various levels of biological hierarchy.

P3.130 STABILE, F. S.*; WOODMAN, N.; The College of New Jersey, Ewing, National Museum of Natural History, Smithsonian Institution, Washington, DC and Pauxtent Wildlife Research Center, United States Geological Survey, Laurel, MD; *stabilf1@tcnj.edu*
Functional Limb Morphology of African Myosoricine Shrews (Mammalia, Soricidae)
Shrews in the African subfamily Myosoricinae exhibit considerable variation in skeletal morphology, which likely reflects variation in substrate use. To quantify this variation, we measured the postcranial skeletons of each of the three Myosoricinae genera (*Surdisorex*, *Myosorex*, and *Congosorex*). We then calculated 20 standard indices and used these to rank the potential burrowing ability of each species relative to *Uropsilus soricipes*, a terrestrial mole, and *Neurotrichus gibbsii*, a semifossorial mole. Indices related to the manus and the humerus provided the best indicators of fossoriality. Our ranking system yielded three groupings: *Congosorex phillipsorum*, *Myosorex cafer*, *M. kihaulei*, and *M. geata* are similar to *Uropsilus* and represent primarily terrestrial species. The remaining *Myosorex M. zinki*, *M. blarina*, *M. varius* have an intermediate morphology between the two moles and show some adaptations for burrowing. The *Surdisorex* are most similar to *Neurotrichus* and are best equipped to burrow. In terrestrial species, the distal phalanges and claws are short, the metacarpals long and thin, and the humerus slender, with small epicondyles, a short teres tubercle, and a small deltopectoral crest. In semifossorial species, the distal phalanges and claws are elongate and the metacarpals short and thick. The humerus is robust with wide epicondyles, a long teres tubercle, and a large deltopectoral crest. Myosoricine shrews exhibit quantifiable morphological variation that reflects a potentially broad range of substrate use. Thus, the postcranial skeleton is useful not only for species identification, but also for predictions of digging behavior.

P2.35 STACY, C.*; MANN, W.T.; MYDLARZ, L.D.; University of Texas at Arlington; *carlen.stacy−lara@mavs.uta.edu*
Variation in immune response of several Caribbean octocorals to stressors
As ocean temperatures rise, corals are becoming increasingly susceptible to infections. As many reef−building corals are dying off, octocorals are increasing in numbers, even though many are susceptible to disease and high levels of mortality have been observed in many Caribbean species including *Gorgonia ventalina* (sea fan), *Pseudoplexaura porosa* (porous sea rod) and *Briareum asbestinum* (corky sea finger). In this study, we examine the individual immune responses of each aforementioned species to disease observed naturally in the field. Healthy and diseased samples were collected from La Parguera, Puerto Rico . Coral tissue was homogenized in liquid nitrogen and proteins were extracted and used in a suite of biochemical assays. We measured prophenoloxidase activity, melanin concentration antioxidant (catalase, peroxidase, and superoxide dismutase), and antimicrobial (bacterial and fungal) activities. Preliminary data indicate varying degrees of response to disease between species. *G. ventalina* had the most significant upregulated immune response. These results suggest that there may be differences in disease susceptibility between species that are linked to their basal immunity and immune responses to infections. Increasing our understanding of how various octocoral species react to disease and stressors in the field can provide a better picture of the structure for future octocoral reef ecosystems.

113.4 STAGER, M*; SWANSON, D.L.; CHEVIRON, Z.A.; Univ. of Illinois at Urbana−Champaign, Univ. of South Dakota; *stager2@illinois.edu*

Molecular mechanisms of metabolic flexibility induced by synthetic, environmental cues in the Dark−eyed Junco (Junco hyemalis)

Phenotypic plasticity is considered a driving force in evolution; environmental variation can induce transcriptional responses that enable an organism to adapt by flexibly altering its phenotype. Although vertebrate biology is replete with examples of profound phenotypic plasticity, very little is known about the mechanisms responsible for these changes in wild animals. In order to gain insight into the fundamental mechanisms of metabolic flexibility, we evaluated the effects of two environmental cues (photoperiod and temperature) on seasonal variation in metabolic performance and correlated differences in underlying gene expression profiles in Dark−eyed Juncos (*Junco hyemalis*). We exposed overwintering juncos (n = 40) to a 6−week acclimation trial with (a) short or long day lengths and (b) cold (3°C) or warm (24°C) temperatures. We quantified thermogenic capacity (cold−induced summit metabolic rate) and collected pectoralis tissue for RNA−sequencing and quantifying enzyme activity. We tested for differential gene expression (n = 1894 genes among treatments) and then identified modules of highly co−regulated genes associated with thermogenic capacity (n = 19 genes). These modules were enriched for terms associated with fatty acid metabolism and muscle contraction. We also tested the connection between transcriptomic and proteomic responses (using activities of key metabolic enzymes and associated transcript abundances) and found them to be correlated, suggesting that transcriptomic responses do indeed result in phenotypic effects; however, gene expression did not predict the abundance of gene products at a 1:1 ratio. These findings show that increased metabolic performance is due to simultaneous changes in genetically independent, but interacting hierarchical pathways.

P1.20 STAHLSCHMIDT, Z.R.*; O'LEARY, M.E.; ADAMO, S.A.; Georgia Southern University, Dalhousie University; *zstahlschmidt@georgiasouthern.edu*

Food limitation leads to risky decision−making and to tradeoffs with oviposition

A growing body of research over the past decade indicates that inter−individual variation in behavior can result from behavioral plasticity (adaptive variation in behavior), behavioral types (individuals with consistent behavioral differences across one or more situations), or both. Although oviposition−site selection (OS) is widespread and affects both parents and offspring, it has been overlooked in the context of the behavioral type. Thus, we used the Texas field cricket (*Gryllus texensis*) to determine if OS could be integrated into the behavioral type paradigm and if a relevant environmental variable (food limitation) influences behavioral type. We found that behavioral type was consistent across contexts because individuals exhibiting riskier (bolder) behavior in a novel environment also exhibited riskier behavior during oviposition. Also, individuals traded off safety with food availability during oviposition that is, fasted crickets were more likely to choose food over safety (shelter) when making an oviposition decision. Last, individuals traded off feeding with oviposition because, relative to fed crickets, those that were fasted oviposited fewer eggs during overnight trials in which food was available. By integrating a behavior tightly linked to multi−generational fitness with an established behavioral assay (behavior to novel stimuli), we show that behavioral type can be both consistent across contexts and plastic in response to a ubiquitous environmental factor (food limitation).

10.3 STAHLSCHMIDT, Z.R.*; ACKER, M.; KOVALKO, I.; ADAMO, S.A.; Georgia Southern University, Dalhousie University; *zstahlschmidt@georgiasouthern.edu*

The balance between immune resistance and immune tolerance is dynamic and influenced by the environment

Animal immune systems must adaptively balance immune resistance (ability to destroy pathogens) with immune tolerance (ability to withstand self−damage caused by immune resistance mechanisms). Insects offer unique insight into this balancing act because phenoloxidase (PO)−mediated melanization is a key feature of immune resistance, but PO activation obligates the production of non−specific reactive species that can cause self−damage. We hypothesized that the resistance−tolerance balance is dynamic and, thus, influenced by the environment. Specifically, we tested two predictions using factorial manipulations of food availability and immune status throughout adulthood in female Texas field crickets (*Gryllus texensis*). We predicted that chronic immune activation would elicit increased levels of antioxidant capacity (a proxy for immune tolerance). Because resource (food) availability affects other important dynamics (e.g., the tradeoff between the number and quality of offspring), we also predicted the resistance−tolerance balance would be influenced by resource availability. Chronic immune activation (but not food limitation) led to greater immune tolerance (ability to survive exposure to paraquat, an oxidative stressor) in support of our first prediction. Chronic food limitation led to a reduction in the protein content of crickets' hemolymph. This, in turn, led to reduced total PO activity of hemolymph in food−limited crickets in support of our second prediction. We demonstrate that the balance between immune resistance and tolerance in insects is dynamic and affected by ubiquitous environmental factors (pathogen exposure and food availability).

62.2 STALEY, M*; BONNEAUD, C; HILL, GE ; Auburn University, University of Exeter; *mms0020@auburn.edu*

Are more ornamented birds better at combatting disease? Assessing the links between condition and ornamentation.

Condition is enigmatic. The concept of condition permeates the behavioral and physiological literature but exactly what it means for an individual to have high or low condition is poorly understood. Recently, condition was defined as the functionality of vital cellular processes, such that poor condition compromises the ability of an individual both to produce ornamentation and to perform well in maintenance tasks such as immune defense. In house finches (*Haemorhous mexicanus*), carotenoid−based plumage coloration in males is widely recognized as an indicator of condition. Our goal was to test the hypothesis that, because ornamentation and immune defense are both dependent on individual condition, plumage coloration would predict the ability of male house finches to resist infection by the bacterial pathogen *Mycoplasma gallisepticum* (MG). We collected male house finches from a population in Arizona that had no exposure history with MG, brought them to Auburn University, and experimentally inoculated them with MG. All finches showed symptoms of mycoplasmosis by 14 days post inoculation, at which time we euthanized all birds and collected tissues. We quantified the degree of bacterial proliferation in the conjunctiva tissue of infected birds with quantitative PCR. We then compared the feather color of birds (recorded at the time of capture) to the bacteria load. By studying this relationship between plumage coloration and individual performance in dealing with a pathogen in wild−caught birds, we can gain new insights into the role of condition in individual performance.

72.7 STAMPER, SA*; PLOCH, C; FORTUNE, ES; COWAN, NJ; Johns Hopkins Univ, Hope College, New Jersey Institute of Tech; *sstamper@jhu.edu*

During closed−loop refuge tracking, Eigenmannia virescens tunes its active sensing behavior to the length and features of the moving refuge

Weakly electric fish seek shelter and will swim to maintain their position within a moving refuge. This refuge tracking' behavior is thought to be an image stabilization task in which the fish swims to maintain the sensory image of the refuge on its sensorium −− retina and skin. However, other strategies may be used in the control of this behavior. For example, when tracking in the dark, fish generate ancillary whole−body oscillations as a form of active sensing, but clearly these movements do not stabilize the image. To better understand the sensory strategies used for refuge tracking, we examined how the length of the refuge and features (presence/absence of windows in the side walls) modulate tracking performance. We also examined active sensing strategies in both light and dark conditions. We found that tracking performance was improved for shorter refuges (less than a body length) and degraded for longer ones (greater than 1.5 body lengths). We found that the magnitude of active movements was dependent on the sensory condition and a combination of refuge length and features. When fish tracked the longest refuge, there was a significant increase in whole−body oscillations, especially when the refuge did not have windows.' Further, our analyses suggest that for longer refuges, the fish may not be simply tracking the refuge, but rather avoiding exiting the ends of the refuge. These data suggest that fish tune their active sensing regime depending on the features of the refuge in order to match the properties of electrosensory processing by neural circuits.

14.6 STARK, A.Y.*; BADGE, I.; WUCINICH, N.; PAOLONI, E.; NIEWIAROWSKI, P.H.; DHINOJWALA, A.; Integrated Bioscience Program, The University of Akron, OH, Department of Polymer Science, The University of Akron, OH, The University of Akron, OH, The University of Akron, OH; *ays3@zips.uakron.edu*

Surface Chemistry and Self−drying in the Gecko Adhesive System

Under certain conditions, geckos can maintain function of their adhesive system even when the surfaces they walk across are wet. For example, adhesion is not compromised when their superhydrophobic toes make contact with a hydrophobic surface. However, when the toe pads are wetted, they become virtually useless. This result is puzzling given that many species of gecko are endemic to rainy, tropical environments where water is likely to wet the toe pads. Wetting of the toe pads can occur during locomotion on submerged surfaces and also when geckos run on surfaces misted with water droplets simulating rain. However, how geckos lose their grip when toes are wetted is still not well understood. In this study we asked two questions. First, how does surface chemistry of the adhesive toe pad effect the likelihood of wetting and successful adhesion to surfaces with differing affinities to water? Second, once toe pads are wet and non−functional, can function be returned through an active self−drying mechanism similar to the active self−cleaning mechanism found in previous work on geckos? Our results suggest that there is a complex interaction between the surface chemistry of the adhesive toe pad and the substrate which determines how adhesion is lost and subsequently regained. This leads us to a better understanding of how geckos are capable of using a dry adhesive system in challenging environments, such as those that are wet from frequent rainfall events or high humidity.

110.4 STAYTON, CT; Bucknell University; *tstayton@bucknell.edu*

Lower morphological but greater functional diversity in aquatic emydid turtles, relative to terrestrial species

Morphological variation is frequently used as a proxy for functional variation. However, a variety of mechanisms can decouple these two forms of variation. Here I investigate whether greater morphological variation in the shells of terrestrial emydid turtles, relative to aquatic emydids, is also associated with greater functional variation. Morphology was quantified with geometric morphometrics, and function was quantified by finite element analysis (FEA) of shell models generated using the morphological data. Twelve load cases on the carapace and plastron were modeled and average and maximum stresses among all elements were extracted and used as functional data. Variation in morphology and function was quantified as per−taxon disparity for both aquatic and terrestrial species. Aquatic emydids show much higher levels of functional variation across all functional axes. This implies that aquatic taxa occupy a region of phenotypic space characterized by a relatively "steep" functional landscape. Previously, low morphological variation in aquatic emydids was attributed to a trade−off between shell strength (optimized by a tall, rounded shell) and hydrodynamic efficiency (optimized by a flat shell); it was assumed that only a limited number of shell shapes could produce adequate performance in both functions. The large amount of functional variation observed in aquatic taxa in the present study does not contradict this assumption, but it does indicate that trade−offs are not incompatible with functional diversity. Aquatic turtles appear to be diversifying along a morphological limited but functionally rich gradient, with strong shells (as strong as those of terrestrial taxa) on one end and streamlined shells on the other, while maintaining acceptable levels of performance in both functions.

121.6 STEFFENSON, M*; SHAIKH, H; MANN, W; BEACH−LETENDRE, J; MYDLARZ, L; University of Texas at Arlington; *mmsteff@uta.edu*

The effect of food constraints on wolf spider (Tigrosa helluo) fitness

All organisms must allocate energy through several major pathways including growth, reproduction, maintenance, and defense. Understanding how organisms distribute energy when faced with constraints gives us an opportunity to identify allocation pathways that are most important to individuals. The goal of this study was to identify how wolf spiders respond to decreases in prey availability using several measures of fitness, behavior, and defense. Spiders (*Tigrosa helluo*) were collected from Arlington, TX and brought back to the laboratory where they were provided one prey item per week or withheld food. At the end of 4 or 6 weeks specimens had their running speed recorded by chasing them down a track with a wooden dowel. They were subsequently weighed, anesthetized using CO_2 gas, and hemolymph was extracted for immunological assessment (protein concentration, antioxidant and antimicrobial activity). Using digital microscopy, the carapace length of each spider was recorded. Preliminary results indicate that body mass and carapace length were not affected by starvation. However, the running speed of the six week starvation group was significantly lower than that of the controls. Both protein concentration and immune activity also decreased significantly in both starvation groups. Overall, individuals with larger carapace lengths had both higher protein concentrations and immune activity. Our results indicate that as prey become less frequent, due perhaps in response to anthropogenic or environmental disturbance, or more erratic climate conditions, spiders may sacrifice immune response to maintain other measures of fitness.

P1.147 STEINWORTH, BM*; LAYDEN, MJ; CHOCK, T; ROTTINGER, E; MARTINDALE, MQ; Whitney Laboratory for Marine Bioscience, Université de Nice Sophia; *bsteinworth@gmail.com*

FGF−independent Mek signaling is required for proper specification of embryonic ectodermal neurons in the sea anemone Nematostella vectensis

To gain insight into mechanisms regulating neurogenesis in *Nematostella*, we treated embryos with Mek inhibitor U0126 and assayed expression of *NvashA*. *NvashA* is expressed in a salt and pepper pattern in wild type animals and promotes neurogenesis by activating expression of neural genes. Treatment with U0126 inhibits expression of *NvashA* and its previously identified targets. Because our previous studies suggested *NvashA* regulated development of a subset of the early nervous system, we wondered if U0126 regulated additional neural or salt and pepper genes during embryogenesis. We used a custom genome−wide microarray to identify transcription factors downregulated by U0126. *In situ* hybridization on wild−type animals identified transcription factors with a salt and pepper expression pattern. We tested whether array−identified genes functioned downstream of *NvashA* by activating or decreasing *NvashA* function and assaying for changes in gene expression. Data suggest only *Nvgfi−like* and *Nvtailless−like* are downstream of *NvashA*, suggesting the remaining genes may regulate *NvashA*−independent neurogenesis. Lastly, we asked if Mek promotes neurogenesis through *NvashA* by a linear pathway. We reasoned that if the pathway were linear, overexpression of *NvashA* in U0126−treated animals would rescue expression of *NvashA* neural target genes. Surprisingly, we were unable to rescue *NvashA* target genes in U0126−treated animals. These data suggest Mek plays at least two roles in embryonic neurogenesis in Nematostella: first, to promote expression of the neurogenic gene *NvashA*, and second, to confer competence for cells to positively respond to *NvashA* expression.

P2.120 STENGEL, A.*; KOHL, K.D.; DEARING, M.D.; Univ. of Utah; *ashley.stengel@comcast.net*

Toxin−degrading gut bacteria facilitate ingestion of tannin−rich foods

Plant polyphenolics, such as tannins, can significantly impair digestibility of food for mammals. It has long been hypothesized that mammals might host beneficial microbes that degrade these compounds. Indeed, tannin−degrading bacteria (TDB) have been isolated from over 20 mammal species, yet their functional significance to the host has never been tested. We investigated whether TDB allow mammals to consume greater amounts of tannins in their diets. We transplanted microbes into a naïve host the lab rat (*Rattus norvegicus*), which does not naturally host TDB, and measured their tolerance to tannic acid. One group was inoculated with isolated TDB cultured from the feces of the desert woodrat, *Neotoma lepida*, a wild rodent that regularly consumes tannin−rich plants. A second group received a full−community transplant of woodrat feces, and a third group received autoclaved feces as a control. Rats were then fed a diet with increasing concentrations of tannic acid (3−12%), and animals were removed from the trial when they lost more than 10% of their body mass. We found that animals inoculated with TDB, either as isolates or full communities, persisted in the trial longer and were able to consume higher doses of tannic acid. Because the groups had no differences in food intake or dry matter digestibility, we hypothesized that TDB facilitate the ingestion of tannin−rich diets by reducing the costs of hepatic detoxification. This is the first demonstration that TDB facilitate ingestion of tannins by mammals. Symbiotic relationships with these bacteria may have influenced the feeding niches of many mammals that consume tannin−rich foods.

70.6 STEWART, J.R.*; ECAY, T.W.; East Tennessee State University, Johnson City; *stewarjr@etsu.edu*

Mobilization of Eggshell Calcium Promotes Embryonic Growth in an Oviparous Snake

The mineralized eggshell of Reptilia was a major innovation in evolution of the amniotic egg. Inorganic components strengthen the eggshell and their proximity to embryonic tissues provides a potential source of nutrients to developing embryos. Evolution of a mechanism in the embryonic chorioallantoic membrane to mobilize eggshell calcium released the embryo from total dependence on yolk for calcium nutrition and increased the potential for further innovation in embryonic calcium acquisition. Embryos of many squamate reptiles are heavily dependent on yolk for calcium nutrition, yet mobilize some calcium from the eggshell. This nutritional pattern suggests that acquisition of eggshell calcium is facultative; i.e., yolk provides sufficient calcium for successful embryonic development, yet supplemental calcium from eggshell enhances embryonic nutrition. Embryos of the oviparous corn snake, *Pantherophis guttatus*, are highly dependent on calcium from yolk. We tested the hypothesis that embryonic development is dependent on eggshell calcium by manipulating eggshell calcium content. We peeled the outer layer of the eggshell of 12 clutches of recently oviposited eggs; control eggs were left intact. We sampled peeled and intact eggs periodically throughout incubation and measured calcium content of egg compartments. There was no difference in survivorship between treatments. Hatchlings from intact eggs contained 25% more calcium than siblings from peeled eggs. The increased calcium availability significantly impacted hatchling size. Hatchlings from intact eggs had 10% greater length and mass than siblings from peeled eggs. Our results indicate that mobilization of eggshell calcium is facultative and the ability of embryos to augment yolk calcium enhances hatchling fitness.

P3.160 STEWART, WJ*; HIGHAM, TE; Univ. of California, Riverside; *wstewart@ucr.edu*

Tokay geckos actively modulate adhesive force

Many geckos can effectively move on inclined surfaces by employing their adhesive system. To do this, they unfurl their digits, initiating contact with the surface and permitting attractive forces. Parallel loading is then induced using the tensile skeleton of the digits. Although the micromechanics of adhesion are well−studied, it is unclear if and how geckos can actively modulate the strength of adhesion when clinging. Here, we test the hypothesis that geckos can control the magnitude of adhesive forces with muscles in the limbs. This was achieved by linking the resistive force generated by the toe pads of Tokay geckos (mean body mass ± 1 SD = 45.0 ± 11.1 g) when pulled on a vertical surface to muscle activity within the forelimb measured with electromyography. A high−sensitivity force transducer measured the force produced by a gecko manus when pulled upwards, downwards, and horizontally on a vertical acrylic surface. A custom force generator attached at the shoulder produced repeatable pulling forces directed medially and in parallel to the acrylic surface, while a high−speed camera imaged the digits in detail. All conditions induced shear loading. We found that a single gecko manus produced high resistive forces that, on average, were over 14 times the total body weight. Force production also varied greatly between trials for each individual, ranging on average from 11.5 to 17.5 times body weight when pulled downwards on the vertical surface. Since toe pad engagement was confirmed with video, such high intra−individual variation in force production suggests Tokays may be able to modulate adhesion strength. Determining the neuromuscular control of adhesion will help us better understand the physiological basis of force modulation in geckos. Supported by NSF IOS−1147043.

51.5 STEWART, TA*; HALE, ME; University of Chicago; *tomstewart@uchicago.edu*

Development of adipose fin innervation and implications for fin evolution.

Adipose fins are found on the dorsal surface of many teleost fishes, between the dorsal and caudal fins. They have evolved repeatedly, at least three times in ray−finned fishes. The developmental programs that generate these structures are, as yet, unknown, and adipose fin function remains poorly understood. To inform these questions, we characterize adipose fin development in the South American armored catfish, *Corydoras aeneus* (Callichthyidae), describing the innervation of the adipose fin. Nerves were stained with antibody labeling in fish that ranged in age from the early larval stage (10 days post−hatching) through complete development of the adipose fin, approximately four weeks post−hatching. We find that the adipose fin of *C. aeneus* is heavily innervated. In adults, a primary nerve runs along the proximo−distal axis of the fin, posterior to the adipose fin spine. This nerve extends projections parallel to the antero−posterior axis of the fin, as well as anteriorly through the adipose fin spine. Adipose fin nerves originate from branches of the recurrent ramus of the facial nerve and from spinal projections. Adipose fin innervation is compared to sensory innervation of the larval fin fold and the anal fin, and evolutionary implications of sensory potential in new vertebrate appendages are considered. We hypothesize that adipose fin evolution involved the retention and elaboration of the larval fin fold. Adipose fins represent a new a model for studying the evolution of form and function in novel vertebrate limbs.

6.3 STEWART, C. J.*; MARUT, K. J.; TAFTI, D. K.; PRIYA, S.; Virginia Tech; *colins@vt.edu*

Tuning the velar kinematics of the hydromedusa Sarsia tubulosa for targeted swimming performance

Fast−swimming hydromedusae produce the majority of their thrust by expelling pulsed jets of water from their subumbrellar oral cavity, with the remaining thrust produced after each pulse, during refilling, when high−speed fluid enters the cavity and stagnates against the surface. Whether exiting or entering the cavity, in both cases the flow interacts with the nozzle−like flexible velum at the cavity orifice and causes it to deform in the flow direction. Previous studies show that velar deformation during fluid expulsion serves to optimize the formation of the starting vortex such that thrust is maximized while energetic cost is minimized, but little has been reported about the influence of velar deformation on thrust production or vortex wake during refilling. In this study, we use a computational fluid dynamics (CFD) model of the hydromedusa *Sarsia tubulosa* to investigate a wide range of velar kinematics, both passive and imposed, and how they can be tuned to fully exploit both thrust producing events in order to maximize swimming proficiency or efficiency.

19.5 STILSON, K/T*; HOPKINS, S/S/B; DAVIS, E/B; University of Texas at Austin, University of Oregon; *stilson@utexas.edu*

50 Million Years of Severe Osteopathology in Rhinocerotidae

Skeletal pathologies in the fossil record are commonly considered indicators of an individual animal's life history and development, and not reflections of processes related to all or part of a lineage's history. Individual elements of many extinct and extant rhinocerotids display arthritis−like osteopathologies. The proportion of severe osteopathology increases over the last 50 million years from about 30% of all elements in a taxon from the Eocene showing some form of osteopathology to 100% of all elements in modern taxa. The Rhinocerotidae preserved in the fossil record do not represent a direct lineage, but a group of closely related organisms that present a study system for pathological evolution and development. Osteopathology is examined here in six extinct taxa spanning 50 Ma (*Hyrachyus eximus, Diceratherium sp., Trigonias osborni, Menoceras arikarensus, Aphelops sp.,* and *Teleoceras sp.*) as well as the five living species of rhinoceroses. Seven pathological indicators (overgrowth, lipping, remodeling, erosions, worn articular surface, and variable foramen shape and size) were scored for each element on a scale of 1−4 and mapped on a phylogenetic tree using Mesquite to establish ancestral and lineage expression of osteopathology (i.e., that present in the common ancestor and also that present as successive points along the tree). We estimated mass from femur length and compared resulting values with the literature. We measured cursoriality using the established proxies of metatarsal length over femur length (MT/F), and total hind−leg length (femur + tibia + metatarsal). Estimated mass increases from 50 Ma to the present and correlates with the increased expression of osteopathology while cursoriality, the other trait examined as a possible contributing factor, did not. This degree of osteopatholgical expression may be an example of evolutionary compromise.

P1.106 STOTE, A*; KENALEY, CP; Harvard University; *astote@college.harvard.edu*

A morphological analysis of the suction−disc performance and interspecific host association in the remoras (Percomorpha: Carangiformes: Echeneidae)

The percomorph family Echeneidae consists of eight species of marine fishes that hitchhike by adhering to a host via a dorsal sucking disc. Osteological components of this unique suction device are composed of serially arranged, hierarchically organized substructures. While recent studies have focused on the evolution and development of the modified dorsal−fin osteology that forms the specialized disc, very little work has focused on the morphological basis of adhesion. Further, the range of disc performance appears to be very broad with some species that adhere to slow−swimming, rough−skin hosts (e.g., requiem sharks) and others that adhere to fast−swimming, smooth−skin species (e.g., rorqual whales). Thus, the relationship between disc design and functional performance remains unstudied. The goal of our study was to identify the anatomical properties of the echeneid disc system that influence adhesion performance and may be implicated in host association. The specific aims of the study were to (1) characterize the morphology of the disc system through micro−CT analysis of all eight species of the family Echeneidae and (2) identify axes of disc morphospace that covary with host surface roughness and locomotor speed. We found that variation in disc morphospace can be explained by only a few of the 18 morphological variables measured. Axes of morphospace defined by these variables have strong positive relationships with both host surface roughness and locomotor speed. The results of our work are discussed in the context of morphological properties that may constrain host specificity and inspire improvements to man−made, suction−based adhesion devices.

P3.126 STOVER, KK*; ROBERTS, TJ; BRAINERD, EL; Brown University; *kristin_stover@brown.edu*

Compensating for an altered center of mass: a comparative study of the pelvis and pelvic limbs of three turkey strains

Domesticated animals potentially provide insight into how selection on physical characteristics may affect other associated morphological features. The domestic poultry industry selects for traits that decrease time to market and increase meat production. The turkey, *Meleagris gallopavo*, has undergone such drastic pectoral hypertrophy that the position of the center of mass (COM) has been significantly altered. The goal of this study is to identify associated morphological changes with increased weight and alterations in COM position in turkeys by comparing the pelvic limbs and the pelvis of wild, heritage, and broad breasted white (BBW) strains. Three female turkeys of each strain were CT scanned and bones were measured. In BBW turkeys, the pelvis is significantly broader at both the ischium and ilium, however the weight−bearing width at the labrum is not significantly different among the 3 strains. The BBW strain had a significantly larger femur diameter−to−length ratio but no significant difference in cortical thickness of the femur or tibiotarsus was found among the three strains. To compare proportions of each segment, the femur, tibiotarsus and tarsometatarsus lengths were plotted in limb morphospace, and while there was no significant difference in BBW and heritage turkeys, both were significantly different from wild turkeys across all measurements. These results indicate that while the pelvis does not necessarily provide a larger locomotor base in BBW turkeys, it provides more surface area for muscle attachments. Additionally, the pelvic limbs have significantly altered morphology, which may help compensate for the altered COM. A study of the forces during locomotion may provide more insight into the functional relevance of these changes.

P2.46 STRADER, M.E.*; MATZ, M.V.; the University of Texas at Austin; *stradermarie@gmail.com*

Dissecting the function of coral fluorescent proteins through global gene expression profiling of coral larvae

Despite their widespread use in biotechnology, the biological functions of coral GFP−like fluorescent proteins (FPs) are yet to be elucidated. *Acropora millepora* larvae exhibit fluorescence polymorphisms within full−sibling crosses enabling comparisons amongst individuals expressing varying levels of FPs. Behavioral differences between color morphs, such as differential responsiveness to settlement cue, suggest fluorescence phenotypes may be associated with the larval ability to sense and respond to the environment during settlement choice, a critical phase in the coral life cycle. To reveal the association between the expression level of a particular FP and known molecular pathways, we compared global gene expression profiles of three distinct larval fluorescence phenotypes (red, green and "mega−green") after exposure to controlled light conditions (darkness, green and red light). We employed a weighted gene co−expression network analysis to identify groups of genes whose expression correlates with fluorescence phenotypes and/or response to light stimulus. Our results support the hypothesis that red FP in particular is involved in sensing external light stimuli, while the overall patterns of gene expression in response to light of different spectral composition elucidates key aspects of larval sensory ecology.

16.3 STRANGAS, M.L.*; RECODER, R.S.; RODRIGUES, M.T.; CARNAVAL, A.C.; City University of New York, Universidade de Sao Paulo; *mariastrangas@gmail.com*

Mechanisms of niche divergence in an Atlantic Forest lizard group

Determining the mechanisms that drive niche divergence in closely related taxa has the potential to greatly improve our understanding of the evolutionary processes that promote diversification. Here, we integrate phylogeny, macro and microclimate and morphology to explore the mechanisms behind the divergent evolution of five gymnophthalmid lizard species in the Brazilian Atlantic Forest. Multi−locus phylogenetic analyses reveal repeated instances of divergent macrohabitat use in sister species, with some taxa in dry, rocky outcrops and others in humid rainforest. By comparing microclimate data from distinct habitats, we test the hypothesis that species found in different macrohabitats have the opportunity to behaviorally select similar environments. Despite potential similarity in microenvironment availability, lizards in different habitats are thought to encounter distinct structural environments. Thus, we expected morphological characteristics to be under strong divergent selection according to habitat type, and thus show high lability in this clade. To test this, we measured and compared eco−morphological traits across species and habitat types.

55.7 STREICHER, J.W.*; ROELKE, C.E.; FUJITA, M.K.; Univ. of Arizona, Univ. of Texas, Arlington; *streicher@uta.edu*

Heterogeneity in Physiological Performance at the Northern Range Edge of a Tropical Frog Complex

The process of spatial sorting is thought to occur when differential dispersal capabilities assemble particular phenotypes at expanding range edges. This evolutionary mechanism may be particularly important to understand in lineages that are geographically widespread and ecologically diverse. Barking frogs (*Craugastor augusti*) are a polytypic species complex that occurs throughout mainland Mexico and the southwestern United States. These amphibians are typically surface active for only a few weeks each year that correspond to heavy spring and summer rains, so much of their biology is unknown. We used a mitochondrial gene fragment and nuclear genome wide SNP data to investigate phylogeographic relationships across the range of barking frogs. We identified multiple geographically circumscribed lineages within the complex and three at the northern range edge. We collected 23 individuals from two of these northern lineages (found to be sister taxa) and maintained them in captivity for several months before examining their physiological traits. Following this acclimation period, we measured oxygen consumption rates at two different temperatures; 24 and 30 C. While the response to temperature was similar in each lineage, we found evidence for significantly different oxygen consumption rates between lineages at both temperature conditions. Given laboratory acclimation, we think it is likely that the observed difference in routine metabolic rate has genetic underpinnings. As such, shifts in physiological phenotypes may have played an integral role in barking frog diversification across their ecologically dynamic range. Our findings are consistent with the tenet that when variable ecological conditions exist across an expanding range edge, environmentally related selective pressures may shift spatially sorted phenotypes along different evolutionary trajectories.

83.6 STUDER, T/P*; MOORE, P/A; Bowling Green State University, Bolwing Green State University; *tstuder@bgsu.edu*

Smelling Out the Competition: Response Behavior of Naïve Crayfish to Invader Odors

In aquatic environments, chemoreception is one of the most commonly used sensory system. A large variety of organisms use chemical signals to perceive and behaviorally respond to environmental stimuli such as avoiding predation, finding mates, fighting competitors and finding prey. While there are extensive studies on the use of chemoreception to detect predators and mates, there has been little work on the role that chemical signals play in detecting invasive competitors. Large−scale invasions of aquatic habitats by invasive organisms (zebra mussels, rusty crayfish, Asian carp) have significantly changed the ecosystem structure of these invaded habitats. The purpose of this study was to determine if crayfish can detect and respond to novel chemical cues being released by potential competitors. We have access to two spatially distinct populations of the native crayfish species *Orconectes virilis*. One population has been invaded by *Orconectes rusticus* (rusty crayfish) and the other is naïve to the presence and odors of this invader. To determine whether native crayfish can respond to novel competitor odors or whether these crayfish need to learn through association that these odors are connected with a competitor, we designed an experiment to monitor flicking responses to different odors. Naïve and experienced crayfish were presented with a series of odors over time and flicking rates (as a proxy measure for detection and response) were measured. The results showed change of flick rate in the presence of crayfish odor with variation between naïve and experienced *O. virilis*. In addition there was modulation of flick rate over time with successive crayfish odor exposures.

P3.112 SULLIVAN, E.M.; University of Massachusetts Lowell; *erin_sullivan@student.uml.edu*

Metazoan parasite infracommunities of juvenile Kemp's ridley sea turtles

The Kemp's ridley (*Lepidochelys kempii*) turtle is the most endangered of all sea turtle species. Physiological surveys of these animals are therefore made difficult due to limited sampling opportunities. This has led to a lack of data on the parasite communities found in these marine hosts. This work represents the first description of metazoan parasite biodiversity in juvenile Kemp's ridley sea turtle hosts that occur in New England using molecular tools to identify parasites. A comprehensive investigation of all parasites and life stages present within each host was aided by mitochondrial (cytochrome c oxidase 1) and/or ribosomal (18S, 28S, internal transcribed spacer 2) genetic markers. Incomplete identifications from morphological indicators were complimented by comparing molecular results to published data. Understanding the parasite infracommunities of endangered sea turtles allows for future investigations into the spatial, temporal and developmental patterns of aggregation and biodiversity as parasites and their hosts respond to a changing ocean climate.

11.1 SUNDAY, J.M.*; BATES, A.E.; KEARNEY, M.R.; COLWELL, R.K.; DULVY, N.K.; LONGINO, J.T.; HUEY, R.B.; Simon Fraser University, Institute for Marine and Antarctic Studies, University of Melbourne, University of Connecticut, University of Utah, University of Washington; *sunday@sfu.ca*

Climate sensitivity, thermal safety, and the importance of behavior across latitude and elevation

Thermal tolerance limits of terrestrial ectotherms often exceed experienced air temperatures, giving rise to an apparently high degree of thermal safety − or an excess of warm or cold thermal tolerance. Yet air temperatures can be wildly different from the realized body temperatures with which ectotherms must physiologically or behaviorally contend. Here, we compile a global dataset of thermal tolerance limits of ectotherms across both latitude and elevation, and compare these to operative temperatures (theoretically equilibrated body temperatures) during the warmest and coldest times of the year. We show that, contrary to previous findings, ectotherms do not have physiological thermal safety. Instead, behavioral retreat from the sun is required to avoid dangerous overheating during the warmest times, and this requirement is greatest at low latitudes and elevations. Likewise, retreats from cold exposure are frequently required for species living at temperate latitudes and in alpine habitats. Under climate warming, the availability of thermally−protective habitats, and the behavioral and energetic constraints to using these habitats, will be critical aspects of species vulnerability.

39.1 SUNDQUIST, L.E.*; DE BURON, I.; MCELROY, E.J.; Harvard University, Boston MA, College of Charleston, SC; *Sundquist.luke@gmail.com*

Temperature mediated myoliquefaction: The effect of a myxozoan parasite Kudoa inornata on the spotted seatrout (Cynoscion nebulosus)

Myoliquefaction has been documented to soften the fillets of numerous teleost fish species, caused by infection of species of the myxosporean genus *Kudoa*. Fishermen reports of soft flesh in their catch and the discovery of *K. inornata* in spotted seatrout, *Cynoscion nebulosus*, suggest that myoliquefaction may lead to decreased firmness over time in this infected species. Specimens of spotted seatrout (n=15) were collected from South Carolina estuaries by trammel fishing during June and July 2013 and examined under a light microscope for presence of *K. inornata*. Biopsies were removed from the epaxial muscle and compressed using a materials tester to evaluate fillet firmness at 24 hours, 72 hours, and 144 hours post−mortem. Prevalence of infection was 93% in wild fish, and force testing revealed significant flesh softening in wild fish compared to the aquaculture control group by 72 hours, and significantly higher firmness in unparasitized fish at all time points. Colder temperature treatments (4°C vs 10°C) also helped maintain firmness in all test groups.

S1.3−3 SUNG, SIBUM; Univ. of Texas, Austin; *sbsung@austin.utexas.edu*

Epigenetic memory of winter by plants

In a model plant species Arabidopsis, one of key determinants for flowering time is a MADS−box floral repressor, FLOWERING LOCUS C (FLC). FLC is silenced after a sufficient period of winter cold has been perceived (known as vernalization response). The epigenetic repression of FLC expression allows plants to achieve the competence to flower in spring through the activation of floral integrator genes. Previous studies revealed that repression of FLC by vernalization is achieved in part by an evolutionarily conserved chromatin modifying complex, Polycomb repressive complex 2 (PRC2). In Arabidopsis, PRC2 (which contains CLF, an E(z) homolog, a H3K27 methyltransferase) is recruited to FLC chromatin upon vernalizing cold and mediates methylations at Histone H3 Lys 27 (H3K27me3), a repressive histone modification mark. Recent reports identified a plethora of long and/or short noncoding RNAs (ncRNAs), which contribute to the recruitment of PRC2 to its target chromatins. In vernlaization, a long noncoding RNA (lncRNA), named as COLDAIR, was shown to mediate FLC silencing by vernalization. COLDAIR lncRNA binds directly to CLF, a PRC2 component, and is necessary for increased enrichment of PRC2 at FLC chromatin by vernalization. Using the FLC regulation as a model system, I will discuss current understandings on epigenetic FLC silencing by protein and noncoding RNA components in Arabidopsis. I will also discuss similarity and difference among flowering plants in respect to vernalization response.

P1.145 SUNSONG, R.C.*; MARTINEZ−ACOSTA, V.G.; Univ. of the Incarnate Word, San Antonio; *vgmartin@uiwtx.edu*

Investigations of segmental regeneration in Lumbriculus variegatus

Gradients in regenerative capacity in *Lumbriculus variegatus* are reminiscent of morphogenic gradients that are responsible for early patterning of vertebrate body axis. Multiple studies in our lab demonstrate the emergence of newly regenerated head is necessary for respecification of neural function along the anterior−posterior body axis. We hypothesize then that inhibition of head regeneration would severely hinder the overall regenerative process and lead to a reduction in the recovery of function. This hypothesis will be tested by measuring the effects of complete inhibition of head regeneration on the neural reorganization events that are hallmarks of neural regeneration in Lumbriculus. Recent studies in other invertebrate species have suggested that inhibition of head regeneration slows down wound formation causing breakdown of the regenerative process and that bioelectric gradients and signaling molecules produced from the wound tissue are necessary for successful regeneration. Reduction in head regeneration has recently been accomplished using voltage−gated ion channel blockers (nicardipine, tricaine), protease inhibitors (AEBSF), protein−kinase inhibitors (Sphingosine, Staurosporine, and PP1/AGL1872), and gap junctional protein blockers (heptanol, hexanol). Using agents such as these we will inhibit head regeneration, and original worm fragments will be subsequently tested for the presence of axial reorganization responses including, changes in giant fiber diameter, changes in giant fiber conduction velocity, changes in reflex behavior, as well as changes in expression of MP66, a molecular marker of neural regeneration in Lumbriculus.

P2.155 SURETTE, F.A.*; DAVIS, J.E.; GUINAN, J.A.; Radford University; *fsurette@radford.edu*

Impacts of daily corticosterone administration on nestling eastern bluebirds' (Sialia sialis) age at fledging and parental behavior and corticosterone

Vertebrates are known to respond to environmental perturbations and life history events such as reproduction, in part, through HPA activation and glucocorticoid release. Our previous research on the relationship between stress, behavior, and reproductive success in eastern bluebirds (*Sialia sialis*), found that as nestling baseline corticosterone levels increased, both female baseline corticosterone and female and male feeding trips to the nest increased. Because of these correlations, we hypothesized that if we experimentally increased nestling corticosterone levels, we would observe an increase in maternal corticosterone and parental feeding trips to those nests. To test this, broods of nestlings were chosen at random to receive a topically applied daily acute dosage of either corticosterone diluted with dimethylsulfoxide (DMSO) or DMSO alone. Parental blood samples were taken twice during the nestling stage, once prior to the start of nestling treatment and once after the nestlings had been treated for 7 days. Additionally, we observed parental nest attentiveness, as well as nestling morphology and age at fledging. Here we discuss the results of our analysis on parental nest attendance and parental and nestling corticosterone levels to determine whether nestling stress levels were related to parental stress levels and behavior.

91.3 SUSTAITA, D.*; RUBEGA, M. A.; FARABAUGH, S. M.; Brown University, University of Connecticut, San Diego Zoo Global; *diego_sustaita@brown.edu*

Come on baby, let's do the twist: the kinematics of killing in Loggerhead Shrikes (Passeriformes: Laniidae)

Shrikes use their beaks for procuring and processing their arthropod and vertebrate prey. Their distinctive hooked bills and powerful bite capabilities are thought to play particularly important roles in dispatching vertebrate prey. We examined the relationship between prey handling performance and bill shape using high−speed video analysis of feeding behavior of captive adult and juvenile San Clemente Loggerhead Shrikes, coupled with geometric morphometrics of upper bill shape. Once shrikes gained purchase on the nape of their prey with their beaks, they typically shook it by way of rapid (6−17 Hz; 49−68 rad/sec) head oscillations (about the rostrocaudal axis) that accelerated the bodies of their prey about their own necks at g−forces of up to 18 g. Adult shrikes showed greater propensities to use head−rolling to dispatch prey, and greater oscillation frequencies. Juveniles demonstrated lower capacities for maintaining a beak−hold on prey, likely resulting from their relatively underdeveloped bill hook and tomial structures. Thus, when tackling relatively large vertebrates, shrikes apparently use their prey's own body inertia to facilitate immobilization by damaging the cervical vertebrae and spinal cord. However, the structure of the bill, coupled with jaw speed and force, may also play important roles for maintaining bill contact with prey during handling.

58.1 SUTTON, E.E.*; STAMPER, S.A.; DEMIR, A.; MITCHELL, T.R.; FORTUNE, E.S.; COWAN, N.J.; Johns Hopkins Univ., Campbell Univ., New Jersey Institute of Technology; *esutton5@jhu.edu*

Multisensory Control of Locomotion in Weakly Electric Fish

While crucial to understanding neural control, few studies investigate multisensory integration during locomotion, especially in freely behaving animals. Here, we show that *Eigenmannia virescens* integrates sensory information from conflicting cues according to the saliency and reliability of the cues. Our apparatus enables the independent manipulation of visual and electrosensory motion stimuli during natural, untrained refuge−tracking in these fish. The electrosensory cue is a moving refuge, and the visual cue is a moving light pattern projected onto the refuge. We establish a general method for estimating the ratio of open−loop sensorimotor gains from two modalities. Specifically, we show that an appropriate pair of closed−loop gains for each sensory modality can be used to determine the *open−loop* gain ratio of the two modalities under certain conditions. This analysis requires pairs of trials in which the frequencies of conflicting probe stimuli in the two experiments are interchanged. In our case, the electrosensory and visual stimuli consisted of a common low−frequency, high−amplitude component and conflicting low−amplitude probe components at 0.45 Hz for the visual stimulus and 0.55 Hz for the electrosensory (and the reverse for the paired trial). Additionally, we used sum−of−sine stimuli to determine the gain ratio across a range of frequencies. Gain ratios were evaluated as a function of conductivity (200 and 600 ¼s/cm) and probe stimulus amplitude. We found the ratio of visual to electrosensory gains increased with increased conductivity, likely because high conductivity decreases electrosensory salience. Also, we found that fish track the modality with the lower amplitude, likely because it is perceived as more reliable.

63.6 SWANSON, DL*; KING, MO; HARMON, E; Univ. of South Dakota; *david.swanson@usd.edu*

Seasonal Variation in Pectoralis Muscle Myostatin and TLL in Small Birds: A Regulatory Role for Seasonal Phenotypes?

Seasonally variable climates produce seasonal phenotypes in small birds such that winter birds are more cold tolerant and have higher thermogenic capacities. One potential regulator of these seasonal phenotypes is myostatin, a muscle growth inhibitor that may be downregulated under conditions promoting muscle hypertrophy in response to increased energy demands. Few studies have examined a role for myostatin in avian responses to periods of changing energy demands. We examined seasonal changes in flight muscle and heart masses and correlated seasonal changes in myostatin gene expression and protein levels, as well as expression of metalloproteinase myostatin activators TLL−1 and TLL−2 in American goldfinches (*Spinus tristis*) and black−capped chickadees (*Poecile atricapillus*). Winter pectoralis and heart masses were significantly greater than in summer for goldfinches. Black−capped chickadees showed no significant seasonal variation in muscle or heart masses, although mass−adjusted pectoralis showed a non−significant trend ($P = 0.087$) toward higher winter levels. Myostatin expression and protein levels in pectoralis muscles of goldfinches were greater in summer than in winter, although not significantly so ($P = 0.058$ for protein levels), but expression of both metalloproteinase activators was significantly greater in summer. Pectoralis expression of myostatin and metalloproteinase activators were also higher in summer than in winter for chickadees, although significantly so only for TLL−2. These data suggest that a downregulation of myostatin function in winter, regulated especially by a reduction in myostatin processing, may play a regulatory role in mediating seasonal metabolic phenotypes in small birds.

S8.3−2 SWANSON, E.M.*; SNELL−ROOD, E.C.; Univ. of Minnesota, Twin Cities; *eliswanson@gmail.com*

Physiological mediation of integrated phenotypes: From plasticity to evolution

Hormones are important mediators of phenotypic responses to environmental variation at both the developmental and the population level. In addition, hormones commonly influence multiple traits simultaneously; this pleiotropy is thought to generate correlations among phenotypic traits and play an important role in phenotypic integration. Nevertheless, many questions persist regarding the role of hormonal pleiotropy in evolution and development. For example, it is unclear whether hormonal pleiotropy stems from a limited number of hormones or represents an adaptation. If pleiotropy results due to a compromise among a limited number of physiological mediators, it suggests that limitations in the extent of physiological variation could constrain the evolution of individual traits. Alternatively, if specific correlations among traits are commonly beneficial, hormonal pleiotropy could potentially facilitate appropriate correlated responses to the environment. Furthermore, we don't know if this hormonal pleiotropy facilitates or constrains developmental responses to environmental variation differently than population−level responses. Is selection for appropriate plastic responses generally at odds with selection for appropriate population−level responses? Here, we develop a framework for a broader approach to studying the evolution of neuroendocrine−regulated plasticity. We first review the current state of knowledge about how hormones hierarchically influence patterns of variation within individuals, within populations and across species. After discussing the gaps in our knowledge, we introduce a developmental model−based approach to help address these questions. Finally, we attempt to bridge and integrate the roles of neuroendocrine variation within individuals, within species, and among species.

P3.93 SWIDER, Z.*; HIEBERT, L.S.; MASLAKOVA, S.A.; VON DASSOW, G.; Oregon Institute of Marine Biology; *zac.swider@gmail.com*

Expression and Function of Otx during Ciliated Band Development in the Pilidium Larva

We identified a homolog of orthodenticle, MaOtx, in a transcriptome of the pilidiophoran nemertean *Micrura alaskensis*. MaOtx is expressed during cleavage in the descendants of 1q2 (primary trochoblasts), 1q12 (accessory trochoblasts in canonical spiralians), and 2q cells (some of which form secondary trochoblasts in other spiralians). In the blastosquare, Otx−expressing cells make an unbroken ring around the perimeter, likely the primordial ciliated band. Otx expression persists in axils − recesses within the primary ciliated band, which are sites of growth and intercalation of new cells into both larval and juvenile bodies. We evaluated MaOtx function using morpholino−mediated knockdown and ectopic expression from injected mRNA. MaOtx morphants gastrulate and make a stomach, esophagus, apical organ and larval epidermis, but fail to develop lappets or a defined ciliated band. Nor do they possess "cone cells", sense organs embedded within the ciliated band. By the time normal pilidia would have begun to feed and grow, MaOtx morphants have instead begun to seal off their own mouths from the outside world. Phospho−histone labeling showed plenty of dividing cells in morphants, suggesting that it is the differentiation of axillary cells, rather than their proliferation, that is impaired. Overexpression of Otx in all cells led to a superficially similar phenotype to morpholino injection − post−gastrulas had a stomach, esophagus, and apical organ but no defined ciliated band. However, a great excess of cone cells in Otx−injected larvae suggested that ectopic Otx diverts would−be epithelial cells to this fate. We conclude that the normal function of Otx is likely to promote differentiation of various constituents of the primary ciliated band, both in the embryo and during larval growth.

P3.147 SWIDERSKI, D.L.*; KAPPY, M.; RAPHAEL, Y.; Univ. of Michigan, Ann Arbor; *dlswider@umich.edu*

Variable Sensitivity of Lab Mice to Fluctuating Acceleration

The vestibular organs of the inner ear play a critical role in maintaining balance and orientation. The dimensions of these organs can differ greatly between species that differ in locomotor ability or inhabit environments differing in spatial complexity. Tests of locomotor performance are commonly used to infer differences in vestibular function; however, locomotor performance can be influenced by many other factors. Thus, we are investigating the utility of involuntary physiological response to vestibular stimulation. Following studies on motion−sickness in humans, we tested for temporary shifts of body temperature of mice exposed to fluctuating high G acceleration. Mice were positioned on a rotating arm with the anteroposterior axis perpendicular to the plane of rotation. An automated controller generating alternating centripetal accelerations of 2G and 6G, for 10 second intervals, over a span of 2 minutes. Core body temperature was measured before acceleration, immediately after, and at regular subsequent intervals. We tested wildtype and affected mice from C57BL/6 (B6) colonies maintained for studies of vestibular mutations, wild−types lesioned bilaterally with streptomycin, and wildtype CD−1 mice. Wildtype female B6s typically exhibited a temporary 2−3° C drop but affected females did not. Also, mice that did have a temperature shift lost that response after streptomycin treatment. In contrast, wildtype male B6 mice from the same colony, generally had a smaller drop of <1.5°, and male CD1 mice showed no drop or an increase of up to 1.5°. Thus, brief exposure to controlled fluctuation of hyper−G acceleration can be used to test for loss of peripheral vestibular function under some conditions but differences between sexes and strains may reflect variations in how stress modulates physiology.

19.2 SWIDERSKI, D.L.*; LI, J.; TRAN, L.A.P.; ZELDITCH, M.L.; Univ. of Michigan, Ann Arbor; *dlswider@umich.edu*

A comparison of two radiations: Jaw morphology of terrestrial squirrels

The dynamics of adaptive radiations have captured much attention recently, but equally interesting are groups famed for their morphological conservatism, particularly those that are speciose and geographically widespread. One such group, the chipmunks (*Tamias*), contains 25 species, many notoriously difficult to discriminate without geographic data. Its sister taxon, the Marmotina (ground squirrels) includes 60 species, many that have evolved to exploit grasslands. In this analysis, we compare the evolutionary dynamics of chipmunks and marmotines, examining jaw size and shape disparity for all chipmunks and 49 marmotines, in a phylogenetic framework based on molecular data for 85 of 91 extant species. As expected, chipmunks are less disparate in both size and shape and its subclade disparity is consistently high relative to the total disparity, sometimes slightly exceeding total disparity. In marmotines, within−subclade size disparity is well below the total disparity because several groups have non−overlapping size ranges. Subclade shape disparities also are much smaller than the total but there is more evidence of later convergence. The most strongly supported model for marmotine size evolution is an early burst; for shape, the initial stage of the radiation is a burst of divergence, then subclade morphology is static for only part of the subsequent history. Size and shape show different evolutionary patterns in chipmunks; size evolves by Brownian motion but shape is constrained; the most supported model is a single stationary peak (Ornstein−Uhlenbeck). While chipmunks initially have low rates of jaw shape evolution, they repeatedly converge to densely fill a smaller morphospace. Marmotines partitioned morphospace into distinct regions early in their radiation into grasslands, and less frequently converge.

18.7 SWITZER, C.S.*; COMBES, S.A.; Harvard Univ., Cambridge; *cswitzer@fas.harvard.edu*

Vibrating Bees: Behavioral Changes in Buzz Frequency

Multiple bee taxa have evolved the ability to collect pollen by shaking it from plants' anthers. While grasping or touching the anthers, bees vibrate their bodies using their flight muscles, without flapping their wings − termed "buzz pollination". Bumblebees perform buzz pollination, but honeybees do not. Many plants depend almost entirely on buzz pollination. Because of these plants' tubular anthers and/or difficult−to−reach pollen, honeybees struggle to pollinate them. Behavioral aspects of buzz pollination in bumblebees have not been fully characterized. We set out to answer the following questions: 1) Can bumblebees change the frequency of their buzz? 2) Do bumblebees' buzz frequencies differ on plant species flowering throughout the foraging season? We surveyed a variety of plants and used a microphone to measure the pollination buzz frequency of over 300 wild bumblebees (*Bombus impatiens*). We captured and measured the frequency of the bees' irritation buzz, which is used as an alarm signal or to help the bee escape tight places. We gathered morphological data and weather conditions, before marking and releasing the bees. To determine if bumblebees can change their buzz frequency, we compared irritation and pollination buzzing. We found that bees can buzz at a much higher frequency than their pollination buzz. To determine if buzz frequencies differ on different plants throughout the foraging season, we compared the bees' buzz frequencies among plants. While accounting for differences in time of year, temperature, time of day, and bees' size, we found significant differences in buzz frequencies. This suggests that bumblebees may have more control over their indirect flight muscles than previously thought. It also shines light on the factors that may play a role in bumblebees' pollination behavior.

27.8 TAFT, NK*; FLAMMANG, BE; BLEVINS, E; LAUDER, GV; University of Wisconsin−Parkside, Museum of Comparative Zoology, Harvard University; *taft@uwp.edu*

Material properties of the pectoral fin rays of basal actinopterygian fishes

The material properties of the pectoral fin rays (lepidotrichia) of actinopterygian fishes determine the flexibility and shape of fins; yet the diversity of fin ray structure and function remains largely unexplored. In previous work, we used microCT scanning to examine the morphology of the lepidotrichia of two basal actinopterygian species, shortnose sturgeon (*Acipenser brevisrostrum*) and longnose gar (*Lepisosteus osseus*). Based on these morphological data we made predictions about the stiffness of the lepidotrichia. Specifically, we predicted that sturgeon would have very stiff lepidotrichia, much more stiff than those of the gar or the bluegill sunfish (*Lepomis macrochirus*), which is the only other species for which we have comparable data. We predicted that the gar, which has a very similar structure to bluegill sunfish, would also exhibit similar material properties. We are interested in variation both among species as well as at different locations in the fin within species. Here we used three−point bending tests to experimentally determine the stiffness of the lepidotrichia in sturgeon and gar. We performed these tests on a dorsal, middle and ventral ray from each pectoral fin, and at three locations along each ray, the proximal third, the middle, and the distal third of the ray. In both species all lepidotrichia examined are stiffer proximally and more flexible distally, which is similar to patterns in bluegill. As predicted, the sturgeon fin rays were stiffer than the gar, which were more stiff then the bluegill. There was also significant variation in stiffness within both sturgeon and gar fins. This was most pronounced in sturgeon, the anterior ray was more stiff than the fin rays of any other species examined to date.

50.4 TAHIR, UH*; MONROY, JA; NISHIKAWA, KC; Northern Arizona University; *ut5@nau.edu*

How does the velocity−dependent behavior of muscles change with activation?

Despite the success of the sliding filament theory, many important properties of muscle remain unexplained. Surprisingly, the goal of predicting muscle force output during natural movements remains elusive, suggesting that the theory of muscle contraction is incomplete. Simple experiments using constant−velocity stretch and shortening of isolated muscles illustrate the non−linearity of muscle force output, which includes velocity− and history−dependent components. During constant velocity stretch, muscle force increases faster in the first 20 ms than during the next 50 ms of the stretch. There is a long−lasting increase in force (force enhancement) after stretch, and a long lasting decrease in force after shortening (force depression). In order to predict changes in muscle force during changes in length, we need to understand how the velocity−dependent behavior of muscle changes with activation. We investigated this using isovelocity stretch and shortening experiments in active and passive muscles. Soleus muscles from mouse was isolated and attached to a servomotor force lever. The muscles were then stretched or shortened through a range of initial lengths, velocities and activation levels. Activation of the muscle ranging from 0% to 100% was achieved by modulating the stimulation voltage and frequency. Preliminary results suggest that damping coefficients and the force−velocity relationship scale linearly from 0 − 100% activation. The results from these experiments have the potential to inform our understanding of muscle contraction and motor control, and to provide algorithms for controlling powered devices that, like muscles, will adapt instantaneously to changes in load. Supported by NSF IOS−1025806, IIP−1237878, and NSF BIOTEC 0742483.

13.5 TAMONE, S.L.; Univ. of Alaska Southeast; *sltamone@uas.alaska.edu*

Comparison of methyl farnesoate and ecdysteroid concentrations in premolt adolescent and adult Tanner crab Chionoecetes bairdi

Crustaceans shed their exoskeleton in order to increase in size and this occurs during the process of molting. Ecdysteroids promote molting directly through the regulation of gene expression. Many male crustaceans undergo a morphological change over subsequent molts as they transition from juveniles to adolescents and from adolescents to adults. In addition to increasing in size, a change in body form requires differentiation. *Chionoecetes* crabs such as snow (*C. opilio*) and Tanner (*C. bairdi*) crab undergo a terminal (ie, final) molt characterized by differentiation and enlargement of the chelae. A disproportionate increase in the size of the chelae after the adolescent to adult transition is associated with increased mating success while the male is better able to guard the female and dominate male−male interactions. It is important to understand factors that influence the terminal molt in *Chionoecetes* crabs since crabs will terminally molt over a broad range of carapace widths. While it is known that ecdysteroids are important for regulating molting it is unclear if methyl farnesoate may act in combination to promote the morphological changes associated with terminal molt differentiation. Hemolymph was sampled from crabs ranging in carapace width (110−135 mm) each week for at least 4 months prior to molting. Nine of these crabs remained small claw adolescents after the molt while the other crabs completed their terminal molt. Ecdysteroids were elevated above intermolt concentrations for 18 weeks prior to molting. The duration and magnitude of increased ecdysteroid secretion was not different between adolescent and adult males. Methyl farnesoate was also measured and was significantly lower in males that terminally molted to the adult morphotype. Further molecular studies will help decipher the regulation of specific genes by hormones during the molt cycle.

104.2 TANAKA, H*; SUGA, K; MAEDA, M; KITAMURA, I; LIU, H; Chiba University; *htanaka@chiba−u.jp*

Passive wing deformation of hovering hummingbirds

Hummingbirds are known as the only birds which are capable of sustained hovering flight. Unlike the other birds, their upper and lower arm bones are very short and the wings do not fold at the elbow during flight. Since most of the wing surface is composed of flight feathers without muscles, the wing is assumed to passively deform due to aerodynamic and inertia forces. Moreover, overlapping of the sliding feathers could change the wing area. Those wing deformations should affect aerodynamic performance. Here we measured the wing shape of a hovering hummingbird, *Amazilia amazilia*, with multiple high−speed video cameras. We also fabricated flexible wings consisting of carbon fiber frames and thin polymer films with the same planar shape as the hummingbird wing. The synthetic wings were tested with an electric−powered tethered 1−DOF (degree of freedom) flapping mechanism to observe the passive deformation. It was found that the synthetic wings twisted in a similar way to the up−stroking real wing, indicating that the hummingbird wings passively twist during upstroke. The wing area of the real wing changed by around 20% of the maximum value during a single flapping cycle, which was caused by spreading motions of the flight feathers. Measured lift of the synthetic wing with a relaxed film which produced larger twist matched the weight of the measured hummingbird. Those results suggest that the passive twist of the wing surface and variation of the wing area should be taken into account in the study of aerodynamics and flight performance of hovering hummingbirds.

121.5 TATE, A.T.*; GRAHAM, A.L.; Princeton University; *annt@princeton.edu*

Roles of immunological and life history dynamics in determining the costs and benefits of trans−generational immune priming

In insects, immune priming allows individuals previously exposed to a pathogen to enjoy reduced susceptibility and higher survival probability upon re−exposure, compared to naïve cohorts. The protection can even be transferred across generations, but currently very little is known about the mechanisms of priming or associated trade−offs with other life history traits. In trans−generational priming experiments reported here, we infected the larval offspring of naïve, sterilely wounded, or bacteria−challenged (primed) adult female beetles (*Tribolium castaneum*) with the bacterial entomopathogen *Bacillus thuringiensis* (Bt) to investigate the influence of maternal treatment on the temporal dynamics of bacterial load and immune gene expression in offspring. Meanwhile, we monitored offspring survival, development, and fecundity to quantify the functional outcomes of priming in this system. Early in infection, primed larvae were better able to curb bacterial proliferation and they subsequently exhibited increased tolerance for high bacterial loads. Moreover, primed larvae had better survival odds and buffered developmental costs of infection, although these phenotypes varied dynamically with brood order after maternal challenge. Using a mathematical model of within−host dynamics, we incorporate this data into a comprehensive framework that examines the relative costs and benefits of immune priming strategies in environments where resources and infection risk vary across ontogeny. Taken together, these results have broad implications for the evolution of immune priming as a plastic trait.

74.5 TATE, KB*; CROSSLEY II, DA; Univ. North Texas; *kevtate@gmail.com*

Chronic hypoxic incubation of embryonic chickens (Gallus gallus) alters the cardiovascular response to angiotensin analogues.

The renin angiotensin system (RAS) is a conserved cardiovascular regulatory system in vertebrates playing a critical role in cardiovascular homeostasis. Angiotensin II (Ang II) is the primary active peptide of the RAS, which is activated in response to hypovolemic/hypotensive stress. Chronic hypoxic conditions have also been suggested to increase RAS activity and elevating circulating levels of Ang II in fetal sheep. Therefore we examined the effects of hypoxic development on the RAS of embryonic chickens (*Gallus gallus*). We hypothesized that chicken embryos chronically incubated in 15% oxygen would have an attenuated pressor response to angiotensin analogues due to increased circulating levels of Ang II. To test this hypothesis we incubated eggs in 15% oxygen from day 0 up to day 19 (21 day incubation). Hypoxic incubation resulted in embryos that were relatively hypotensive and bradycardic compared to control embryos. Heart rate and blood pressure responses to angiotensin analogues: Angiotensin I, Ang II, and angiotensin converting enzyme (ACE) inhibitor, captopril were assessed. Angiotensin analogues, Ang I and Ang II resulted in a significant increase in arterial pressure in both groups. Hypoxic incubation blunted the response to Ang I suggesting an impact of reduced oxygen on ACE function. Delivery of Ang II prior to ACE inhibition with captopril resulted in a relatively reduced hypertensive response in hypoxic embryos, which was absent following ACE inhibition. These data suggest that Ang II levels are increased by chronic hypoxic incubation, and the conversion of exogenous Ang I to Ang II, is depressed by possibly reduced activity or availability of ACE. Our findings support our hypothesis that cardiovascular responses to exogenous angiotensin analogues are attenuated following chronic hypoxia in embryonic chickens.

P2.159 TAYLOR, G.R.; GREEN, C.C; KUHL, A; HAUKENES, A.H.*; University of Arkansas at Pine Bluff, Louisiana State University; *ahaukenes@uaex.edu*

Developing Proxies for Evaluating Cross−Protection in Channel Catfish Ictalurus punctatus

Molecular chaperones and their involvement with induced cross−protection (CP) are important components of an organismal response to environmental stress. Increasingly, molecular chaperones, such as HSP70, and CP are being examined in a therapeutic context in both human and veterinary medicine. For example, we have previously observed that brief bouts of heat treatment of channel catfish lead to both an enhanced resistance to subsequent heat extremes and an increased tolerance to noxious changes to water chemistry. We are currently evaluating cellular markers for this organismal response in order to more efficiently evaluate protocols designed to induce CP in finfish. In recent experiments we measured HSP70 mRNA expression in gills of channel catfish following treatments previously observed to induce CP. A time−series experiment comparing non−treated channel catfish to fish that were briefly exposed to 36°C was performed. Both these groups were then compared to channel catfish that were exposed to 36°C for one hour. Relative rates of expression of HSP70 mRNA in gills from channel catfish briefly exposed to 36°C was significantly higher than control animals immediately after treatment. However, no differences between these two groups were observed at 30 and 60 minutes after treatment. Gills from both of these groups had significantly lower HSP70 mRNA expression than catfish held at 36°C for one hour. While it is not surprising that the increased duration of heat treatment led to a more robust signal of HSP70 activation, the marginal increase (relative to non−treated control animals) in the expression of HSP70 mRNA in fish that were administered a heat treatment that was known to induce CP warrants further examination.

81.7 TAYLOR, J.C.*; WILLIAMS, M.B.; KATIYAR, S.K.; WATTS, S.A.; University of Alabama at Birmingham, Birmingham; *jchrisrun@gmail.com*

Dietary beta−carotene supplementation in broodstock affects F1 embryonic development and embryonic stress response to UVR in the sea urchin Lytechinus variegatus

Carotenoids are selectively accumulated in sea urchin gonad but their function is unknown. These carotenoids have been suggested to function as in vivo antioxidants and facilitators of reproductive tissue maintenance. Adult *Lytechinus variegatus* broodstock with gonads in the growing phase were fed diets either with or without supplemental beta−carotene for 5 months and subsequently induced to spawn. Fertilized eggs were collected from each feed treatment and exposed to differing intensities of UVA (0−4 J/m^2) or UVB (0−100 mJ/cm^2) radiation. Larval mortality counts and developmental status were recorded at 34 and 55 hours post−fertilization and compared between feed treatments. Increasing intensities of UVA and UVB radiation were positively correlated with larval mortality in both dietary treatments. UVB induced higher mortality than UVA. Larval mortality in the beta−carotene supplemented treatment was significantly higher than the beta−carotene free treatment. F1 larvae within the beta−carotene supplemented treatment developed at a slower rate and suffered significantly higher developmental abnormalities when exposed to UVB. These data suggest that dietary supplements of carotenoid do not provide photoprotection and may, through unknown mechanisms, enhance the deleterious effects of UV exposure. We suggest that excessive levels of beta−carotene in the diet may negatively affect outcomes of both FO and F1 progeny.

11.3 TELEMECO, R S*; ADDIS, E A; BRONIKOWSKI, A M; CORDERO, G A; POLICH, R L; Iowa State University, Gonzaga University; *telemeco@iastate.edu*

Here be dragons: Thermal ecology and biogeography of alligator lizards

Important goals of modern biology are to understand how the geographic distributions of species are set. However, there is little consensus as to which organismal traits, life−history stages, or aspects of the environment are most limiting. To begin bridging this knowledge gap, we performed a series of experiments examining the thermal physiology of northern and southern alligator lizards (*Elgaria coerulea* and *E. multicarinata*). These lizards are ecologically similar, but *E. coerulea* exist at higher elevation and latitude (i.e. colder environments) than do *E. multicarinata*. Even so, previous work suggests that mean temperature does not differentially affect adults of these species. We examined the effects of biologically−relevant extreme temperatures on the stress physiology and mitochondrial functioning of adult lizards, and then the effects of incubation temperature on developing embryos. Cold temperatures elevated corticosterone in *E. multicarinata*, but not *E. coerulea*. In addition, mitochondrial respiration rates suggested that *E.multicarinata* have high aerobic scope at warm temperatures while *E. coerulea* have high aerobic scope at cold temperatures. Finally, *E. multicarinata* embryos could not tolerate developmental temperatures as cold as those tolerated by *E. coerulea*. Our results suggest that the affects of commonly experienced extreme temperatures on each life−history stage are important for setting thermal limits in alligator lizards. Generally, distribution models consider the effects of average temperature on adults only. Such models would not accurately predict the current or future geographic distribution of alligator lizards.

P2.72 TELEMECO, M.S.C.*; KELLY, C.D.; Iowa State University, Universitè du Quèbec; *msct@iastate.edu*

Trade−Offs Between Reproduction and Immunity in Attractive and Unattractive Males in the Texas Field Cricket (Gryllus texensis)

Investment in immunity and reproduction imposes significant costs to an individual's resource pool, and so the performance of these fitness−related life−history traits is expected to trade−off with each other. Because sexually attractive males are assumed to be of high genetic quality and better able to acquire and assimilate resources, they should suffer fewer costs from allocating resources to fitness−determining traits. This hypothesis predicts that an immune−challenge will have significant negative effects on reproduction in unattractive males but not in attractive males. Our test of this prediction involved immune−challenging (with lipopolysaccharide, LPS) attractive and unattractive male Texas field crickets (*Gryllus texensis*) and then quantifying their investment in reproduction, as measured by ejaculate quality (sperm number and viability) and mate−calling effort. Contrary to prediction, mate calling was reduced by our immune challenge in both attractive and unattractive males. Neither attractiveness nor immune challenge significantly affected ejaculate quality. We conclude that male attractiveness does not play a significant role in mediating the effect of an immune−challenge on reproduction in this cricket species.

20.5 TEPOLT, C. K.*; PALUMBI, S. R.; Hopkins Marine Station, Stanford University; *carolyn.tepolt@gmail.com*

Genetic correlates of local adaptation in the globally invasive European green crab, Carcinus maenas

The European green crab (*Carcinus maenas*) is a globally invasive species, with established populations across a wide range of thermal environments in both its native and invasive ranges. This demonstrated ability to survive and thrive across novel environments makes the species ideal for examining the mechanisms underpinning success in a rapidly changing climate. Previously, we have demonstrated differences in heat tolerance after common−temperature acclimation between seven diverse populations of green crabs in both the native and invasive range. This work suggested the existence of local adaptation to temperature. In this study, we use transcriptome sequencing to examine the genomic mechanisms associated with these differences. Using a panel of 10,809 nuclear SNPs generated by mRNA−Seq, we are able to distinguish significant differentiation between populations with different heat tolerances. An outlier F_{ST} analysis identifies 51 genes likely to be under selection between these populations. The outlier genes are significantly enriched for Gene Ontology terms associated with mitochondrial cellular components, including the mitochondrial inner membrane. We directly sequenced several candidate genes from this group in crabs tested for heat tolerance during physiological experiments, examining the relationship between genotype and phenotype on the level of the individual animal. Despite high potential gene flow, green crabs can be locally adapted to their environments, and show genetic differences at particular loci that seems to indicate the action of selection. Adaptive differences between populations are likely to include selection on energy production via nuclear−encoded mitochondrial proteins.

129.1 TERUSAKI, A.T.*; TSUKIMURA, B.; California State University, Fresno; *Aterusaki@gmail.com*

Elucidating the Synthesis of Methyl Farnesoate in the Tissues of the Tadpole Shrimp, Triops longicaudatus

In crustaceans, methyl farnesoate (MF) acts as a juvenilizing factor, maintaining juvenile characteristics and delaying reproductive development. The synthesis of MF is catalyzed by the enzyme farnesoic acid O−methyltransferase (FAMeT) in the mandibular organ (MO) of crustaceans through the methylation of farnesoic acid (FA). The tadpole shrimp (TPS) have a simplified body structure lacking such endocrine organs like the MO. Previous research in our lab showed that TPS fed on nutrient pellets containing the hormone MF have decreased oocyte production during larval and juvenile stages. This decrease in oocyte production is due to a delay in the reproductive development mirroring the effects seen in other crustaceans. However, the site for MF synthesis has yet to be determined. In this study we look to identify tissues responsible for the synthesis of MF. A radiochemical assay was used to measure the synthesis activity of select TPS tissues. Our results show that TPS synthesize MF ubiquitously across their entire body. This notable difference correlates with the absence of a MO in the TPS and suggests that there may be no central site of synthesis of MF. FAMeT activity decreased in 6 day old TPS. This decrease at 6 days old may be associated with the end of the TPS juvenile stage and reproductive development. We also measured the activity of TPS fed daily on a diet containing MF. Isolated tissues and whole body homogenates of animals fed on the MF diet showed no observable difference in activity compared to controls. FAMeT activity increased on day 9 and then decreased by day 12, which corresponds to low MF levels in adults.

85.6 THEOBALD, J.C.*; MAZO, C.; Florida International University, Miami; *theobald@fiu.edu*

Flies use visual elevation to modulate different responses to translational and rotational displacements

When a flying insect deviate from its intended path, it uses the optic flow field help steer back. Unexpected rotational optic flow indicates an unintended change in heading, while unexpected translational optic flow indicates an unintended change in position. Any object that contrasts with its background can contribute to rotational optic flow, but due to the geometry of parallax only relatively near objects contribute to translational optic flow. Far away features, even the high contrast sun and moon, appear fixed while position deviates, offering no information to correct translational perturbations. For many insects in nature, the nearest objects are below, leading to the prediction that insects might respond more strongly to translational optic flow that occurs beneath them. In these experiments rigidly tethered fruit flies steered in response to computer generated flow fields. When correcting for unintended rotations, flies weight the motion in their upper and lower visual fields about equally. However, when correcting for unintended translations, flies weight the motion in the lower visual fields more strongly. These results are consistent with the interpretation that flow fields are filtered to concentrate on directions where flies likely get the strongest signals during natural flight conditions.

P3.25 THOMAS, J.R.*; WOODLEY, S.K.; Duquesne University; *thomasj6@duq.edu*

Chronic elevation of the stress hormone, corticosterone, slows cutaneous wound healing in a terrestrial salamander (Desmognathus ochrophaeus)

In vertebrates, a physiological response to a stressor is the activation of the hypothalamic−pituitary−adrenal (HPA) axis. One consequence of this activation is the release of gluccocorticoid hormones, such as corticosterone (CORT). CORT has a number of physiological and behavioral roles including regulating glucose metabolism, vascular tone, and anti−predator behaviors as well as having effects on reproduction and immune function. Specifically, chronic elevation of CORT is immunosuppressive in lizards, birds, and mammals; however, little is known of the relationship between CORT and immunity in amphibians following metamorphosis. To analyze the effects of chronic CORT elevation on amphibian immunity, we monitored cutaneous wound healing in both male and female salamanders exposed to daily stress treatments over the course of 30 days. Subjects that had received a daily dermal CORT patch healed more slowly than controls and subjects that had been handled daily. This suggests that under chronic conditions, CORT suppresses the inflammatory phase of wound healing. Also, females healed significantly less than males in all treatment groups, suggesting that females may be more energetically limited than males.

P3.124 THOMAS, W.H.*; FUNG, J.K. ; THOMAS, F.I.; University of Hawai'i, Hawai'i Institute of Marine Biology; *hoaka.thomas@me.com*

Comparative toxicity of antifouling coatings on the larval development of the sea urchin Tripneustes gratilla .

Urban development in the watershed of K ne'ohe Bay, Hawai'i has been increasing since the 1920's. Runoff, introduced species, dredging and other anthropogenic activities have ecologically changed the bay. Increasing human population of the region has led to a great increase in recreational use of the bay, accompanied by a large expansion of boat ownership and yacht harbors. The use of antifouling (AF) coatings is common among boaters. The main focus of this study was to examine the extent to which antifouling coatings affect development of larvae of *T. gratilla* . Three commercial marine coatings containing one of three AF compounds, cuprous oxide, cuprous thiocyanate or zinc, were applied to applicator sticks. After drying, solutions of soluble compounds from the coatings were made by soaking the coated sticks in filtered seawater for two days. Test solutions were made by serial dilutions of the coating treated water. Urchin embryos were allowed to develop for three days in 10 mL of onshore, offshore, control seawater and diluted AF solutions. These experiment revealed that larvae are sensitive to AF materials even when highly diluted. Across trials, larvae in the cuprous oxide treatment showed the highest rate of normal development (70%) at a dilution of $1x10^{-23}$. Results of the onshore and offshore water treatments revealed that offshore bay water allowed higher rates of normal development compared to water collected at onshore locations. This may mean that there is continual leaching of toxic AF chemicals into the bay, creating a water quality gradient, with lowest water quality in onshore areas where most boats are moored.

13.7 THOMAS, P.*; ZHANG, C.; University of Texas at Austin, Univeristy of Texas at Austin; *peter.thomas@utexas.edu*

Testosterone acts at the cell surface to induce apoptosis of Altantic croaker granulosa/theca cells via a mitochondrial apoptotic pathway

The teleost ovarian follicle undergoes extensive remodeling and regression during the reproductive cycle, involving apoptosis and cell death, but the hormonal regulation of these processes remains unclear. In the current study the role of testosterone in regulating apoptosis of Atlantic croaker ovarian follicles was investigated in co−cultured granulosa/theca (G/T) cells. Testosterone (T) enhanced serum−starvation induced cell death and apoptosis of G/T cells and this effect was mimicked by a cell−impermeable T conjugate, T−bovine serum albumen, indicating that this androgen action is initiated at the cell surface. Previously an androgen binding moiety was biochemically characterized on croaker ovarian membranes with the features of a novel membrane androgen receptor. Mibolerone, a nuclear androgen receptor agonist, was ineffective in promoting apoptosis of G/T cells which suggests the membrane androgen receptor mediating T induction of cell death is unrelated to the nuclear receptor. Gene expression of Bcl−2 associated X protein (Bax), a pro−apoptotic member of the Bcl−2 gene family, was upregulated by T treatment indicating that it is a likely intermediary in T−induced cell death through the mitochondrial apoptotic pathway. Gene expression of JNK and p53, two upstream regulators of Bax, was also upregulated after T treatment. Collectively these results indicate that T activates a novel membrane androgen receptor to induce cell death of G/T cells in croaker through the mitochondrial apoptotic pathway involving JNK, p53 and Bax. Preliminary studies with mammalian granulosa cells suggest this mechanism of androgen action to promote apoptosis is evolutionarily conserved in vertebrates.

P2.79 THOMAS, A.*; SOLOMON−LANE, T.K.; WILLIAMS, M.M.; ROGERS, L.; GROBER, M.S.; Agnes Scott College, Atlanta, Georgia State Univ., Atlanta; *tsolomonlane1@student.gsu.edu*

Sexually dimorphic allometric scaling in the sex changing fish Lythrypnus dalli

Allometric relationships frequently differ between males and females and provide insight into the life history of a species. For the bluebanded goby (*Lythrypnus dalli*), a bidirectionally sex changing fish, sex and size are closely tied to an individual's social and reproductive role, and as a result, important aspects of allometry may be sexually dimorphic. The *L. dalli* population is female−biased, and females form harems defended by large, territorial males. Sex is socially regulated such that the dominant fish is always male. With the exception of smaller mini males' that do not hold territories and utilize an alternative reproductive strategy, subordinates are female. Here, we quantified gonad, liver, and brain mass in field−collected males and females across a range of sizes. There was no overall relationship between gonad and body mass, but gonad mass was positively associated with body mass for males and females separately. As expected, the increase in ovary mass with size was greater than in males because female reproductive success increases with gamete production, while male reproductive success is a function of harem size. Liver mass scaled positively with body mass for males and females, but, corrected for size, females' livers were approximately 20% larger, suggesting a sex−specific physiological role. Brain mass was positively associated with body mass for all fish together, as well as males and females separately, and the proportional increase in brain size with body size was not different in males and females. These data suggest there can be substantial physiological consequences to being a male vs. female *L. dalli*.

P2.71 THOMPSON, D.M.*; LIGON, D.B.; Oklahoma State University, Missouri State University; *denise.thompson17@gmail.com*

Reproductive Investment Patterns in a Captive Population of Alligator Snapping Turtles (Macrochelys temminckii)

Identifying resource allocation patterns is fundamental to understanding reproductive investment strategies that maximize maternal fitness. Turtles are useful model organisms for such studies because most species do not invest in parental care; therefore, variation in maternal investment can be assessed solely from variation in clutch characteristics (e.g., egg size and egg number). We examined alligator snapping turtle maternal investment patterns by measuring reproductive output of captive turtles reared under similar conditions. Larger females tended to produce larger eggs (r^2 = 0.420, p < 0.0001), but the number of eggs per clutch (mean = 34) did not correlate with female body size (r^2 = 0.140, p = 0.1867). However, larger females exhibited greater total reproductive effort as clutch mass positively correlated with female size (r^2 = 0.441, p = 0.0095). Hatchling size increased with increasing egg size (r^2 = 0.162, p < 0.0001); thus, larger females produced larger offspring (r^2 = 0.284, p < 0.0001). Additionally, females with greater body condition produced hatchlings that were both larger (r^2 = 0.1089, p < 0.0001) and had greater body condition (r^2 = 0.027, p = 0.0082). We found that resource availability affected the number of eggs females produced, and that as the number of eggs per clutch increased, egg size decreased (partial correlation r^2 = 0.27, t = −13.32, p < 0.0001). These results indicate that alligator snapping turtles primarily increase maternal investment by producing more eggs rather than larger eggs and that female size and body condition have potentially important implications for hatchling condition and, ultimately, survival.

26.4 THOMPSON, N.E.*; O'NEILL, M.C.; DEMES, B.; Stony Brook University Medicine; *nathan.thompson@stonybrook.edu*

Three−Dimensional Head Kinematics During Terrestrial Locomotion in Humans and Chimpanzees

Osseous semicircular canal morphology has been used to reconstruct aspects of locomotor behavior in living and fossil primates. Relative to chimpanzees and other apes, humans exhibit significantly larger anterior and posterior canal radii of curvature. As such, humans and chimpanzees should differ significantly in their head motion across speed and gait. However, the three−dimensional (3D) head motion of apes during terrestrial locomotion is currently unknown. To address this issue, head kinematics during terrestrial locomotion were collected from three male chimpanzees (*Pan troglodytes*; 29.6±6.7 kg) and five male humans (78.3±7.9 kg). A 3D head marker set was used to determine roll, pitch and yaw angular velocity parameters (i.e. maximum, root−mean−square and average resultant velocity) about anatomical axes of the skull over a full stride. Angular velocities during human walking and running are lower than for any chimpanzee gait (i.e. bipedal walking, quadrupedal walking and galloping). Our data expands the body mass range of primate species for which 3D kinematic data exist by 18−fold. Over this range, angular head velocities are negatively correlated with body mass (pGLS, r^2 = 0.63). Relative to mass, humans exhibit negative residuals during walking and running, indicating uniquely stable heads. Based on this, we propose that the adoption of habitual bipedal locomotion in the hominin lineage was characterized by an overall decrease in 3D head motion. Therefore, the enlargement of human semicircular canal radii is likely an adaptation for greater head stability during locomotion. Supported by NSF BCS 0935321.

61.1 THOMPSON, ZAL*; SHELTON, S; LEVIN, P; CLAGHORN, GC; GARLAND, JR, T; Univ. of Calif., Riverside, Humboldt State Univ., Cal. State Univ., San Bernardino; *zthom002@ucr.edu*

Size and neuronal density of midbrain regions in selectively bred high−runner mice

How does selection on a behavior alter brain structure? Previous studies showed that mice from 4 replicate high runner (HR) lines had increased total brain mass and increased midbrain volume (~13%), as compared with 4 non−selected control (C) lines, supporting the mosaic model of brain evolution. The midbrain includes several areas that are involved in locomotion and reward. The goal of the current research is to determine which areas within the midbrain have changed size in HR mice. Total wheel revolutions on days 5 and 6 of a 6−day wheel−running trial are used as the basis for selection in four HR lines. Four control (C) lines are bred without regard to wheel running. HR mice voluntarily run almost 3 times as far as C mice on a daily basis, primarily because they run faster. Female mice from generation 66 were housed without access to wheels for 8 weeks. Mice were then perfused, and their brains dissected and weighed. Brains were sliced into 40 micron coronal sections with a cryostat, Nissl stained, and photographed. ImageJ was used to outline and calculate the area of the substantia nigra (SN), periaqueductal gray (PAG), and red nucleus (RN) in relevant sections according to an atlas. Individual nuclei were counted with the help of the ITCN plugin for ImageJ. Nested ANCOVA in SAS Proc Mixed with body mass as a covariate showed larger total brain mass in HR lines but no statistical difference in either average areas or total neuronal counts for the SN or PAG. More areas will need to be analyzed to determine which are responsible for the enlarged midbrain volume in HR mice. In addition, HR and C mice with 8 weeks of wheel access will be compared, and 3D volume reconstructions of brain areas will be made, which should enhance our ability to detect differences. Supported by NSF IOS−11212732.

120.2 THOMPSON, A.M.*; ZAKON, H.H.; Univ. Texas, Austin; *ammonthompson@gmail.com*

Two roads diverged 100 million years after a duplication.

Gene duplication is an important source of new genetic information. How gene families expand and diversify is especially important in the research of the genetics of adaptation. One particularly interesting example of gene duplication is the expansion of the voltage−gated ion channel gene family during the evolution of the nervous system in animals. This gene family has expanded from many duplication events to provide numerous channels selective to different ions, contributing to a wide variety of electrical functions in excitable tissue along with the elaboration of unique and adaptive cell types. One novel excitable cell type is the electrocyte, which has evolved in two different teleost fish lineages. It is derived from muscle cells and specializes in generating electrical impulses used for communication with conspecifics as well as for sensing and navigating their nocturnal world. Interestingly, in both electric lineages the same duplicate sodium channel was co−opted from its muscle function to specialize as an electrocyte−specific sodium channel, leaving the other duplicate behind in the muscle. Why was the same paralog co−opted for this novel organ? Through measuring relative gene expression of the two paralogs in muscle and ancestral character state reconstruction we have determined that the paralog that was turned off was greatly down−regulated in the non−electric ancestor of both these electric fish, suggesting it was "easier" to turn off in muscle and specialize for a novel function in electrocytes. The evolution of a duplicate sodium channel during the convergent evolution of a novel excitable tissue is another fascinating chapter in the expansion of the ion channel gene family as animal nervous systems grow and diversify in complexity and function.

114.5 THOMPSON, JA*; NAVARA, KJ; Univ. of Georgia;
judd@uga.edu
Effects of maternal stress on offspring growth and stress responsiveness in White Leghorns
The secretion of glucocorticoids in response to stress mediates physiological and behavioral changes needed to survive challenges to maintaining homeostasis. However, when glucorticoids pass from mother to offspring, deleterious programming effects can occur. Programming of offspring phenotype by maternal glucocorticoids is well−documented in rodent models, however the influences of glucocorticoids on growth and development of avian offspring is conflicting. To test the hypothesis that offspring phenotype is influenced by maternal glucocorticoids, we induced stress in female White Leghorns by restricting food availability, varying social interactions, or administering corticosterone via drinking water. We then measured weight, tarsus length, stress responsiveness, and reproductive efficiency of offspring produced by stressed and control hens. Offspring of hens stressed by food restriction and social interaction exhibited reduced growth rate ($p = 0.001$), tarsus length ($p = 0.005$), and body condition ($p = 0.022$) relative to control . This study demonstrates that maternal stress exerts long−term effects on offspring growth. Relationships between these influences and the effects on stress responsiveness in offspring will be discussed.

39.5 THOMPSON, J.T.*; LAVALVA, S.; CLARICI, D.; MOORE, M.; Franklin & Marshall College, University of Maine;
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The remarkable properties of the obliquely striated nuchal retractor muscle of squid
We investigated the *in vivo* function and *in vitro* contractile properties of the nuchal retractor muscle of the Atlantic longfin squid (*Doryteuthis pealeii*). This muscle, which is actually a muscular hydrostatic organ composed of both longitudinal and radial muscle fibers, functions during jet locomotion to alternately protrude and retract the squid's head during jet locomotion, and in so doing appears to ensure the appropriate flow of water during the jet cycle. Synchronized sonomicrometry and electromyography records of 21 squid revealed that the muscular organ operates over an impressive range of strains during escape jets, with mean maximum elongations and contractions of $+0.26 \pm 0.29$ and -0.64 ± 0.22, respectively. In addition, the muscular organ operates at impressive strain rates, with mean maximum elongation and contraction strain rates at 15°C of 1.61 ± 1.14 and -5.74 ± 3.8 muscle lengths s^{-1}, respectively. During some of the most vigorous escape jets, we noted a two−stage contraction in which the muscle would shorten rapidly, pause for a few milliseconds, and then shorten even farther. The second phase of contraction was always accompanied by a second burst of EMG activity. *In vitro* experiments revealed that the longitudinal fibers of the nuchal retractor have the highest maximum unloaded shortening velocity measured for an obliquely striated muscle: 7.0 ± 2.4 lengths per second at 15°C. The longitudinal fibers were able to produce relatively high force over a wide range of muscle preparation lengths. While the left side of the ascending limb of the length−tension curve was relatively linear, force increased in step−wise fashion as preparation length approached L_0. Funded by NSF grant IOS−0950827.

81.5 THOMSEN, O.; COLLIN, R.*; CARRILLO−BALTODANO, A.; Univ. Oldenburg, Smithsonian Tropical Res. Inst., Clark Univ.;
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Are Planktotrophic Calyptraeids "Pre−adapted" for Adelphophagic Development?
Adelphophagy, development where embryos grow large by consuming morphologically distinct nutritive embryos or their own normal siblings is common in some families of marine gastropods and worms and rare or unknown in others. In calyptraeid gastropods phylogenetic analysis indicates that adelphophagy has arisen at least 9 times, generally from species with planktotrophic larval development. This suggests that the evolution of adelphophagy is relatively simple in this group, and that the embryos of planktotrophic species might already express features that enable them to take advantage of dead or damaged siblings. Here we used three species of planktotrophic calyptraeids, one from each of three major genera in the family, to answer the following 3 questions: (1) Can planktotrophic developers benefit from the ingestion of yolk and tissue from siblings? (2) Does ingestion of yolk and tissue from siblings increase the variation in offspring size? and (3) Does ingestion of yolk and tissue from siblings alter the allometry between the velum and the shell, increasing morphological similarity to embryos of adelphophagic species? We found an overall increase in shell length and velum diameter when embryos could feed on smashed siblings within their capsules, but we did not detect any increase in variation or changes in allometry. The overall effect of our treatment was small compared to the growth observed in naturally adelphophagic development, but each embryo probably consumed only one sibling on average, whereas adelphophages usually consume at least 10−30 siblings.

S2.2−1 TIBBETTS, Elizabeth; University of Michigan;
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The evolution of honest communication: integrating social and physiological costs of ornamentation
The honesty of animal communication systems is a central issue in behavioral and evolutionary biology. What prevents weak, low quality individuals from cheating' by signaling that they are strong? The general answer is that quality signals are costly and signaling a high level of quality is relatively more costly for low quality individuals. Thus far, honesty−ensuring costs of ornamentation have often been studied in isolation. However, real systems are likely to be complex, so multiple types of costs may be involved in maintaining the honesty of ornaments. Here, I use agonistic signals in *Polistes dominulus* paper wasps to test the interplay between two well−known costs: aggressive social costs and physiological costs. The results suggest that the interaction between physiology and behavior may be key to maintaining ornament accuracy. Identifying the interplay among multiple different types of costs may clarify some long−standing challenges associated with understanding the evolutionary stability animal ornaments.

P3.154 TIETBOHL, M.D.*; PERLMAN, B.M.; ASHLEY−ROSS, M.A.; Wake Forest University; *tietmd11@wfu.edu*

What a fine spine: ontogenetic changes in the vertebral column of the mangrove rivulus (Kryptolebias marmoratus)

Kryptolebias marmoratus is a unique quasi−amphibious fish with the ability to move over land via controlled jumps generated by the axial musculoskeletal system. As a part of a study of the ontogeny of terrestrial jumping ability, we examined the development of the caudal vertebrae, quantifying inter−vertebral as well as ontogenetic differences. We predicted isometric scaling of the linear dimensions of the vertebral centra and neural and hemal spines with growth. We also predicted, based on previous research with adult fish of multiple species, that neural and hemal spine angles would become more acute toward the tail. Five individuals were selected for each of six age groups (1, 2, 4, 8, 12, and 16 weeks post−hatching) and cleared and stained. The most posterior twelve vertebrae anterior to the terminal (hypural) vertebra were photographed using a stereomicroscope and the following variables were digitally analyzed: vertebrae length/height, neural/hemal spine angles relative to the long axis of the centrum, neural/hemal spine lengths, number of intervertebral joints spanned by the neural/hemal spines, and area of the hypurals. Ossification of the vertebral column was completed by week 4; spines were fully ossified by week 8. As predicted, centrum height and length increased with age, and from posterior to anterior position within the column. In contrast, spine length increased in the posterior direction as well as the number of joints spanned by the neural and hemal spines, increasing to 2−3 joints toward the tail. Neural and hemal spine angles became more acute toward the tail in all age classes. We would predict the jumping ability of these fish to improve with age as vertebral elements further ossify.

34.2 TIETZE, SM*; GERALD, GW; Nebraska Wesleyan University; *shaunatietze@hotmail.com*

Trade−offs between salinity preference and anti−predator behaviors in a euryhaline fish (Poecilia latipinna)

Studies examining how animals balance conflicting physiological and behavioral demands provide valuable insight into how natural selection shapes the behavior of animals in their environment. Salinity preference and responses to predatory chemical cues were examined both separately and simultaneously in sailfin mollies (*Poecilia latipinna*), a freshwater species known to be euryhaline. We hypothesized that mollies would favor predator avoidance over salinity preference when presented with both demands. However, our results suggest that, despite being euryhaline, these fishes preferred lower salinities (freshwater), even if there were chemical cues from a crayfish predator present in freshwater. Our results raise questions pertaining to the potential stress saltwater places on freshwater fishes that are supposedly euryhaline and whether or not it is an advantageous strategy that can be utilized to avoid predators. This study sheds light on the potential benefits and consequences of being salt tolerant or intolerant and complicates our understanding of the selection pressures that have favored the different physiological mechanisms that permit euryhaline abilities in fishes.

P2.138 TIPSMARK, CK*; BREVES, JP; RABENECK, DB ; TRUBITT, RT; LERNER, DT; GRAU, EG; Univ. of Arkansas, Fayetteville, Univ. of Massechusetts, Amherst, Univ. of Hawaii, Kaneohe; *tipsmark@uark.edu*

Effects of Salinity and Cortisol on Gill Claudin−10c, −10e, −28a, −30 and Occludin in Tilapia

In euryhaline fishes, reorganization of gill epithelia, including tight junctions, has a key role during salinity acclimation. Five tight junction proteins were identified in the gill transcriptome of tilapia; occludin and four claudin isoforms (10c, 10e, 28a and 30). Branchial expression of these genes in Mozambique tilapia was examined during acclimation to freshwater (FW) and seawater (SW) and in response to cortisol treatment in vitro. A survey of the tissue distribution showed that occludin expression was present in many tissues with high abundance in gill, intestine and kidney. The four claudin isoforms were expressed at the highest levels in gill tissue. Transfer of tilapia from FW to SW stimulated claudin−10c and −10e, while claudin−28a, −30 and occludin were highly stimulated during FW acclimation. To evaluate if cortisol could be involved in the salinity induced changes, gill filaments were incubated with cortisol in vitro. Cortisol stimulated expression of both FW and SW induced claudin isoforms and thus had a general stimulatory effect on these targets. These data suggest that claudin−10c and −10e are important during acclimation of tilapia to SW, possibly by changing paracellular permeability. Occludin and claudin−28a and −30 appear involved in reorganization of gill epithelium during FW acclimation.

24.5 TOBALSKE, B.W.*; LITTLE, P.J.; Univ. of Montana; *bret.tobalske@mso.umt.edu*

Effects of Transmissivity on Aerodynamics of Bird Feathers

Bird feathers are flexible and transmissive (permeable) to air. The functional effects of these properties are not well understood but are hypothesized to be important to the evolution of flight and for bioinspired design of robots. As development proceeds in precocial birds, their wings become more effective at producing aerodynamic force, and this trend is correlated with increasing feather stiffness and decreasing transmissivity. We undertook the present study to reveal the effects of within−feather transmissivity in isolation from other morphological variables. We manipulated primary feathers from adult peafowl (*Pavo cristatus*). Intact feathers exhibited average transmissivity of $8.1 * 10^{-4} m^3 s^{-1} N^{-1}$. Using hairspray to clog spaces between barbules, we eliminated transmissivity, and using a fine brass brush to disrupt barbule overlap we increased transmissivity to an average of 5x the intact value. Flexural stiffness increased by 6% for sprayed feathers, and decreased by 7% for brushed feathers. Intact feathers exhibited the best aerodynamic performance, with peak lift : drag = 3.4 and peak coefficient of lift 0.8, although brushed feathers also exhibited peak coefficient of lift = 0.8. Spraying resulted in the poorest aerodynamic performance, with the lowest lift : drag ratio (2.3) and peak coefficient of lift (0.6). Thus, the level of transmissivity exhibited by intact flight feathers was optimal, but drastic disruption of feather structure by brushing had relatively minor impacts upon aerodynamic function.

1.6 TODD, J.N.; PIRTLE, E.I.; SANDMEIER, F.C.; TRACY, C.R.; TRACY, C.R.*; Univ. of Nevada, Reno, University of Melbourne, Lindenwood University, Cal. State Univ., Fullerton; *crtracy@mac.com*
Can physiological flexibility mitigate the effects of climate change in desert lizards? Part I: thermoregulation
Others have predicted that climate change will cause mass extinctions of lizards because hotter thermal environments will preclude lizards from thermoregulating to optimal body temperatures. Several lizard species are able to adjust their preferred body temperatures in the different thermal conditions of warm and cool activity seasons, and that ability can mitigate adverse effects of climate change. We studied the common chuckwalla (*Saromalus ater*) to assess its flexibility to change body temperatures in the cool and hot seasons at two study sites: a cooler high−elevation site (Granite Mts, CA) and a hot low−elevation site (Amboy Crater). In a laboratory thermal gradient, chuckwallas selected the same body−temperature range (34−39°C, corresponding to temperatures at which lizards can sprint maximally) regardless of season or site, and that *T*b range is that previously observed in 1970. Lizards in the field emerged from their rock shelters in spring when their preferred body temperatures were possible. In the high−elevation site, lizards were active in springtime during only 70% of the hours when preferred body temperatures were possible, and on 98% of activity−season days, while lizards at Amboy (where food was scare due to a drought) were active only 20% of the hours when preferred temperatures were possible, and on only 54% of activity−season days. These results suggest considerable flexibility for chuckwallas to adjust to predicted change in thermal environments due to global climate change.

P2.11 TODD, G.J.*; ENSMINGER, A.L.; PEARSON, T.L.; FERNANDEZ−JURICIC, E.; Purdue University, West Lafayette, IN; *gtodd@purdue.edu*
From the Individual's Visual Perspective: How Foraging Behavior is Related to Chromatic Contrast of Seeds and the Retinal Physiology of Individual House Sparrows
The configuration of the visual system plays an important role in foraging behavior of organisms that rely heavily on vision to locate food. Factors such as the location of the fovea, the width of the binocular field, the density of photoreceptors, and the absorbance properties of photoreceptors combine to determine how easily organisms identify food items against substrates. We hypothesized that these factors can affect head movement rates, head positions, and seed−finding rate. We tested this hypothesis in house sparrows in two treatments: seed against high−contrast and low−contrast backgrounds. We predicted that individuals would have a higher seed−finding rate in the high−contrast background and that there would be a difference in head positions between the two treatments. We will present head movement rates, the proportion of time spent in various head positions, and the seed−finding rates, in relation to chromatic contrast. For these individuals, we also collected data on photoreceptor densities and oil droplet absorbances (components of an individual's ability to discriminate colors). Having both behavioral and physiological data allowed us to test whether an individual's behavior is related to its visual physiology. We predicted that individuals with higher photoreceptor densities would have higher seed−finding rates in both treatments, due to having higher visual resolution. We also predicted that the oil droplet absorbances of individuals would affect performance in the two trials, perhaps differently in the two treatments due to the difference in chromatic contrast. This study has implications for understanding the relationship between visual physiology and foraging behavior.

109.8 TOMANEK, L.*; CHILTON, H.; FOWLER, A.; CAMPBELL, J.; PETERSEN, N.; ROSNER, M.; California Polytechnic State Univ., San Luis Obispo; *ltomanek@calpoly.edu*
The role of sirtuins in environmental stress tolerance
Sirtuins are important modulators of the post−translational state of proteins, e.g., deacetylation. We tested their role in the cellular stress response by analyzing the proteomic changes in two blue mussel species in response to heat, oxidative and hypoxia stress without and with sirtuin inhibitors. Specifically, we compared the responses of the warm−adapted Mediterranean blue mussel species *Mytilus galloprovincialis* with the Californian native *M. trossulus*, with the former having invaded southern California during the last century and replaced the cold−adapted native from its southern range. Suramin inhibits sirtuin (SIRT)1, 2 and 5. When applied during heat stress, suramin affected the abundance of molecular chaperones, RNA−binding, oxidative stress, ATP−generating, cytoskeletal and signaling proteins in both species, but affected many more proteins in the cold−adapted *M. trossulus*. Specifically, oxidative stress proteins and enzymes of fatty acid oxidation were more affected by suramin in *M. trossulus*, possibly linking oxidative stress to a shift in metabolism towards the oxidation of fatty acids, thereby reducing the production of reactive oxygen species. Western analysis showed that SIRT5 abundance increased with suramin treatment at moderate temperatures, suggesting a possible feedback mechanism and a role in the proteomic changes. In addition to heat stress, we tested the effect of suramin and nicotinamide (a SIRT3 inhibitor) on the proteomic responses to chemically−induced oxidative stress and hypoxia. Treatment with sirtuin inhibitors during hypoxia led to increased mortality in *Mytilus*. Thus, sirtuins are important in the cellular stress response and contribute to interspecific differences in stress tolerance in *Mytilus*.

79.1 TOMMERDAHL, AP*; BURNETT, KG; BURNETT, LE; College of Charleston; *annatommerdahl@gmail.com*
Respiratory properties of wild and aquacultured penaeid shrimp hemocyanin
Respiratory properties of hemocyanin (Hc) are well documented within the crustacean subphylum, yet a gap remains in the literature regarding properties of Hc in penaeid shrimp. Understanding how Hc operates in this most basal extant group of decapod crustaceans is central to evaluating the evolution of Hc in derived species. Furthermore, it is important to characterize the effects of low O_2 (hypoxia) on marine organisms since the size, intensity, and frequency of hypoxic zones continues to increase in nearshore marine habitats worldwide. The Atlantic white (*Litopenaeus setiferus*) and brown (*Farfantepenaeus aztecus*) shrimp are abundant in Charleston Harbor and provide a good model to study hypoxic effects as they inhabit routinely−hypoxic estuaries and they play important ecologic and economic roles. *L. vannamei* (Pacific whiteleg shrimp) is the most commonly aquacultured shrimp species worldwide, giving economic importance to understanding their ability to cope with hypoxia commonly found in aquaculture ponds. We evaluated Hc O_2 binding properties and [Hc] among wild populations of these three species plus an aquaculture population of *L. vannamei* and found differences in O_2 affinity between Atlantic and Pacific species (P_{50}=1.6 kPa ±0.03 SEM Atlantic, 3.9±0.03 kPa Pacific, pH=7.4), and higher [Hc] in aquacultured *L. vannamei* relative to all wild populations (10.3±0.23g/100mL SEM vs. 7.0±0.5g/100mL in both wild *L. vannamei* and *F. aztecus*, and 8.0±0.2g/100mL in *L. setiferus*). Hc in all four populations appears to be extremely stable with regards to chronic hypoxia exposure, as derived crustaceans have been found to alter Hc O_2 affinity in response to chronic hypoxia exposure, but we did not observe any alteration of this parameter after 30 days in hypoxia. (NSF IOS−1147008)

75.2 TORSON, A.S.*; YOCUM, G.D.; RINEHART, J.P.; KEMP, W.P.; BOWSHER, J.H.; North Dakota State University, USDA−ARS; *Alex.S.Torson@ndsu.edu*

The genetic components of extended life expectancy in chilled, post−diapause quiescent alfalfa feafcutting bees, Megachile rotundata

The alfalfa leafcutting bee (*Megachile rotundata*) a solitary bee native to Eurasia, is the worlds most intensively managed solitary bee and has become the primary pollinator for alfalfa seed production. These bees, when commercially managed, are overwintered as diapausing prepupae under static thermal regime (STR) at 6°C until the spring when individuals are moved to 29°C and development resumes. Recent work has shown that individuals overwintered using a fluctuating thermal regime (FTR), consisting of a daily temperature increase to 20°C for one hour, show a dramatic increase in survival when compared to those overwintered in the current management practice. In this study individuals reared under FTR and STR protocols were collected as post−diapausing quiescent prepupae at two different time points and transcriptome profiling was performed using high−throughput mRNA sequencing (RNA−seq). An expression analysis identified differentially regulated transcripts between both treatments and time points. Transcript annotation and functional class analysis were used to identify differentially expressed transcripts. Transcripts belonging to oxidative stress and metabolic pathways predicted to protect against chill−injury were observed. This data provides first description of the genetic components that drive the differences in life expectancy between individuals reared under FTR and STR protocols.

P2.107 TOTTEMPUDI, M.*; LOVE−CHEZEM, T.; WOLFE, L.S.; DERBY, C.D.; Georgia State University, Atlanta, GA; *mtottempudi1@student.gsu.edu*

Ink from longfin inshore squid, Doryteuthis pealeii, as a chemical defense against two predatory fishes, summer flounder, Paralichthys dentatus, and sea catfish, Ariopsis felis

Chemical defenses are used by many organisms to avoid being attacked or eaten by predators. An example is inking molluscs, including gastropods such as sea hares and cephalopods such as squid, cuttlefish, and octopus, which release a colored ink upon attack. Previous work showed that ink can protect molluscs through a combination of chemical, visual, and/or mechanical effects. In this study, we examined the effects of ink from longfin inshore squid, *Doryteuthis pealeii*, on the behavior of two species of predatory fishes, summer flounder, *Paralichthys dentatus*, and sea catfish, *Ariopsis felis*. Using a cloud assay, we found that ink from longfin inshore squid affected the approach phase of predation by summer flounder, primarily through its visual effects. Using a food assay, we found that the ink affected the consummatory and ingestive phase of predation of both sea catfish and summer flounder, through the ink's chemical properties. Fractionation of ink showed that most of its deterrent chemical activity is associated with ink's melanin granules, suggesting that either compounds adhering to these granules or melanin itself are most biologically active. This work provides the basis for a comparative approach to identify deterrent molecules from inking cephalopods and to examine neural mechanisms whereby these chemicals affect behavior of fish using the sea catfish as a chemosensory model.

51.6 TOVAR, R.U.*; FREMAUX, B.P.; GARCIA, D.M.; Texas State University, Texas State University ; *r_t63@txstate.edu*

Ocular histology of three south central Texas Eurycea, a novel system for the study of evolutionary developmental biology

The south central Texas *Eurycea* clade presents a continuum of morphologies unique to the tetrapod lineage. The Texas blind salamander (*Eurycea rathbuni*) with its reduced eyes and skin pigmentation exemplifies subterranean phenotypes. The San Marcos salamander (*Eurycea nana*) and the Barton Springs salamander (*Eurycea sosorum*) are epigean species, and exhibit well−developed eyes and full pigmentation. While external morphology suggests differing ocular anatomy and functionality between epigean and subterranean species, ocular histological descriptions have yet to be accomplished for *E. nana* and *E. sosorum*. The paucity of ocular histology warrants a holistic review of this novel clade and its potential as a new tetrapod model system for ocular studies. Herein we present the first ocular histological description of *E. nana* and *E. sosorum* with *E. rathbuni* for a comparative review. Adult specimen heads were donated by the San Marcos National Fish Hatchery Aquatic Research Center and preserved for cryosectioning. The sections were mounted and imaged using confocal microscopy via auto−fluorescence of the specimen. We observed well−developed retinal layers, cornea, iris, and lens in *E. nana* and *E. sosorum*. These results suggest the epigean species have the histological structures necessary for visual function. Reciprocally, *E. rathbuni* has vestigial eyes, including an undifferentiated cell mass covered by pigment epithelium suggesting non−functioning eyes. Interestingly, a prominent optic nerve was noted in the vestigial eye of *E. rathbuni*. Further research is needed to understand the functions of these structures. Knowledge of adult ocular histology is critical for future investigation of this novel system, with particular regard to their evolutionary developmental biology.

P2.34 TRAN, T*; BOUGHTON, R; WILCOXEN, T; FAIR, J; HOFMEISTER, E; GRINDSTAFF, J; OWEN, J; FASSBINDER−ORTH, C; Creighton University, Archbold Biological Station, Millikin University, Los Alamos National Laboratory, USGS National Wildlife Health Center, Oklahoma State University, Michigan State University; *carolfassbinder−orth@creighton.edu*

Expanding our toolbox in avian ecological immunology: effectiveness of a new anti−passerine IgY detecting antibody in wild birds

Immunological reagents for wild, non−model species are limited or often nonexistent for many wild species. In this study, we compare the reactivity of a new anti−passerine IgY detecting antibody with existing avian IgY detecting antibodies in birds. Samples from 41 species from the following 6 avian orders were analyzed: Anseriformes (1 family, 1 species), Columbiformes (1 family, 2 species), Galliformes (1 family, 1 species) Passeriformes (16 families, 34 species), Piciformes (1 family, 2 species), and Suliformes (1 family, 1 species). Direct ELISAs were performed to detect total IgY using goat−anti passerine IgY−HRP, goat anti−chicken IgY−HRP, or goat anti−bird IgY−HRP (Bethyl laboratories, Inc.) as detecting antibodies. The anti−passerine antibody exhibited significantly higher IgY reactivity compared to the anti−chicken and anti−bird antibodies in 75% of the passerine families tested (12/16). Birds in the Piciformes order (woodpeckers) and Suliformes order (cormorants) were poorly detected by all three detecting antibodies. Birds from the Anseriformes, Columbiformes, and Galliformes orders exhibited the highest IgY recognition with the anti−chicken detecting antibody. The results of this study indicate that the anti−passerine IgY detecting antibody can effectively be used in immunological assays to detect passerine IgY for species in most passerine families tested in this study. This new detecting antibody appears to be most useful at detecting antibodies in passerine birds, as birds from other avian orders exhibited lower IgY recognition with this antibody compared to the anti−chicken IgY or anti−bird IgY detecting antibodies.

P3.50 TRAYLOR, AL*; EDWARDS, TM; Louisiana Tech University; *trayloal@gmail.com*

Effects of Dietary Phytoestrogens on the Development of Xenopus laevis

Flavonoids are interesting plant molecules that can affect reproduction and development of herbivores by altering estrogenic signaling. These so−called "phytoestrogens," although non−steroidal, have structures similar in shape and function to animal estrogens. The effects of phytoestrogens on animal physiology have been primarily studied in terrestrial animals, and a study performed on aquatic animals could expand our current understanding of animal−phytoendocrine interactions. The objective of this study was to investigate whether diets that vary in soy phytoestrogen levels could affect *Xenopus laevis* tadpoles by causing changes in developmental rate, time to metamorphosis, sex ratios and gonadal development. Using a yeast−based reporter gene assay for nuclear estrogen receptor beta (ER²), we validated estrogenic activity levels in five commercially formulated, experimental soy−based diets that varied in phytoestrogen (isoflavone) content. Results show the effects of these diets on *Xenopus laevis* tadpole development, overall improving our understanding of how dietary phytoestrogens can affect amphibian development.

P3.22 TREIDEL, LA*; PAITZ, RT; BOWDEN, RM; Illinois St. Univ., Univ. of Illinois; *latreid@ilstu.edu*

Characterization of yolk glucocorticoids and their metabolism during the embryonic development of the red−eared slider (Trachemys scripta)

Oviparous vertebrate eggs contain a number of steroids, including glucocorticoids, at the time of laying. During embryonic development, maternally derived glucocorticoids can act to modify the offspring's phenotype, while embryonically produced glucocorticoids are important for hatching. The multiple roles of glucocorticoids make it likely that regulating the timing of embryonic exposure throughout development is necessary for proper offspring development and hatching. Yet, little is currently known about the mechanisms by which this occurs, especially in oviparous reptiles such as the red−eared slider (*Trachemys scripta*). In our first study, we characterized the changing concentrations of yolk corticosterone occurring during embryonic development. Eggs from ten clutches were sampled throughout incubation and yolk corticosterone was quantified via a radioimmunoassay. We found that while prior to the start incubation only trace amounts of corticosterone are present, late in development, yolk corticosterone levels spike. Next, to investigate the metabolism and movement of corticosterone during embryonic development, we topically applied 150,000 cpm of tritiated corticosterone to eggs. Using eggs sampled at different points in development, an ether extraction was used to separate and quantify ether soluble and water soluble metabolites in the yolk, extraembryonic fluid, and embryo. From this study we found that applied corticosterone is rapidly metabolized during development and remains as metabolites mostly in the yolk and extraembryonic fluid. Together, these two studies suggest that the glucocorticoid environment is subject to modulation prior to the embryonic production of glucocorticoids.

P2.105 TRENT, S.*; SMOTHERMAN, M.; Texas A&M University; *strent@bio.tamu.edu*

Expiratory muscle activity in a flexible mammalian vocal motor program.

The main objective of this study is to investigate how respiratory muscle activity shapes the acoustic features of mammalian communication sounds. Mammalian vocalizations are generated by expiratory force which comes from coordinated actions of intercostal and abdominal muscles compressing the thoracic cavity to rapidly increase subglottic pressure. The acoustic properties of some mammalian vocalizations can be fine−tuned in a behavioral context by manipulating expiratory force. Echolocating bats demonstrate an exceptional level of vocal control and the abdominal musculature may play a central role in the bats' ability to adjust the shape of outgoing echolocation pulses. Here we explore how bats manipulate muscle activity to produce different sounds. We used chronically−implanted wire electrodes for obtaining electromyograms (EMGs) from the external oblique muscle in awake and actively echolocating bats. By mapping the electrical activity of this muscle with concurrent ultrasound recordings, we were able to identify stereotyped patterns of external oblique muscle activity immediately preceding each echolocation pulse, showing the involvement and requirement of this muscle in sound production. From this data we can evaluate how the temporal dynamics of this muscle's activity patterns relate to the spectrotemporal features of the bats' echolocation pulses. These results provide important insight to the neural−motor transfer functions that create these highly stereotyped vocalizations. By ultimately linking changes in motor cortical activity to changes in this abdominal muscle force this project will offer new insights to how the brain controls vocal communication in mammals.

S5.2−4 TRIMMER, B.A.; Tufts University; *barry.trimmer@tufts.edu*

Bone−free: Soft Mechanics for Adaptive Locomotion

Both muscular hydrostats (such as mollusks) and fluid−filled animals (such as annelids) exploit their constant volume tissues to transfer forces and displacements as articulated animals use hinges and levers. However, body control is more complicated for soft animals with layers of muscle oriented in multiple planes or with compressible tissues. Using caterpillars as a tractable model system it is now possible to identify the novel biomechanical and neural strategies for controlling movements in a highly deformable animal. For example, *Manduca sexta* , can stiffen by increasing muscular tension (and therefore body pressure) but the internal body cavity (hemocoel) is not iso−barometric nor is pressure used to directly control the movements of its limbs. Instead fluid and tissues flow within the hemocoel and the body is soft and flexible to conform to the substrate. During crawling the body is kept in tension for part of the stride and compressive forces are exerted on the substrate along the axis of the caterpillar (an "environmental skeleton"). The timing of muscle activity suggests that crawling is coordinated by proleg retractor motoneurons and that the large segmental muscles produce anterograde waves of movement requiring little timing precision. This strategy produces a robust form of locomotion in which the kinematics changes very little with orientation. In different species of caterpillar the presence of prolegs on particular body segments is related to alternative kinematics such as "inching". Some of these findings are being used to design and test novel control strategies for highly deformable robots. These "Softworm" devices are providing new insights into the challenges faced by any soft animal navigating in a terrestrial three−dimensional world.

45.7 TSAI, H.P.*; MIDDLETON, K.M.; HOLLIDAY, C.M.; Univ. of Missouri; *hptkr7@mail.missouri.edu*

Archosaur hip joint and its significance in body size and locomotor evolution

Reconstructing joint anatomy and function is critical to understanding posture, locomotor behavior, ecology, and evolution of vertebrates. Archosaurs evolved a wide diversity of hip joint morphology and locomotor postures. Among archosaurs, the very largest dinosaurs tend to exhibit terminal ends of long bones that differ in shape and size, suggesting the presence of large volumes of soft tissue. This study tests the association between hip joint dimensions, morphological characters, body mass, and locomotor postures of archosaurs. Femora and pelves of 72 taxa were digitized using 3D imaging techniques. Discrete and continuous characters were analyzed using phylogenetically corrected correlation to reveal trends in body size and postural evolution. Among saurischians, large theropods (e.g., Tyrannosaurus) and sauropods (e.g., Apatosaurus) convergently evolved incongruent hip joints, medially deflected femoral heads, reduced supraacetabular crests, and cranioventrally oriented antitrochanters. Sauropods retained the rugose proximal femur plesiomorphic for stem archosaurs, suggesting a reliance on femoral epiphyseal cartilage to increase joint congruence. In contrast, even the largest theropods exhibit smooth subchondral surfaces, suggesting the presence of thinner femoral epiphyseal cartilage and reliance on acetabular soft tissue to maintain congruence. Retention of thick femoral cartilage likely constrained sauropods to largely columnar hind limb postures, whereas the extensive modification of theropod acetabular tissues may be associated with greater degrees of hip joint movement (e.g. abduction and long−axis rotation) during locomotion.

91.4 TURINGAN, R.G.*; KENYON, J.E.; SHENKER, J.M.; Florida Institute of Technology, Melbourne; *turingan@fit.edu*

Modulating growth trajectories of the feeding mechanism in sympatric species may contribute to functional morphological diversity in teleost fishes

The quest into the advancement of our understanding of organismal diversity has inspired our renewed interest in investigating the developmental and molecular bases of functional morphological diversity. In this study, we attempt to contribute to our understanding of the origins of functional morphological diversity by comparing the trajectories of growth in key components of the suction−feeding mechanism in teleost fishes through ontogeny. Growth trajectories were generated in larval, juvenile and adult fish ranging in size from 3.0 to 210.0 mm. We derived the scaling coefficients (growth rate) of the Suction Index (SI), as well as key components of SI including the physiological cross−sectional area of the epaxialis muscle and the mechanical advantage of the neurocranial rotation mechanism. We compared the stage−specific growth rate of these performance metrics between the suction−feeding bluegill, *Lepomis macrochirus*, and the durophagous redear, *Lepomis microlophus*. In all fishes, SI and its morphological determinants scaled positively with body size. At the larval through the juvenile stages, growth rates of these metrics were statistically similar in both species. However, in bluegill, SI growth rate in late juvenile− to adult−stage was at least seven times faster than that of the larval− to early juvenile−stage. SI growth rate remained the same in both larval and adult stages of development in redear. SI growth rate in the late juvenile− to adult−stage was about three times faster in bluegill than in redear. Results suggest that the divergence in growth rate of functional morphological traits contributes to the formation of organismal diversity.

88.2 TURNER, JS*; PINSHOW, B; SUNY College of Environmental Science and Forestry, Ben−Gurion University of the Negev; *jsturner@syr.edu*

On transient−state ventilation of burrows with a single opening

Burrows provide shelter and accommodation for thousands of animal species, but they also can isolate their occupants from the atmosphere. If gas exchange between burrow and atmosphere is impeded, a burrow might become unsuitable for occupation. Standard models for gas exchange between burrows and atmosphere commonly invoke either diffusion, which is suitable only for exchange over distances that are smaller than the typical lengths of animal burrows; or bulk flow of air driven by winds, which requires that the burrow have at least two entrances. In Namibia, the burrow of the Cape skink, Trachylepis capensis, consists of a single vertical tunnel, 3−4 cm in diameter and 35−52 cm deep, which opens to the atmosphere through a single wide opening. We used laser−enhanced smoke visualization (LESV) to examine transient−state mechanisms for air exchange in these burrows. Capture of low−Reynolds number turbulent eddies, combined with probable viscous entrainment of burrow air, produces vigorous mixing of the upper air mass of the burrow, which facilitates mixing throughout the burrow. Clearance time constants were 30−40 s, and were commonly second−order, and in some instances, third order. In addition, the transient nature of eddy capture produced a sort of tidal ventilation in these burrows, with intermittent capture of eddies producing intermittent spurts of air exchange between the burrow and atmosphere. Our data support observations made by White et al. (1978 − Physiological Zoology 51:140−154) on European bee−eater nests, and we suggest that such transient−state air exchange may be a ubiquitous mechanism for gas exchange in burrows of all types.

P3.104 TURNER, S.E.*; BROWN, J.B.; RAMIREZ, J.N.; CORY, W.C.; WELCH, A.M.; College of Charleston; *seturner@g.cofc.edu*

Acute and chronic effects of naproxen and its photodegradants on southern toad tadpoles

Pharmaceutical pollution is an emerging environmental issue. Many pharmaceuticals pass through the body and are not completely removed during wastewater treatment, leading to the release of these compounds into the environment. The nonsteroidal anti−inflammatory drug naproxen is a widely used over−the−counter medication in the US and has been detected in natural waterways around the world. When exposed to sunlight, naproxen is converted into two related compounds. These photodegradants are predicted to be more toxic than naproxen because they have lower polarity. We tested the acute and chronic toxicity of naproxen and its two degradants using tadpoles of the southern toad (*Anaxyrus terrestris*). Amphibians are important components of freshwater ecosystems and may be particularly sensitive to pollutants due to their permeable skin. Acute toxicity was measured as median lethal concentration at 96 hours. The acute toxicity of naproxen was similar to that of its first degradant, but the second degradant was markedly more toxic. In the chronic toxicity tests, tadpoles were exposed to each compound at half of the median lethal concentration determined in the acute tests, through metamorphosis in a static renewal experiment. After 15 days of exposure, tadpoles exposed to either of the two degradants showed significant reductions in survival and growth, while those exposed to naproxen were not affected. Results at metamorphosis will also be presented. These tests suggest that photodegradation of naproxen in the environment may increase risk to freshwater organisms. With increasing concern about pharmaceutical pollution, more attention should be paid to degradation products of pharmaceuticals, which can be both more toxic and more environmentally persistent than the original compounds.

48.4 TYRRELL, L.P.*; FERNANDEZ−JURICIC, E.; Purdue University; *ltyrrell@purdue.edu*

Looking above the prairie: localized and upward acute vision in a native grassland bird

The visual system of open habitat vertebrates is predicted to have a band of acute vision across the retina (visual streak) and a wide angle of visual coverage to gather information along the horizon. We tested whether the eastern meadowlark (*Sturnella magna*) had this visual configuration given that it forages and nests in open grasslands. Contrary to our expectations, the meadowlark retina has a localized area of acute vision (fovea). The fovea projects above rather than towards the horizon when the head is at rest, and individuals modify their body posture in tall grass to maintain the same foveal projection. Meadowlarks have relatively large binocular fields and are able to see their bill tips, which may help with their probing foraging technique. Overall, the meadowlark visual system does not fit the profile of vertebrates living in open habitats and may be specialized in detecting and tracking aerial stimuli (predators, conspecifics).

80.4 TYTELL, E. D.*; OSWALD, L. E.; Tufts Univ.; *eric.tytell@tufts.edu*

The effects of viscosity on swimming in lampreys (Petromyzon marinus)

For most animals, locomotor movements result from a coupling between a flexible body and external environmental forces. To better understand this coupling, it is helpful to alter the balance of internal and external forces. Therefore, we examined the steady swimming kinematics of lampreys swimming in normal water, and water in which the viscosity was increased by 10 and 20 times by adding methylcellulose. Increasing the viscosity over this range increases the drag coefficient, potentially increasing fluid forces up to 40%. Previous computational results suggested that if lampreys did not compensate for these forces, the swimming speed would drop by at least 50% and body wavelength would decrease by about 25%, while tail beat frequency would remain the same. Five juvenile sea lampreys (*Petromyzon marinus*) were filmed swimming through still water and midlines were digitized using standard techniques. Swimming speed was about 1.77 body lengths (L) / s in normal water, and dropped by 40% in 10x viscosity, and by a further 51% in 20x viscosity, corresponding to Reynolds numbers of 1300, 80, and 20, respectively. Tail beat frequency also decreased: from about 3Hz in normal water to 2.9Hz and 2.3Hz in 10x and 20x viscosity, respectively. Body wavelength, contrary to our expectation, remained fairly consistent at 0.68 L. The estimated drag coefficient, using a cylindrical approximation, increased as expected in higher viscosity. Due to the large drop in speed, however, the estimated drag forces still decreased as viscosity increased. Thus, lampreys do change their muscle activity in high viscosity water, but perhaps not in response to higher drag forces. Future work may need to examine the changing dynamics of vortex shedding at the range of Reynolds numbers to account for the change in swimming speed.

66.6 UDAKA, H*; LI, D; DENNIS, A.B.; SINCLAIR, B.J.; Western Univ, ON, Canada, ETH Zürich & EAWAG, Switzerland; *hudaka@uwo.ca*

Gene expression associated with freeze tolerance in goldenrod gall fly, Eurosta solidaginis

Temperature affects many physiological processes in insects, and insects in temperate and polar zones have developed overwintering strategies to survive winter sub−zero temperatures. Some insects cannot survive internal ice formation and the other ones can tolerant internal ice formation. The goldenrod gall fly, *Eurosta solidaginis*, overwinters as a prepupa and can survive both extra− and intra−cellular ice formation. The molecular mechanisms underlying this freeze tolerance are not well−understood. We used illumina high−throughput RNA sequencing to identify genes associated with the response to freezing stress. *E. solidaginis* prepupae were frozen at −12 ºC for 2 h and samples were collected after the cold treatment. Sequences obtained from all sampling points and control individuals were used for de novo transcriptome assembly, and transcription profiles were compared among control and cold treated samples. These comparisons will allow us to identify candidate genes associated with freeze tolerance, and to generate novel hypotheses about the physiological mechanisms underlying insect freeze tolerance.

106.5 UHRIG, E.J.*; FRIESEN, C.R.; MASON, R.T.; Oregon State University, Corvallis, University of Sydney, Australia; *uhrige@science.oregonstate.edu*

Reproductive implications of endoparasitic infections in two garter snake species (Thamnophis sirtalis parietalis and T. radix)

Red−sided garter snakes (*Thamnophis sirtalis parietalis*) are host to several genera of endoparasites including nematodes and trematodes in the lungs, cestodes in the digestive tract, and trematodes concentrated in the visceral fat deposits and the ventral tissue of the tail. The trematodes found in the fat deposits and tail tissue (*Fibricola* and *Alaria* species, respectively) are very prevalent and tend to have high infection intensities that can lead to extensive tissue damage. Indeed, it is not uncommon for a portion of the tail to be lost, an injury that can interfere with reproductive success due to mechanical impairment. Whether reproduction is affected in other ways, such as altered gamete production, has not been previously investigated, nor have prior studies investigated whether these parasites have similarly high prevalence and intensity in other garter snake species. Our current study demonstrates that plains garter snakes (*Thamnophis radix*) are host to parasite infracommunities similar to those of the congeneric red−sided garter snake and we discuss patterns in the distribution of parasites in these two garter snake species. Further, as a step toward understanding the consequences of these infections, we evaluate the potential for these parasites to impact the reproduction of their hosts.

P1.63 UHRIG, E.J.*; FRIESEN, C.R.; MASON, R.T.; Oregon State University, Corvallis, University of Sydney, Australia; *uhrige@science.oregonstate.edu*

Effects of an immune response on reproduction and appetite in the red−sided garter snake (Thamnophis sirtalis parietalis)

Mounting an immune response, typically a costly endeavor for an organism, can have physiological implications of its own that are independent of the direct effects of the infection. Fever, lethargy and loss of appetite, for example, commonly occur as part of the immune response for many organisms. In addition, as organisms generally have a finite pool of resources to allocate to biological processes, an elevated immune response may lead to reduced investment in other costly processes such as reproduction. To date, despite the red−sided garter snake (*Thamnophis sirtalis parietalis*) being the focus of numerous studies of reproductive physiology and behavior, endocrinology, and chemical ecology, the effects of their immune response have not been extensively studied. Here, we present a study in which male and mated female red−sided garter snakes were injected with lipopolysaccharide (LPS) over the course of ten weeks. LPS is a non−pathogenic compound extracted from *E.coli* bacteria and is able to elicit an immune response when injected. To investigate potential effects of an immune response on reproductive investment, for females, we analyzed litter size and sex ratio, as well as offspring size and weight. For males, we determined testes masses and sperm counts. All snakes were weighed weekly before and after feeding. We found evidence suggesting that an immune response alters appetite in female snakes, but these effects may be mediated by reproductive state.

P1.22 UNKEFER, MK*; HOLSCLAW, J; HALL, E; PETERSON, J; CRESPI, E; Washingotn State University, Washington State University; *maggie.unkefer@wsu.edu*

The importance of local adaptation and environmental influences on foraging behaviors in the wood frog (Rana sylvatica)

Success in obtaining food is a factor in any animal's survival and fitness, and behavioral syndromes related to food intake may predict an animal's success in an environment. Using wood frogs (*Rana sylvatica*), we conducted an experiment to test whether behavioral syndromes related to foraging behavior are intrinsic to populations or are mediated by environmental conditions experienced as tadpoles, and whether composite behavioral phenotypes correlate with unique neuroendocrine profiles. We collected wood frog eggs from multiple populations, and raised tadpoles to metamorphosis at high and low densities in laboratory mesocosms; after metamorphosis frogs were housed individually in standardized conditions. At approximately 12 weeks after metamorphosis, a subset of frogs from each population were placed in an open field container with crickets, and 10 behaviors, such as hopping, orienting, and numbers of strikes, were recorded for 15 minutes. Hierarchical cluster analysis resolved two behavioral phenotypes characterized as frogs that 1) stay in one place and strike often at passing prey with moderate accuracy, or 2) pursue prey and make fewer strikes with high accuracy. Low density control animals from geographically similar populations often clustered in similar behavioral groups, indicating potential for behavioral syndromes adapted to local conditions. However, animals that developed in high−density mesocosms did not cluster with their source populations, suggesting possible environmental mediation of feeding behaviors. To characterize the neuroendocrine profiles of each of these behavioral phenotypes, we are currently measuring circulating corticosterone levels and mRNA levels of neuropeptides associated with foraging behavior.

1.7 VAN DAMME, R*; VROONEN, J; Univ. of Antwerp, Belgium; *raoul.vandamme@ua.ac.be*

Testing the thermal melanism hypothesis for lizards

Melanism is possibly the most common rarity in animal coloration. Starting with Kettlewell's classic experiments on peppered moths, the phenomenon has received ample attention from evolutionary biologists, but the adaptive significance of melanism remains heavily debated. For heliothermic ectotherms, the popular thermal melanism hypothesis (TMH) holds that darker colors will result in faster heating, increasing the time available for activity near physiologically optimal body temperatures. This thermal benefit would give ectotherms a fitness edge, at least if attaining optimal body temperatures is difficult, and dark coloration does not increase the risk of predation too much. The empirical evidence for this idea is surprisingly meager. Here, we test a number of assumptions of the TMH for squamate reptiles, focusing on medium sized lizards. We measured shortwave absorptivity and heating rates in four insular populations of *Podarcis melisellensis*, two of which are melanic, one is dark brown, and one is of the normal greenish color. Using information on the lizards' thermal preferences and local climatic conditions, we constructed two models to estimate the ecological significance of a darker skin. One model simply calculated the amount of time a lizard could reach its preferred body temperature range throughout the year and compared that among color types. A second model recognized that lizards will alternate basking bouts with spells of activity (e.g. foraging) which will bring them into thermally unfavorable microhabitats. It estimates the amount available for non−thermoregulatory activity and compares it among color types. The models suggest that the benefits of dark integuments are small for most of the activity period, but more substantial in spring.

P2.158 VAN DER WALT, M*; SMITH, G.D.; FRENCH, S.S.; Utah State University; *Marilize268@gmail.com*

Noise Pollution as a Stressor in Side−Blotched Lizards

Urbanization is accompanied by a lot of changes to the landscape that have the potential to affect the native species inhabiting the area. If animals are chronically exposed to these anthropogenic disturbances and are unable to acclimatize, changes in circulating glucocorticoid hormones may cause adverse effects to the animal's health, such as an impairment in innate immune activity. One such disturbance is human−induced noise. Using the side−blotched lizard, *Uta stansburiana*, because of their localized habitat and inability to escape such disturbances within the urban environment, we looked at the field and lab components of noise as a stressor. We first measured decibel levels in urban and rural field sites in their natural habitats in St. George, Utah, and conducted a lab study exposing *Uta* to either a synthesized urban sound recording or no sound recording (control) for ten days. We collected blood samples and measured circulating corticosterone and testosterone concentrations and bactericidal ability to determine if there are endocrine and immune alterations in response to increased noise decibels. Our results show that the lizards experienced a physiological response to noise, such as an elevated corticosterone concentration in animals exposed to noise.

80.1 VAN WASSENBERGH, S.*; VAN MANEN, K.; STAMHUIS, E.J.; Ghent Univ., Univ. of Groningen; *sam.vanwassenbergh@ugent.be*

Boxfish carapace hydrodynamics: a test of the self−stabilization and low body−drag hypotheses

Previous work by Bartol en co−workers indicated that the shape of the bony carapace of boxfish (Ostraciidae) plays a significant role in the hydrodynamic stability during swimming. Their flow tank measurements and flow visualizations showed specific vortical flow patterns that were argued to be responsible for course self−stabilization: when the animals pitches or yaws a certain angle with respect to the swimming direction, fluid forces exerted on the carapace would cause stabilizing moments about its centre of mass, reorienting the fish parallel to the flow. Additionally, drag coefficients reported for certain species (e.g. 0.1 for *Lactophrys triqueter*) are remarkably low for such poorly streamlined shapes. Both swimming−direction self stabilization and a low body drag fit best to migratory swimmers, whereas boxfish usually are slow speed manoeuverers of tropical reefs. To test this apparent contradiction, flow tank drag force and turning moment measurements of realistic body models and computational fluid dynamics simulations were performed for the species *L. triqueter* and *Ostracion cubicus* at a series of yawing and pitching angles of attack (Re = 6.5 x 104). Both the empirical and computational approach found strong de−stabilizing moments instead of stabilizing moments, thus rejecting the self−stabilization hypothesis. The minimal drag coefficient for *L. triqueter* was considerably higher than reported earlier (Cd = 0.27), the minimal Cd for *O. cubicus* being of similar magnitude (Cd = 0.29). These results indicate that the shape of the boxfish carapace promotes manoeuvrability, and any stabilization must be controlled by action of the fins.

S3.3−2 VAN WOLFSWINKEL, JC*; WAGNER, DE; REDDIEN, PW; Whitehead Institute for Biomedical Research − MIT, Cambridge; *josien@wi.mit.edu*

Heterogeneity in planarian neoblasts by single cell analysis

Planarians have a legendary capacity for adult regeneration that is mediated by a class of cells referred to as neoblasts. Neoblasts have been historically described based on their morphology, their radiation sensitivity and their capacity to divide. Recently it was found that at least part of the neoblast population is made up of pluripotent stem cells. Gene expression analysis by in situ hybridization has shown that all neoblasts share the expression of numerous genes, among which homologs of several known stem cell markers. However several other genes are expressed only in subsets of the neoblasts. It is currently unclear whether these differences in gene expression reflect the presence of several functional subclasses, or whether all neoblasts are part of one more or less homogeneous population. To address this question we used single cell transcriptional profiling to obtain "gene expression fingerprints" of several hundreds of cells from the neoblast population. These fingerprints suggest that multiple different classes of cells are present within the neoblast population, an observation central for defining the molecular basis for both cellular pluripotency and stem cell differentiation in planarian regeneration. We will discuss key molecular and cellular attributes of defined neoblast classes, including their localization, their potency, and their responses to wounds.

94.5 VANDEN HOLE, C*; TKINT, T; ADRIAENS, D; Ghent University; *Charlotte.Vandenhole@Ugent.be*

Does breeding strategy influence head morphology? A case study on mouthbrooding tilapiine cichlids.

Cichlids are morphologically very diverse. They are considered an excellent model to study explosive speciation and adaptive radiation, with resulting morphologies from an interplay between natural selection and sexual selection. We hypothesize that different breeding strategies are reflected in head morphology, both at an interspecific and intersex level (the latter through sexual dimorphism). More specifically we expect that uniparental mouthbrooding species will exhibit sexual dimorphism in buccal morphology that is more pronounced than in biparental mouthbrooders or non−mouthbrooders. In addition, for uniparental mouthbrooding species, we expect the mouthbrooding sex to attain the largest buccal cavity, as this could increase reproductive success. To test these hypotheses, we compared the body shape of males and females of four species of tilapiine cichlids that reflect the different breeding strategies within Cichlidae (maternal mouthbrooding, paternal mouthbrooding, biparental mouthbrooding and substrate brooding). Considering the highly integrated nature of the buccal system, being involved in several biological functions and roles (including mouthbrooding but also feeding, respiration, agonistic display and nest building), we also expect to see differences at the interspecific level, in relation to different feeding strategies and differences in diet.

55.4 VANDENBROOKS, JM*; HARRISON, JF; Arizona State University; *jvandenb@asu.edu*

Using impression fossils and 3D tomography to investigate the role of oxygen in insect evolution

Changes in atmospheric oxygen levels have been hypothesized to have driven evolutionary changes in insect body size, including Paleozoic gigantism. However, the fact that not all insect groups exhibited gigantism coupled with the paucity of the fossil record and the complex interactions between oxygen, organisms and communities makes it difficult to definitively accept or reject the oxygen−size link. We have taken two approaches to address this issue. One approach was the first statistical study of average and maximum body size of insect impression fossils across geologic times of both high and low oxygen levels. The results of these studies support the link between fluctuations in oxygen and insect evolution: 1) the maximal and average size of *Protodonata* and *Paleodictyoptera* fossils correlate positively with modeled atmospheric oxygen, 2) *Blattodea* fossils showed little variation in maximum size, but average size was correlated with atmospheric oxygen, and 3) the Triassic hypoxic event appears to have a larger impact on insect body size than the Paleozoic hyperoxic event. These results support both our previously reported results on modern insects, and the hypothesis that variation in atmospheric oxygen was a key control on insect body size through the Phanerozoic. Secondly, we have used x−ray synchrotron imaging to generate 2D images and 3D tomographic reconstructions of both modern insects and amber fossils, including the tracheal system. Our studies on modern insects have shown that the tracheal dimensions are strongly affected by oxygen variation. The ability to measure fossil tracheae provides a unique look at the impact of oxygen on insect respiratory systems and a possible biological proxy for atmospheric oxygen. Supported by NSF EAR 0746352.

P1.111 VANDER LINDEN, A.R. *; WILSON, G.P.; University of Washington, Seattle; *avanderl@uw.edu*

Functional constraint and convergent evolution of plagiaulacoid dentition in extant marsupials

Distantly related taxa often have independently evolved the same or similar complex structure as a solution to common functional demands presented by their environment. One such example is the plagiaulacoid tooth an unusual shearing blade that convergently evolved in four clades of extant and extinct mammals. Precisely how the function of the plagiaulacoid tooth and the tooth−bearer's diet vary across these taxa is an open question. To test the association of plagiaulacoid tooth shape, diet, and function, I measured the surface complexity of lower cheek tooth rows of 13 species from five families of extant marsupials (Caenoelstidae, Burramyidae, Phalangeridae, Potoroidae, Macropodidae). I created three−dimensional digital elevation models from microCT scans of these specimens and used GIS software to generate orientation maps of the tooth surfaces. Contiguous pixels with the same orientation were grouped as a "patch" on the tooth surface, and the total number of patches (Orientation Patch Count, or OPC) approximates the number of shearing surfaces available to mechanically process food. Previous studies of placental mammals have shown that increases in tooth surface complexity as measured by OPC correlate with increased consumption of plant material. I found no correlation between OPC and diet in the marsupial taxa sampled. However, I did find that the surface complexity of the plagiaulacoid blade is negatively correlated with the surface complexity of the molars. Although broader taxonomic sampling is necessary to determine the pattern of tooth surface complexity and diet in marsupials, these results suggest a more nuanced and complex role for functional constraint in the convergent evolution of the plagiaulacoid dentition.

62.6 VANESSA NEUTZLER, VP*; PALOMA REINOSO, P; St. Edward's University; *vneutzl@stedwards.edu*

Examination of the effects of physiological stress and cortisol levels on the acquisition of long−term declarative memories

Previous studies have indicated an effect of stress on learning, however, the relationship between stress, stress hormones and memory in humans has yet to be fully elucidated. The hippocampus is required for declarative memory consolidation, and studies suggest that cortisol, a steroid stress hormone which crosses the blood−brain−barrier, binding to glucocorticoid receptors in the hippocampus, may negatively impact learning. The present study examines the effect of stress−induced endogenous cortisol release on the acquisition of long−term declarative memories in humans. Experiments were conducted from 1:30− 4:30 p.m., to offset fluctuations in cortisol levels normally seen in the morning. Male and female subjects (n= 54, age 18−24 yrs) were asked to engage in memory acquisition and retrieval tasks, while experiencing a stressful or neutral (control) stimulus. To induce stress the socially evaluated cold−pressor stress test was used, with a room temperature water bath as control. Physiological indicators of stress were monitored throughout, and saliva samples were gathered before and during memory consolidation. Memory performance was assessed by free recall 24h later. An enzyme−linked immunosorbent assay (ELISA) was used for the quantitative analysis of salivary cortisol. Memory performance and physiological vitals were analyzed. Physiological stress induction was confirmed, as cortisol levels increased and heart rate was found to be significantly higher than baseline in stressed subjects. Data indicates decreased memory performance in stressed subjects compared to controls.

P2.7 VANLEUVEN, A.*; ABBOT, J.; SKOPEC, M.; Weber State University; *ashleyvanleuven@mail.weber.edu*

Caching behavior of the specialist woodrat Neotoma stephensi

Woodrats (genus *Neotoma*) are known for their prolific caching behaviors. *Neotoma stephensi*, a juniper specialist, frequently builds its middens in juniper trees and consumes up to 90% of its diet as juniper. Field evidence suggests that *N. stephensi* caches predominantly juniper in its middens. By contrast, the sympatric generalist *N. albigula* appears to cache a larger variety of both plants and non−plants in its middens. In order to determine if the two species have differences in their caching behavior, we compared them in a laboratory setting. Woodrats of both species were placed in cages that had two external compartments where different food and or non−food items were placed for caching. When offered rabbit chow (food) in one compartment and jingle bells (non−food) in the second compartment, the generalists cached more food and non−food than the specialists; who solely cached food. When offered the choice between juniper in one compartment and rabbit chow in the second compartment, the specialists cached more juniper than rabbit chow and consumed more juniper than the generalists. However, the generalists still cached more juniper and rabbit chow than the specialists. Given that juniper was the specialists'preferred item to cache, we next offered the specialists jingle bells that covered juniper in one compartment; while the other compartment contained only jingle bells. The specialists showed a preference for the jingle bells that impeded their access to juniper. We conclude that the specialist, *N. stephensi*, displays a decreased caching behavior in terms of both quantity and variety of items cached compared to the sympatric generalist, *N. albigula*.

27.7 VARSHNEY, S. *; ZOLOTOVSKY, E.; REICHERT, S.; LI, Y.N.; OXMAN, N.; BOYCE, M.C.; ORTIZ, C.; Massachusetts Institute of Technology; *svarsh19@mit.edu*

Mechanical design rules of articulated fish scale armor

The mechanical design rules of the ganoid squamation in the armored fish, *Polypterus senegalus*, were investigated with macroscale biomimetic models. The translational design process involved four steps: (1) X−ray micro−computed tomography of excised fish scales, (2) quantitative morphometric analysis of the reconstructed scale geometries, (3) 3D geometric abstraction and associative modeling, and (4) multi−material 3D printing to fabricate an articulated, synthetic scale assembly on a flexible substrate. Experimental testing of synthetic models quantified the mechanical behavior across multiple length scales. The introduction of morphometric variation into the prototype illustrated that a combination of scale geometry and materiality control the anisotropic mechanical flexibility of the global surface, which is composed of four degrees of freedom in scale−to−scale relative motion. Synthetic models that replicate the complex biomechanics of actinopterygian fish armor give insight into design rules for developing flexible, human−fit protection that maintains both full−body coverage and user mobility.

P1.129 VASSALLO, BG*; FASANELLO, VJ; PAITZ, RT; HAUSSMANN, MF; Bucknell Univ, Lewisburg, Univ Illinois, Urbana; *mfh008@bucknell.edu*

In ovo movement and metabolism of corticosterone throughout avian development

Maternal effects are a parental method of prenatally fine−tuning offspring for current, local environmental conditions, alternative to genetic inheritance. Accordingly, a parent's physiological state can affect the physiological condition and life trajectory of their offspring. Glucocorticoids (GCs) are steroid hormones, implicated in a number of maternal effects, which function in metabolic homeostasis, as well as an animal's response to stressful conditions. The mechanism by which GC−induced maternal effects proceed is still relatively unknown. Here we tracked the movement and metabolism of corticosterone (cort; the main avian GC) in developing Japanese quail eggs (*Coturnix japonica*). To first test the importance of injection site (yolk vs. albumen), fertilized eggs were injected into the yolk or albumen with [H3]−cort and allowed to develop for 5 d. In the second experiment both fertile and unfertile eggs were injected into the yolk with [H3]−cort and allowed to develop for 3, 6, 9, 12, or 15 d. After development, eggs from each experiment were separated into albumen, yolk, and embryonic portions and the radioactivity within each portion was characterized. Results from the first experiment indicate that distribution of [H3]−cort depends on site of injection. The second experiment clearly showed that embryonic factors modulate the maternally derived prenatal environment. Unexpectedly, cort injected into the yolk did not remain in its original form, but was conjugated over the course of development. While less than 20% of the [H3]−cort entered the embryo, the majority of this was also found in a conjugated form, indicating that in metabolizing cort the embryo may be playing an active role in altering potential maternal effects.

P3.136 VEGA, CM*; ASHLEY−ROSS, MA; Wake Forest University; *vegacm11@wfu.edu*

Role of Lateral Undulation in Salamander Locomotion

With the exception of turtles, lateral undulation of the vertebral column is an important characteristic of sprawling−postured tetrapods' locomotion. To elucidate the contribution of lateral undulation in swimming, underwater walking and terrestrial walking, we experimentally reduced vertebral flexibility in tiger salamanders (Ambystoma tigrinum) to mimic the condition in turtles. Three adult tiger salamanders (n =3) swam, walked underwater, and walked on land under each of three conditions: with nothing attached (baseline), with flexible tygon tubing around the trunk (control), and with rigid PVC pipe around the trunk (experimental). The tygon and PVC tubing was cut into half circles and fit over the mid−body of the salamanders between the fore and hind limbs, thus forming a "shell" that restricted lateral movement of the vertebral column to greater or lesser degrees. Two high speed cameras (Fastec TroubleShooter HR, 250 fps) captured dorsal and lateral views for kinematic analysis. Electromyography (EMG) was used to determine which muscles are active during aquatic and terrestrial walking and whether the activity patterns, timing, or intensity change when vertebral flexibility is eliminated. The five muscles targeted for EMG were as follows: (1) the dorsalis trunci; (2) the triceps; (3) the deltoid; (4) the pectoralis; and (5) the coracobrachialis (6) the latissimus dorsi. The same muscles will be targeted for EMG in turtles providing a basis for a direct comparison of their movement patterns in an aquatic and terrestrial environment. The comparative salamander data will be used to provide a context for comparison to turtles' movement patterns to provide insight into their debated evolutionary history.

60.7 VELLUTINI, B.C.*; HEJNOL, A.; Sars International Centre for Marine Molecular Biology, Univ. of Bergen, Norway; *bruno.vellutini@sars.uib.no*

Beyond boundaries: expression of "segment polarity" genes during larval lobe development in brachiopods

Brachiopods are sessile bivalved spiralians closely related to annelids, molluscs, and nemerteans. Despite having an unsegmented adult body, the larval body of many brachiopods is divided in lobes disposed along the anterior−posterior axis. This morphology and presence of partitioned coeloms in some larvae have been treated as evidence that brachiopods evolved from a segmented ancestor. We approached this hypothesis by characterizing the development of brachiopod larval lobes and the expression of genes commonly expressed in segments of arthropods and annelids (i.e. "segment polarity" genes) in the trilobed larva of *Terebratalia transversa* and the bilobed larva of *Novocrania anomala*. We have cloned Engrailed, Wnt genes, and components of the Hedgehog pathway and analysed their expression by in situ hybridization. The three lobes of *T. transversa* larva were delimited by an anterior ectodermal groove and a posterior less prominent constriction. We detected adjacent stripes of *wnt1* and *engrailed* transcripts in the ectoderm delimiting the anterior boundary. At the posterior boundary, *wnt1* and *engrailed* were co−expressed on a ventral and a dorsal band. Genes of the Hedgehog pathway were not expressed on the larval lobes. Adjacent stripes of *wnt1* and *engrailed* are also found at parasegment and segment boundaries of arthropods and annelids, respectively, while co−expression is observed in the chordate mid−hindbrain boundary and hemichordate collar−trunk boundary. Thus, our results suggest that *engrailed* and *wnt1*, but not *hedgehog*, might be involved in the development of lobe boundaries of *T. transversa* larvae in a similar manner as observed in other morphological boundaries.

32.2 VELOTTA, J.P.*; SCHULTZ, E.T.; JUE, N.; O'NEILL, R.J.; MICHALAK, P.; MCCORMICK, S.D.; University of Connecticut, Virginia Bioinformatics Institute at Virginia Tech, Conte Anadromous Fish Research Center, United States Geological Survey; *jonathan.velotta@gmail.com*

Genomic imprints of freshwater transitions in the Alewife (Alosa pseudoharengus)

Among fishes, ecological transitions into freshwater environments are often associated with episodes of diversification and adaptive radiation. The functional changes that accompany such transitions, and whether they are predicable or idiosyncratic, have rarely been characterized. We used Alewives *(Alosa pseudoharengus*) as a model system to test for such changes; Alewives are found in ancestrally anadromous migratory populations and in multiple, independently evolved landlocked populations. We subjected juvenile Alewives from two landlocked populations and one anadromous population to seawater and deionized freshwater challenge and sequenced gill transcriptomes. Overall, restriction to freshwater in Alewives is predictably associated with differences in patterns of expression of well−known osmoregulatory genes, which may be driving divergence in osmoregulatory function.

50.3 VELTEN, B*; WELCH, K; University of Toronto; *brandy.velten@mail.utoronto.ca*

Myosin heavy chain isoforms of the flight and leg muscles of hummingbird and zebra finch

The maximum shortening velocity of a muscle fiber is strongly correlated with the myosin heavy chain (MHC) isoforms it contains. While MHC isoforms of mammalian skeletal muscle are well characterized, less is known about avian MHC isoforms or how they correlate to fiber type. Avian flight muscles are primarily composed of fast−twitch fibers [fast glycolytic (FG) and/or fast oxidative, glycolytic (FOG)], and it's been suggested that FG and FOG fibers can have different MHC isoforms. Wingbeat frequency, and thus, muscle strain rate, also differ across species, ranging from 2.5−80 Hz. Ruby−throated hummingbirds (*Archilochus colubris*) and zebra finches (*Taeniopygi guttata*) have relatively high wingbeat frequencies (25−65 Hz), requiring rapid shortening of their flight muscles, which are composed exclusively of FOG fibers. We examined whether the MHC isoform(s) present in the pectoralis and supracoracoideus of these species differed from that present in the chicken superficial pectoralis, which contracts at a slower rate and is composed of FG fibers. Leg muscles were also examined as they are of mixed fiber type and play a more postural role. MHC isoforms were separated using SDS−PAGE electrophoresis. Primarily fast isoforms were observed in the leg muscles of both species, but isoforms varied between muscles, with some exhibiting multiple isoforms including those associated with slow tonic fibers. Flight muscles of both species had only one MHC isoform corresponding to the adult fast isoform of the chicken. Although these muscles likely operate at faster shortening speeds, this finding suggests that the strain rates associated with flight led to a convergence of flight muscle MHC isoforms across species. Other properties of muscle, such as myosin light chain isoforms, may also play a role in varying shortening velocities across species.

48.5 VIDAL−GADEA, AG*; WARD, KA; TRUONG, N; PARIKH, A; BERON, C; PIERCE−SHIMOMURA, JT; The Univ. of Texas at Austin, Austin; *agvg75@gmail.com*

Magnetic orientation in C. elegans is mediated by a pair of magnetosensitive neurons

The Earth's magnetic field is a constant source of directional information for organisms able to detect it. For over half a century the list of species capable of this feat has grown steadily, while the mechanisms responsible for it remain elusive. Magnetotactic bacteria are known to build nanometer−sized "compasses" from iron in their environment. Evidence of similar biological magnetite has been reported in many magnetotactic animals. It remains unclear if and how animals may use these "biological compasses". In no small measure, this is a consequence of the absence of an identified magnetosensory neuron in any animal. We show that the nematode *C. elegans* readily orients to the magnetic field of the Earth. Like bacteria, worms may use the magnetic field during vertical migrations. Using standard mutant analysis, cell−specific rescue and cell ablations, we identified a pair of sensory neurons as necessary and sufficient to mediate magnetotaxis in *C. elegans*. Functional calcium imaging performed on these neurons revealed calcium transients induced by magnetic fields. Magnetic orientation in *C. elegans* appears to take place through a light−independent mechanism, and to rely on a cGMP−dependent transduction pathway. To our knowledge, this represents the first report of sensory neurons required for magnetic orientation in any species.

3.6 VIDAL−GADEA, AG*; TOPPER, S; YOUNG, L; KRESSIN, L; ELBEL, E; BRETTMANN, L; WARD, KA; PIERCE−SHIMOMURA, JT; The Univ. of Texas at Austin, Austin; *agvg75@gmail.com*

Dopamine and serotonin are responsible for locomotor gait transitions in C. elegans.

Transition between motor gaits is a task shared among many species. Its failure often has devastating consequences for the organism. The nematode *C. elegans* is a small worm adapted for locomotion on land and in water. It remains controversial if swimming and crawling are distinct gaits in *C. elegans* and if this was the case, how transitions between them are accomplished. Answering these questions could enable its use to study the mechanisms underlying locomotory transitions. We used an interdisciplinary approach spanning in depth behavioral assays, mechanic and optogenetic stimulation, laser ablations, mutant analysis, and in vivo photolysis of caged amines to test whether *C. elegans* uses distinct gaits and to determine how they transition between them. We show that in *C. elegans* crawling and swimming are distinct gaits. Dopamine released by a subset of mechanosensory neurons is necessary and sufficient to initiate and maintain crawling by a pathway activating D1−like receptors. Conversely, serotonin is necessary and sufficient to initiate and maintain transition from crawling to swimming and to inhibit a set of crawl−specific behaviors. These transitions appear to be modulated by the balance between these biogenic amines. Both amines have been found to play crucial roles in transition between alternate locomotory forms in diverse species stressing the importance locomotor transitions have for survival. Further study of locomotory switching in *C. elegans* may provide insight into the evolution of motor gaits across animal taxa.

P1.13 VILLAVICENCIO, CP*; QUISPE, R; GAHR, M; GOYMANN, W; Max Planck Institute for Ornithology, Seewisen, Germany; *cvillavicencio@orn.mpg.de*

Disentangling Territorial Behavior in a Year−Round Territorial Songbird

Testosterone affects several traits of animals including physiology, morphology and behavior. Seasonal elevation of testosterone often correlates with aggressive and mating behaviors. Therefore testosterone has been related to territorial and mating behavior in a wide variety of bird species. However, this relationship is not always straightforward. For example, male black redstarts (*Phoenicurus ochruros*), a socially monogamous songbird, do not only show territorial behavior during the breeding season but year−round. Further, they do not increase testosterone during male−male challenges. Thus, the objective of our study was to investigate the role of testosterone and its relationship with aggressive behavior, as well as looking for aromatase expression during different stages in male black redstarts. We measured plasma levels of testosterone of males during three different stages: breeding, molting and non−breeding. We compared these hormone levels to territorial behavior during simulated territorial intrusions, including song behavior. In addition we measured the aromatase expression in the preoptic area (POA). Our results show differences in plasma testosterone levels between stages, being higher at the beginning of the breeding season, compared to molting and non−breeding. The same was found for aromatase expression in the POA. Aggressive behavior was similar between stages, but song parameters differ between breeding and non−breeding. In combination with prior work our data suggest that sex steroids play only a minor role in the regulation of territorial behavior in this species. We propose that the control of territorial behavior in species that are territorial throughout their annual life cycle can be decoupled from testosterone.

55.2 VISSER, B.*; CASAS, J.; GIRON, D.; Institut de Recherche sur la Biologie de l'Insecte, Université de Tours, IRBI UMR CNRS 7261, Avenue Monge, 37200 Tours, France; *bertannevisser@gmail.com*

Larval lipid accumulation strategies when adults fail to synthesize lipids: Carry over between life stages in holometabolous insects

Accumulating energetic reserves in anticipation of poor environmental conditions is essential for survival and reproduction. Remarkably, the majority of parasitoid species lack the ability to store energy in the form of lipids in the adult life stage. The loss of lipogenesis evolved concurrently with the parasitoid lifestyle, but it remains unclear how and at which life stage selection acted on parasitoids to fuel the loss of lipogenesis. We hypothesized that the parasitic larval lifestyle has facilitated these insects with the means to carry over reserves from their hosts, rendering their own lipid synthesis redundant or too costly to maintain. If losing lipogenesis is indeed neutral or beneficial to larvae, similar lipogenic strategies can be expected between larvae and adults. Using two parasitoid species that differ in lipogenic strategy as adults (i.e. one species that synthesizes lipids and one species that lacks lipogenesis), the aim of this study was to determine if lipogenic strategies are similar between life stages.

53.5 VITOUSEK, MN*; WINKLER, DW; Cornell University; *mnv6@cornell.edu*

Does individual variation in corticosterone levels predict the behavioral response to ecologically relevant stressors?

Within populations and sexes individuals can vary substantially in circulating glucocorticoid (GC) levels during exposure to acute stressors, and this variation has been found to predict survival in some populations. Individual variation in GC levels could influence fitness in part through the differential performance of high and low responders during stressful events, but there is surprisingly little data on whether naturally strong GC responders also exhibit a stronger behavioral response to ecologically relevant stressors in the wild. We tested the relationship between natural variation in acute stress−induced GCs and the behavioral response to the presence of a predator in nesting songbirds, and found evidence of context−dependent links. Characterizing and testing the links between natural variation in GCs and specific adaptive behaviors is necessary to elucidate when and how individual variation in circulating GCs may be a functionally significant driver of fitness.

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NGS analyses of spatiotemporal variation in the avian gut microbial community

Microbes occur in extraordinary abundance and diversity in vertebrates, yet factors driving the assembly of microbial communities and the role of microbes in determining fitness in wild vertebrate populations remain predominantly understudied. The neonatal vertebrate life stage is a particularly relevant period during which microbiota may shape host fitness. Vertebrates are generally born immunologically immature and free of microbes, whereby the initial microbial colonization has longlasting effects on metabolic programming. To better understand mechanisms underlying microbial colonization and variation during early periods of vertebrate development, this study characterized the gut microbiota of nestlings and their mothers in a natural population of Western Bluebirds (*Sialia mexicana*). An effective method was developed to extract metagenomic DNA from noninvasive avian fecal and swab specimens. Illumina sequence analysis of bacterial 16S rRNA genes was performed on oropharyngeal, cloacal, and fecal samples collected longitudinally from nestlings throughout the nestling period across multiple nests and over three consecutive breeding seasons. Some samples from Oak Titmice (*Baeolophus inornatus*) and Ash−throated Flycatchers (*Myiarchus cinerascens*) were also included in comparative analyses. These data inform hypotheses on the drivers of avian host−microbial associations and the extent to which microbiota may impact host growth in natural systems. Discerning how microbiota may generate phenotypic or fitness differences among vertebrate host organisms is essential to our understanding of the evolution and maintenance of biodiversity.

P1.88 VON DASSOW, M; Duke University Marine Laboratory; *mvondass@gmail.com*

A generalized mechanical model of effects of salinity on blastula expansion

The physical mechanisms that drive morphogenetic shape changes could influence how organisms respond to environmental variation. The formation of the blastocoel (a cavity inside the embryo) in echinoderm embryos provides a good test case both because of its simple geometry and direct relation to dispersal ability. Planktotrophic echinoderm embryos form hollow spherical blastulae which swim in the plankton. The size of the blastula and the blastocoel−to−cell−layer volume ratio might influence swimming ability after hatching. Different mechanisms could drive expansion of the blastocoel in different taxa. Here I use a generalized mathematical model to investigate how combinations of expansion mechanisms would interact with salinity variation (which alters cell size) to alter embryo proportions. The model is based balancing forces after a differential change in cell size. It allows one to investigate responses to cell swelling given differing mechanical contributions of the cell layer, the apical extracellular matrix, and the blastocoel. This model predicts that if cell packing geometry determines blastula size, the blastocoel will expand with the cells as salinity drops. However, the model predicts that if the balance between internal pressure and elastic resistance to expansion determines blastocoel size, the blastocoel will shrink as cells swell. How these relations are altered depending on the nature of the resistance to blastula expansion (whether elastic, viscous, or plastic) will be discussed. This model indicates that mechanisms that drive expansion and mechanisms that resist expansion should be equally important in determining sensitivity to salinity.

37.4 VON DASSOW, G.*; SU, K. C.; BEMENT, W. M.; University of Oregon, Massachusetts Institute of Technology, University of Wisconsin, Madison; *dassow@uoregon.edu*

The Starfish Oocyte is an Excitable Medium

Most animal oocytes undergo two extreme−asymmetrical divisions during meiosis, creating the egg and two polar bodies. In oocytes of the starfish *Patiria miniata* and several other species, meiotic cytokinesis is preceded by a wave of Rho activity which sweeps from vegetal to animal, culminating in formation of a ring around the emerging polar body. Close inspection shows that the Rho wave is actually composed of smaller, transient wavelets. We found that overexpression of Ect2, the principle cytokinetic activator of Rho, progressively amplified Rho activation: at moderate levels Ect2 enhanced and prolonged wavelet activity associated with meiotic telophase; at higher levels, Ect2 converted the normal cortical behavior into a cataleptic state in which repeating trains of Rho waves, followed closely by actin assembly waves, traversed the entire oocyte surface. Experiments with enucleation, cyclin mutants, and roscovitine suggested that cortical excitability is strongly damped by, but dependent on, MPF activity. Meanwhile, application of actin poisons showed that actin assembly antagonizes Rho activation; local application of latrunculin elicited immediate Rho activation and a change in wavelet wavelength. Rho wavelets are also present during cytokinesis in the large blastomeres of early starfish embryos, in the zygotes of sand dollars, and in large cells of early *Xenopus* embryos. We suggest that excitability reflects the operation of a feedback−regulated amplifier of cortical contractility. This amplifier may be an adaptation to facilitate cytokinesis in large cells in which the key furrow−inducing signal from the mitotic apparatus is faint and poorly confined. Such adaptations, if they exist, are sure to be important factors in the evolution of egg size and developmental mode.

124.5 VON DASSOW, Y.J.*; SBROCCO, E.J.; MCCLAIN, C.R.; Duke University Marine Lab, National Evolutionary Synthesis Center; *yasmin.vondassow@duke.edu*

Ecology and phylogenetic history as predictors of marine life history mode

Biogeographic patterns of marine organisms are largely a result of dispersal of early life stages. Because developmental mode directly impacts dispersal potential, factors affecting developmental mode also affect patterns of biogeography, diversity, and abundance. Marine invertebrate life histories may involve either direct development or a larval stage. The developmental mode of any given taxon may be a result of two major factors: phylogenetic constraint and ecology (or a combination of the two). Using a variety of analytical techniques, our goal is to determine the extent to which environmental and phylogenetic variables can predict developmental mode in marine invertebrates. Specifically, we examine the effects of phylogenetic history, body size, trophic level, climate, available food energy, and habitat type on development. These factors are evaluated in the marine gastropod family Conidae, which has varying developmental modes, and for which species−level phylogenies are available. Quantifying the predictive power of these variables is a first step in untangling the complex biogeographical patterns observed in marine organisms.

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Teaching with data and student perception of active learning and inverted classroom

Creating learner−centered classrooms through the inversion of instruction has the potential to create more engaged students and improve student achievement at a time of rising enrollments and cutbacks. In a large enrollment upper−division majors' Evolutionary Biology course at a large minority serving university, the primary activities in the classroom have been modified to focus on the use of models, simulations, and data analysis, which include searches of online museum records through the quaardvark portal, and the professor's own experimental datasets. We present the results of student feedback for the in−class activities, and statistical analysis of student comprehension of specific evolution−based subjects, such as sexual selection. Equally importantly, we present the effects of inverted instruction on student performance on a concept inventory pre/post−test.

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The Effects of Annetocin on the Isolated Crop−Gizzard of Lumbricus terrestris

Numerous neurotransmitters and hormones can regulate the earthworm digestive tract. Previously, we showed that oxytocin and vasotocin, two members of the mammalian oxytocin/vasopressin family of peptides, modulated the isolated crop−gizzard of the earthworm, *Lumbricus terrestris* . This study examined the effects of annetocin, an oxytocin−related peptide, that was isolated from *Eisenia foetida*, on the isolated *Lumbricus* crop−gizzard. The crop−gizzard was placed in a tissue bath and mechanical recordings were recorded by a force transducer. The tissues were challenged by increasing concentrations of the peptide and the resulting changes in contraction rate and amplitude were used to create log−concentration response curves. Annetocin caused an increase in rate of contraction with a threshold of 10^{-8} M and an increase in contraction amplitude at 10^{-9} M. Compared to the other members of the peptide family annetocin had the highest efficacy in both contraction rate and amplitude, suggesting the *Lumbricus* receptor recognizes the earthworm sequence to a greater degree than the mammalian sequences. We are currently examining the effects of this peptide family on other regions of the digestive tract in *L. terrestris* .

75.5 WAGNER, J.T.*; PODRABSKY, J.E.; Portland State Univ.; *josw@pdx.edu*

DNA damage tolerance and photorepair of ultraviolet−C irradiated Austrofundulus limnaeus embryos: unique insight into annual killifish development

Exposure of cells to ultraviolet radiation has long been known to cause DNA damage, with the most abundant form being cyclobutane pyrimidine dimers. If left unrepaired, these lesions can lead to mutations or cell death by apoptosis. Free−living eggs of oviparous aquatic organisms are particularly at risk of exposure to solar ultraviolet radiation, and must repair, tolerate, or block this radiation to complete normal development. Embryos of the annual killifish *Austrofundulus limnaeus* are capable of surviving long bouts of desiccation, anoxia, and extremes in salinity. Depending on environmental conditions, much of their life may be spent as an embryo in a state of metabolic and developmental arrest, also known as embryonic diapause. Here, I show that their stress tolerance extends to DNA damage caused by ultraviolet radiation. *A. limnaeus* embryos were irradiated with ultraviolet−C radiation (254 nm) with doses ranging from 0 J/m^2 to 4,500 J/m^2 at three distinct stages: before axis formation, during axis formation/somitogenesis, and during embryonic diapause. After exposure, embryos were allowed to recover under either full−spectrum lights or darkness and development was tracked. Irradiated embryos were also stained for DNA lesions and evidence of apoptosis. Interestingly, embryos at all three stages appear to be reliant on a photorepair mechanism to repair DNA lesions. In addition, diapausing embryos may be able to sustain massive DNA damage for several weeks without observable effects. These data suggest that while *A. limnaeus* embryos share DNA repair mechanisms with other aquatic organisms, these embryos may also possess unique strategies to cope with DNA damage that have not yet been described.

P3.87 WALCEK, A*; PINSHOW, B; KORINE , C; Mitrani Department of Desert Ecology, The Jacob Blaustein Institutes for Desert Research, Ben−Gurion University of the Negev, Mitrani Department of Desert Ecology, Ben−Gurion University of the Negev; *walcame@bu.edu*

Respiratory and Cutaneous Water Loss in Egyptian Fruit−bats (Rousettus aegyptiacus)

The sum of respiratory and cutaneous evaporative water losses (REWL, CEWL) make up total evaporative water loss (TEWL) in endothermic animals. Compared to non−volant mammals of similar body mass, bats have as much as six times greater surface−to−volume ratio, ostensibly resulting in relatively large CEWL, especially when they fly. In Israel, most microchiropteran bats (7−35 g) save water and energy by entering torpor daily or by hibernating. In torpor REWL drops with decreasing resting metabolic rate (RMR); consequently, the CEWL:REWL ratio is also reduced. Although sympatric in Israel with many microchiropteran species, the Egyptian fruit bats, *Rousettus aegyptiacus* a130 −150 g Pteropodid, do not become torpid, but must nevertheless survive the winter shortage of nutritious food and the hot, dry summers. In summer, fruit bats are unlikely to be energy or water stressed since their fruit diet contains 70−90% water; in winter, their food has lower water and nutrient content and they must drink regularly. This being complicated by lower ambient temperatures (T_as) that induce high metabolic rates; in turn, increasing REWL. We tested the prediction that at low T_as (in winter), the ratio of CEWL to REWL in *R. aegyptiacus* decreases, due to subcutaneous vasoconstriction. Using an open−flow respirometry system we are measuring the changes in CEWL and REWL over a wide range of T_as (10, 20, 30, 35, and 40 °C) for both summer and winter acclimatized animals. To do this, we constructed a latex bat face−mask to separate CEWL and REWL. Our initial results support our prediction that CEWL in resting *R. aegyptiacus* is reduced in the cold.

74.6 WALDROP, LD*; MILLER, LA; Univ. of North Carolina, Chapel Hill; *lwaldrop@email.unc.edu*

Simulations of heart−beat reversal in sessile tunicates

Sessile tunicates (Chordata: Urochordata) possess an open circulatory system with a few major vessels and a tubular heart that drives blood flow through interconnected sinuses. The heart pumps blood by a peristalsis−like mechanism, in which a wave of muscular contraction travels down the tube from one end to the other. Every few minutes, the heart stops these contractions and after a brief pause, the contractions restart in the opposite direction which forces a reversal in the direction of blood flow. Several reasons for this reversal have been suggested, including heart−beat reversal serves to more efficiently transport nutrients and waste in an open system with porous components than unidirectional flow. We test this hypothesis by using the immersed boundary method to simulate flow created by the tubular heart in a racetrack circulatory system with a porous component representing the open nature of the system. Transport efficiency for periodic, bidirectional flow created by heart−beat reversal and unidirectional flow are compared.

P2.33 WALEK, M*; KAWAMOTO, B; SHRESTHA, R; TRAN, T; FASSBINDER−ORTH, C; Creighton University; *carolfassbinder−orth@creighton.edu*

Effects of an arbovirus infection on nestling house sparrow digestive enzyme activity

The effects of arboviruses on nestling bird development and digestion have been understudied. In this study, we analyzed the effects of two strains of an arthropod borne alphavirus called Buggy Creek Virus (BCRV−A and BCRV−B) on house sparrow digestive enzyme function. Tissue samples were taken from the pancreas, duodenum, jejunum, and ileum of nestling house sparrows 2, 3, and 4 days post infection (at 9,10 and 11 days of age) in order to test digestive enzyme function. The tissue samples were cut, weighed, and homogenized. Enzymatic activity was then quantified for the pancreatic enzymes trypsin, chymotrypsin, amylase, and lipase as well as the membrane−bound intestinal enzymes maltase and aminopeptidase−N. Maltase activity in nestling house sparrows infected with BCRV−A was significantly lower than control nestlings 2,3, and 4 days post infection while maltase activity in response to BCRV−B infection was significantly lower in nestlings 2 and 3 days post infection. There was no effect of BCRV infection on aminopeptidase−N infection. BCRV−A infection significantly decreased amylase activity all three days (2, 3, and 4) post infection, but BCRV−B had no apparent effect on amylase activity compared to control birds. BCRV−A infection decreased lipase, trypsin, and chymotrypsin activity 3 and 4 days post infection, but no changes in activity were recorded for these enzymes in the BCRV−B infected birds compared to control. These results indicate that BCRV−A impairs nestling house sparrow digestive enzyme function more than BCRV−B, which may contribute to the decreased digestive efficiency and growth that has been documented for BCRV−A infections in nestling house sparrows.

126.2 WALKER, SM*; TAYLOR, GK; University of Oxford, UK; *simon.walker@zoo.ox.ac.uk*

Unravelling the insect flight motor using in vivo time−resolved x−ray tomography

Flies are among the smallest and most agile of all flying animals. Their wings are driven indirectly by large power muscles, which cause cyclical deformations of the thorax that are amplified through the intricate wing hinge. This mechanism leaves little scope for control and wingbeat asymmetries are instead produced using an array of tiny steering muscles, which attach directly onto the components of the wing hinge. Little is known about the mechanics of these steering muscles due to the difficulty in measuring fast−moving, micron−scale structures, which are also hidden from view by the thoracic shell. Here we present time−resolved microtomography of blowflies, *Calliphora vicinia*, flying in a synchrotron beamline. This technique allows us to visualize and measure the three−dimensional movements of the steering muscles and place them in the context of the deforming thoracic structures that they actuate. The insects were rotated rapidly during experiments, producing compensatory asymmetric wing movementsm, and we compared the muscle kinematics and thoracic movements between low− and high−amplitude wingbeats. Our visualizations reveal mechanisms not foreseen by earlier electrophysiological and anatomical studies. The tendons of some steering muscles buckle on every wingbeat to accommodate high amplitude motions of the wing hinge. Other steering muscles absorb kinetic energy from an oscillating control linkage, which we hypothesise plays in important role in power management. Our results show that the steering muscles operate through a diverse range of nonlinear mechanisms, and represent the first four−dimensional visualizations of an organism's internal movements on sub−millisecond and micron scales.

92.1 WALLACE, R.L.*; WALSH, E.J.; WEBER, K.; RICO MARTINEZ, R.; DAS, S.; Ripon College, University of Texas at El Paso; *wallacer@ripon.edu*

Coloniality in rotifers: Implications for survival and fitness

Colonial life in rotifers presents significant tradeoffs. In terms of survival, it provides protection from tactile predators with limited gape size; however, their larger size puts colonies at risk from visual predators. Here we investigate the role of epidermal warts found at the anterior of *Sinantherina socialis* as deterrents to predation. We hypothesized that both individuals and colonies are rejected as prey due to a defense mechanism related to the warts. Wart morphology was investigated using lipid specific stains to elucidate compounds within the wart. In predation experiments, colonies showed increased survival rates in the presence of predators as compared to alternate prey (*Daphnia*). Individuals also showed increased survival in the presence of predators, but were consumed slightly more than colonies. Nearly all prey survived in the absence of a predator, indicating some level of protection afforded to individuals, but that it is not as strong as in intact colonies. In addition, we found high concentration of lipids in warts supporting the hypothesis that the warts hold unpalatable substances that function in defense. Unpalatable lipids have been observed in other animals, including mites, and may function in a similar way in *S. socialis*. Coloniality also poses challenges to mating. In solitary species, males circle females before mating, but in colonies access to a female may be impeded. Mating in *S. socialis* differed in two ways. (1) Duration of the circling phase is protracted for males encountering colonial v. solitary females. Males encountering single females behave similarly to those of solitary species. (2) Duration of copulation in *S. socialis* is the shortest reported for any rotifer species. The rarity of coloniality in rotifers may be a consequence of these tradeoffs.

95.7 WALLACE, J.A.S.*; DEATON HAYNES, R.; FRAKER, T.; SCOBELL, S.K.; St. Edward's University, Brooklyn College; *jwallac7@stedwards.edu*

The effects of social subordination on female reproductive success in the sex−role reversed Gulf pipefish (Syngnathus scovelli)

Intrasexual aggression is a natural stressor in the animal kingdom that often results in social subordination of the losing individual. Previous research on subordination has focused mainly on conventional mating systems where males compete for females. In this study, we examined social subordination in a sex role reversed species where females compete and males are choosy. In syngnathid fishes (seahorses, pipefish, and seadragons), females transfer eggs to the male, inducing male pregnancy. Studies in female pipefish have shown that smaller competitors shift their energetic effort from reproduction to growth and reduce investment in ornamentation. We tested the effects of intrasexual competition on growth and fecundity in female Gulf pipefish (*Syngnathus scovelli*), a highly polyandrous, sex−role reversed species. Size−matched females were each designated a male and allowed to mate to obtain their baseline fecundity. Pregnant males were removed, and the females competed for 10 days. During this time, social behavior was scored for 15 minutes on four days; a female was designated as dominant if she was displaying the temporary ornament on the last day of observation. Then, females were given a second mate to test for post−competition fecundity. Preliminary data showed that intrasexual competition affected growth and fecundity. Dominant females mated post−competition whereas subordinates did not. Dominant females also had larger ovaries than subordinates. However, subordinate females grew more in total length than dominant females. This study suggests that social subordination can negatively affect fitness in sex role reversed species, and subordinate females display a trade−off between investment in reproduction and growth.

P3.162 WALLACE, I.J.*; JUDEX, S.; DEMES, B.; Anthropology, Stony Brook Univ., Bioengineering, Stony Brook Univ., Anatomy, Stony Brook Univ.; *ian.wallace@stonybrook.edu*

The effects of weight−bearing exercise on skeletal structure and strength differ between outbred populations of mice

The effects of weight−bearing exercise on skeletal structure and strength are frequently observed to vary from one individual to the next. Here, we examine whether such variation also exists at the population level. An experimental approach was adopted involving mice from two commercial outbred stocks that have been reproductively isolated for >100 generations (Hsd:ICR, Crl:CD1). Beginning shortly after weaning, females from each stock were either treated with a treadmill−running regimen for 1 month or served as sedentary controls (n=20/stock/activity group). Home−cage activity of all animals was monitored during the experiment. Limb forces were recorded to verify that they were similar in the two stocks. At the end of the experiment, ¼CT was used to quantify cortical and trabecular bone structure in the femoral mid−diaphysis and distal metaphysis, respectively, and mechanical testing was used to determine femoral diaphyseal strength. Among the Hsd:ICR mice, treadmill running led to significant improvements in diaphyseal bone quantity, structural geometry, and mechanical strength, as well as enhanced trabecular bone morphology. In contrast, among the Crl:CD1 mice, the same running regimen had a negative effect on femoral cortical and trabecular structure, and led to significant reductions in femoral diaphyseal strength. Importantly, in neither stock was body mass, muscle mass, or cage activity level significantly different between runners and sedentary controls. Given that most environmental variables were controlled in this study, we suggest that the differential effects of exercise on the limb bones of Hsd:ICR and Crl:CD1 mice were due to genetic differences between the stocks.

P3.101 WALLACE, G/T*; JAMIESON, A/J; BARTLETT, D/H; CAMERON, J; GOTZ, M/G; YANCEY, P/H; Whitman College, The University of Aberdeen, Scripps Institution of Oceanography, DEEPSEA CHALLENGE; *wallacgt@whitman.edu*
Depth adaptation in hadal crustaceans: potential piezolytes increase with depth in the tissues of marine amphipods
A longstanding question in deep−sea biology is how organisms adapt to extreme hydrostatic pressures of hadal zones. One hypothesis involves piezolytes that counteract the protein−destabilizing effects of high pressure. Bony fish appear to adapt to high pressure with the piezolyte trimethylamine oxide (TMAO), which increases intracellularly with depth and allows them to exist down to 8 km. The mechanisms used to cope with pressure at even greater depths are still unclear. To address this question, we examined the tissues of amphipods (*Alicella* spp., *Hirondellea* spp., *Lysianassidae* spp., and *Talitridae* sp.) collected from depths of 0.0, 1.7, 2.3, 7.9, 8.1, 8.4, 9.3, and 10.9 km. Deep specimens were caught using baited landers in the Northwest Hawaiian Islands and the New Britain, Kermadec, and Mariana Trenches. Using HPLC, NMR, mass spectrometry, and free amino acid analysis, we identified concentrated molecules that may be piezolytes in these animals. Shallow species predominantly contain the non−piezolytes taurine, glycine, betaine, and alanine. As depth increases, these compounds are largely replaced by methylamines (TMAO and glycerophosphorylcholine), hydrophobic amino acids (valine, methionine, isoleucine and leucine), and the polyol scyllo−inositol. Of these molecules, only TMAO has been studied as a protein stabilizer against pressure. There may be a synergistic interaction among several piezolytes in hadal crustaceans; unlike fishes' use of TMAO as a primary piezolyte, marine amphipods may have evolved a more complex solution to the protein−perturbing effects of high pressure. Funding: National Science and Blue Planet Marine Research Foundations.

P3.6 WALLACE, G*; DEHGHANI, Z; OKHOVAT, M; BERRIO ESCOBAR, A; PHELPS, S; Univ. of Texas, Austin; *GerardnWallace@gmail.com*
Does cis−regulatory variation in avpr1a shape sexual fidelity through spatial memory?
Prairie voles are socially monogamous, but many young are sired outside the pair. Males who obtain extra−pair fertilizations (EPFs) intrude more often into neighboring territories and have low expression of vasopressin 1a receptor (V1aR) in retrosplenial cortex (RSC), a region important in spatial memory. We hypothesize that males lacking RSC−V1aR have poorer memory for locations of aversive interaction, and that this leads to both territorial intrusion and EPFs. RSC−V1aR is predicted by 3 tightly linked SNPs in the vicinity of the V1aR gene (avpr1a). To test this association more fully, heterozygous parents (HET) were crossed to obtain HI, LO and HET offspring. We found both breeding pair ($P<0.001$) and offspring genotype ($P<0.02$) were significant predictors of RSC−V1aR abundance. The socio−spatial memory of HI and LO males was assessed using a Barnes maze modified to simulate spatial memory demands during territorial escape. On the first trial of each day, a pair−bonded resident male was tethered in the center of the arena; on subsequent trials subjects were tested with no male present. Subjects readily learned escape routes using spatial cues, with fewer errors on trial 8 than on trial 1 ($P<0.05$), and fewer on trial 16 than trial 8 ($P<0.01$). We did not observe an effect of genotype ($P>0.05$) on error rates. To our surprise, pair−bonded stimulus animals were not aggressive, thus the spatial memory demands may not accurately model memory for punitive encounters in the field. We are currently examining RSC−V1aR to determine whether neuronal phenotype is a stronger predictor of memory in this task than genotype. Overall, we expect these experiments to clarify the role of genetics and neuronal phenotype on memory and sexual fidelity in the field.

S3.1−4 WALLINGFORD, John; HHMI/UT, Austin; *wallingford@austin.utexas.edu*
Planar cell polarity and the developmental control of cell behavior
Planar cell polarity (PCP), the orientation and alignment of cells within a sheet, is a ubiquitous cellular property that is commonly governed by the conserved set of proteins encoded by so−called "PCP genes." The PCP proteins coordinate developmental signaling cues with individual cell behaviors in a wildly diverse array of tissues. Consequently, disruptions of PCP protein functions are linked to defects in axis elongation, inner ear patterning, neural tube closure, directed ciliary beating, and left/right patterning, to name only a few. We will present recent work aimed at understanding how PCP proteins act to integrate developmental patterns with the fundamental machinery of cells.

16.2 WALSH, E.J.*; REYES, D.E.; HAMDAN, L.; RAMOS CHAVEZ, J.; KORDBACHEH, A.; Univ. of Texas at El Paso; *ewalsh@utep.edu*
Genetic diversification in Rotifera: Successful Dispersal and Colonization or Local Adaptation
Advances in molecular systematics have uncovered cryptic species in a wide variety of aquatic microinvertebrates. Here we examine genetic diversification of four cosmopolitan rotifers (*Epiphanes senta* complex, *Philodina megalotrocha*, *Euchlanis dilatata*, *Lecane bulla*) using COI mtDNA sequences. We found high levels of sequence divergence (≤24%) in all taxa. These levels are comparable to those typically found in morphological species and exceed the 4X rule used to delineate species based on sequence data. We also found evidence of widespread haplotypes: Phylogenetic analyses based on Bayesian inference distinguish a monophyletic clade of *E. chihuahuaensis* with sequence divergence of 0−1.6% among populations at one site. While at the other site, no *E. chihuahuaensis* isolates were found but individuals representing two other members of the *E. senta* complex were detected. Several isolates showed no sequence divergence from *E. hawaiiensis*. *E. chihuahuaensis* may be a rock pool specialist, adapted to these ephemeral habitats while *E. hawaiiensis* may be widely dispersed among more permanent habitats. Similarly, phylogenetic and Isolation by Distance analyses of the other taxa showed three distinct patterns: isolates with low geographic and genetic distances, isolates with high degrees of genetic divergence at nearby sites, along with a large group of widely dispersed isolates with low genetic distances. Our results indicate that a complex pattern of dispersal, colonization, and local adaptation contribute to the biogeography of these microinvertebrates.

S8.1−4 WALSH, M.R.; Univ of Texas, Arlington; *matthew.walsh@uta.edu*

The evolution of within− and among generation phenotypic plasticity in natural populations of Daphnia

Many environmental forces (invasive species, climate change, habitat loss) threaten native biodiversity. The mechanisms that permit persistence, such as the ability of organisms to evolve genetically or alter the expression of traits (phenotypic plasticity), have been the focus of much research. However, it is now becoming clear that the environment can induce phenotypic changes that span multiple generations. Such transgenerational plasticity' occurs when the environment experienced by parents alters the reaction norms of subsequent generations. Transgenerational plasticity has been documented in many organisms for a variety of environmental perturbations. Theory predicts that similar conditions favor evolutionary shifts in within− and among−generation plasticity. Specifically, plasticity is predicted to be favored when (1) environmental conditions are variable but predictable (within− and among generation plasticity) and when (2) parent and offspring environmental conditions covary (among−generation plasticity only). Our understanding of the conditions that favor the gain or loss of transgenerational responses is limited. In this presentation, I will describe a series of experiments that explored the link between environmental stressors (i.e., predator cues, temperature, resources) and variation in patterns of phenotypic plasticity in natural populations of *Daphnia*. These results highlight the potential for plasticity to covary within− and among−generations.

1.1 WALTHER, K; CRICKENBERGER, S; MARCHANT, S; MARKO, P; MORAN, A*; Clemson Univ., South Carolina, Univ. of Hawaii, Manoa; *morana@hawaii.edu*

Thermal tolerance of larvae of an antitropically−distributed barnacle species

Many benthic marine organisms disperse by means of a free−living larval stage whose physiological tolerances may be key to determining species' range limits. We investigated whether thermal tolerances of larvae from three widely−separated populations of an "antitropical" barnacle, *Pollicipes elegans*, might play a role in limiting connectivity between populations separated by warm tropical waters. We measured three indicators of physiological performance swimming activity, oxygen consumption, and LT_{50} and found strong evidence for population−dependent physiological adaptations that may affect dispersal. Thermal tolerance profiles were consistent with populations' characteristic environmental temperatures, although the width of their optimum, pejus, and pessimum ranges varied. All three populations live within their respective optimal ranges, but larvae from the northern population (Mexico) are close to the upper border of their optimum during warm months and thus have limited capacity to disperse through warmer waters. Larvae from the southern population (Peru) also would not be likely to tolerate tropical temperatures, so for the southern and northern *P. elegans* populations, high tropical temperatures are likely to be a direct physiological barrier to equatorward larval dispersal. The critical temperature of larvae from El Salvador, the population in the warmest region, was well above environmental temperatures that population would normally experience, suggesting factors other than larval thermal tolerance limit this population's distribution.

117.4 WANG, S.*; RAMSEY, M.; CUMMINGS, M.; Univ. of Texas, Austin; *silu.wang@utexas.edu*

Plasticity of the mate choice: a courter male evokes choice−like brain response in a coercive female

Female mate choice is fundamental to sexual selection, and determining genetic underpinnings of female preference variation is important for understanding mating character evolution. Previously it was shown that whole brain expression of a synaptic plasticity marker, neuroserpin, positively correlates with mating bias in the female choice poeciliid, Xiphophorus nigrensis, when exposed to conspecific courting males, whereas this relationship is reversed in Gambusia affinis, a mate coercive poeciliid with no courting males. Here we explore whether species−level differences in female mating response are driven by divergent genetic functions in female brains or instead by variation in male phenotypes. We exposed female G. affinis to conspecific males, coercer male Poecilia latipinna, courter male P. latipinna, and conspecific females for preference assays followed by whole brain gene expression analyses of neuroserpin, egr−1, and early B. We found positive correlations between gene expression and female preference strength during exposure to a courting heterospecific male, but a reversed pattern following exposure to coercive heterospecific male. This suggests that the neural activity of mate choice−associated genes is plastic to courting versus coercive males rather than intrinsically wired to mating systems. Further, we propose that female plasticity may involve learning because female association patterns shifted with experience. We found larger, more experienced females spent less time associating with coercive males but more time with males in the presence of courting males than younger females. We thus suggest a conserved learning−based neurogenetic process underlying the diversity of female mate preference across the mate choice and coercion−driven mating systems.

P1.55 WANG, J.*; JANECH, M.G.; BURNETT, L.E.; BURNETT, K.G.; College of Charleston, Medical University of South Carolina; *jasonwang103@gmail.com*

Oxygen−binding properties of purified hemocyanin oligomers in penaeid shrimp

The respiratory pigment hemocyanin (Hc) is the most abundant protein in penaeid shrimp hemolymph. Hc is composed of subunits arranged as *n*×6−oligomers which have intrinsic, species−specific properties. Along with extrinsic allosteric factors such as pH and lactate, the intrinsic oligomeric structure of Hc may influence O_2−binding. Regulation of intrinsic and extrinsic factors is important in estuaries and aquaculture where O_2, CO_2, pH, and other factors fluctuate widely. The Pacific whiteleg shrimp, *Litopenaeus vannamei*, is farmed globally. Its Hc binds O_2 more tightly (higher affinity) than other penaeid shrimps, including the brown shrimp *Farfantepenaeus aztecus*. Previous studies have shown that Hc 2×6−mers (dodecamers) are more abundant than 1×6−mers (hexamers) in *L. vannamei* hemolymph. The goal of this study is to compare O_2−binding properties of purified hexamers and dodecamers in *L. vannamei* and *F. aztecus*. We hypothesize that Hc will occur mostly as high affinity dodecamers in *L. vannamei* compared to low affinity hexamers in *F. aztecus* hemolymph. We have purified Hc oligomers using a BioSep™ SEC−s3000 column (Phenomenex); O_2−binding properties of isolated oligomers are measured tonometrically. The Cu−O_2 complexes in Hc absorb at 338 nm and represent the dominant protein peaks observed in hemolymph. Only one dominant band, migrating at the molecular weight of a hexamer (~400 kDa) is detected in *L. vannamei* hemolymph by BN−PAGE at pH 7.5 while two dominant bands are seen for *F. aztecus*. SEC−HPLC appears to be a more reliable approach for Hc separation. Understanding the intrinsic O_2 binding properties of Hc oligomers may provide insight into the success of *L. vannamei* in aquaculture. (NSF IOS−1147008)

P3.183 WANG, Z.−J.; HEINBOCKEL, T.*; Howard University, Washington, DC; *theinbockel@howard.edu*

GABA−A Receptor−Induced Changes in Firing Pattern Mediated by Ionotropic Receptors in Mitral Cells of the Main Olfactory Bulb

In the main olfactory bulb, we observed that one type of output neuron, the mitral cell (MC), exhibits two modes of integrative behavior: long−lasting depolarizations with a burst of action potentials and regular firing of action potentials. We hypothesize that these integrative behaviors distinguish two physiologically distinct mitral cell populations. We used whole−cell patch−clamp recording in mouse brain slices and tested if blockade of GABA−A receptors modified the firing pattern of MCs. In MCs with spontaneous regular firing, the GABA−A receptor antagonist gabazine evoked burst firing in ~57% of these cells. In MCs with spontaneous bursting, gabazine greatly enhanced the strength of bursting. Gabazine−evoked burst firing was reversed by blocking ionotropic glutamate receptors with CNQX and APV, indicating that the transformation of firing pattern was mediated by ionotropic glutamate receptors. In voltage−clamp recording, the burst firing of MCs was expressed as a rhythmic long−lasting depolarizing current (LLC). Both spontaneous LLCs and gabazine−evoked LLCs were blocked by CNQX plus D−AP5, indicating that they share the same mechanism of LLC initiation. This suggests that inhibition of GABA−A receptors was involved in the transformation of firing pattern via activation of ionotropic glutamate receptors. Our results suggest the existence of two MC subtypes: one subtype might be involved in dendrodendritic transmission between MCs in a single glomerulus, and, therefore, exhibits bursting or can be transformed from regular to burst firing. Another MC subtype generates regular firing, possibly due to the lack of dendrodendritic interactions. Support: Whitehall Foundation, U.S.−PHS grants GM08016, MD007597.

8.4 WARD, K/S*; AKANYETI, O; LIAO, J/C; University of Florida, University of Florida, Dept. of Biology; *jliao@whitney.ufl.edu*

The Iridescent Catfish (Pangasianodon hypophthalmus) as a Hybrid Rigid−Undulatory Model for Aquatic Robotics

At over 32,000 species, fishes can provide a rich source of inspiration for the design of undulatory aquatic robots. One challenging constraint is to establish a platform geometry that accommodates space to house electronic hardware while still preserving an efficient, propulsive body wave. The swimming kinematics and energetics of rainbow trout (*Oncorhynchus mykiss*) have been well documented and have inspired several robotic designs in the past. Here we investigate the swimming efficiency of another riverine species, the Southeast Asian catfish *Pangasianodon hypothalamus*, which has a larger, rigid region that is more conducive to housing electronics (almost 50 percent of the rostral body compared to 20 percent in trout). We calculated catfish swimming kinematics and energetics over a range of speeds from 2 to 80 cms^{-1} total length = 6.26 ± 0.71 cm, n= 6 fish) and compared them to rainbow trout. We found that catfish consistently have a tail beat amplitude that is about half of the magnitude seen in trout. At swimming speeds less than 20 cms^{-1}, both species have comparable tail beat frequencies and body wave speeds. At speeds above 20 cms^{-1}, the body wave speed and tail beat frequency in catfish are lower than that of trout. At lower flow speeds, catfish have a smaller body wavelength than trout, but this value increases to approach the body wave value of trout at higher flow speeds. Overall, at swimming speeds less than 20 cms^{-1} catfish have a comparable swimming (e.g. Froude) efficiency to trout. However, at higher swimming speeds, catfish demonstrate lower drag coefficients and therefore swim more efficiently than trout. Our experimental analysis illustrates the power of comparative studies in providing fundamental insight for designing new bio−inspired, undulatory underwater robots.

P1.178 WARKENTIN, K. M.*; ADDIS, C. J.; COHEN, K. L.; Boston Univ.; *kwarken@bu.edu*

Ear development and function in red−eyed treefrog embryos: a sensor for egg−predator cues?

Red−eyed treefrog, *Agalychnis callidryas*, embryos hatch rapidly and prematurely in predator attacks, cued by physical disturbance of eggs. Playback of vibrations recorded during snake attacks can induce hatching, but the mechanosensory system mediating the response is unknown. We have begun to assess a potential role for inner ears in predator−induced hatching. Mature frog ears receive inputs from sound, vibration, linear acceleration, and angular acceleration via eight sensory surfaces, but the ontogenetic onset of these functions is known in few species. In Gamboa, Panama, *A. callidryas* hatch as early as age 3 d in extreme hypoxia. They begin hatching in snake and wasp attacks at 4 d; escape success improves from 4−5 d and is ~80% thereafter. Undisturbed embryos typically hatch at 6−7 d. We histologically examined 3−8 d *A. callidryas* and found their ears developed from small otic vesicles to large, complex labyrinths during this period. Invagination of the otic vesicle, an early stage of horizontal canal formation, appeared at 4 d. In *Xenopus* this coincides with the first appearance of hair cells and onset of vestibuloocular reflexes (VOR), eye movements that compensate for head movements to stabilize the visual field and depend on otic sensory input. We tested the roll−induced VOR of *A. callidryas* to assess ear function. Some, but not all, 4−d embryos showed VOR and all older embryos tested showed strong reflexes, indicating otic sensory function. Thus, sensory information available to embryos must change during the period of hatching competence, and older embryos are likely better able to sense egg motion. The apparent ontogenetic coincidence of the onset of predator−induced hatching and otic mechanoreception suggests a role for developing ears in perception of predator cues.

S9.1−1 WARNE, Robin; Southern Illinois University; *rwarne@siu.edu*

The micro and macro of nutrients across biological scales

There is a great breadth of research exploring the importance of micro− and macronutrients in physiology, ecology and evolution. Here I provide a synthesis that details the integrated roles and profound affects that limiting nutrients have across biological scales. Our understanding of the biological impacts of macronutrients (protein, lipids and carbohydrates) have been greatly advanced by theories such as ecological stoichiometry and state based models like the Geometric Framework of Raubenheimer and Simpson, as well as empirically by the advent of stable isotope and genomic techniques. It is becoming clear however, that not all nutrients are created equal from a biochemical perspective. Certain classes of nutrients despite their bulk elemental content have a disproportionate effect on organismal function and ultimately influence ecological processes. While it's clear that micronutrients like highly unsaturated fatty acids (HUFAs) and indispensable amino acids (IAA) influence organismal performance, we do not have a strong understanding of their potential cascading effects on population, community or ecosystem dynamics. Recent work suggests that because the de novo synthesis of HUFAs is largely restricted to aquatic primary producers (e.g. algae, diatoms), most metazoans cannot synthesize these key nutrients, both aquatic and terrestrial consumers assimilate and sequester dietary HUFAs at rates twice that of bulk carbon and nitrogen or other measures of macronutrient flow. Deficiencies in IAA availability are also common and co−limitation with other micronutrients including HUFAs, carotenoids, sterols and limiting salts may alter population and community dynamics. These findings suggest that micronutrients may be significant drivers of ecological feedbacks, perhaps acting as keystone nutrients that could influence ecosystem structure and function.

16.4 WARNER, D.A.*; HARRISON, A.; REEDY, A.; University of Alabama at Birmingham, Harvard University, University of Virginia; *dawarner@uab.edu*

Spatial and temporal variation in phenotypic selection in the lizard Anolis sagrei

Populations often experience substantial spatial and temporal variation in environmental and demographic features. This variation can impact the strength and form of natural selection on fitness−relevant phenotypes, and therefore could result in broad phenotypic variation through space and time. We performed a large−scale manipulative study on island populations of the invasive brown anole (*Anolis sagrei*) in Florida. We established nine experimental island populations and manipulated the adult sex ratio (an important demographic parameter that should affect the level of intra−sexual competition) on each island. Subsequent mark−recapture studies enabled us to quantify survival and assess the strength and form of viability selection on body size over the reproductive and non−reproductive seasons. Our results reveal substantial spatial variation in adult survival and reproduction across islands, with generally greater survival and reproduction on female−biased islands. The strength of selection operating on body size also varied spatially and differed between males and females, particularly on female−biased islands. Spatial variation in selection on body size was not due to island size, but preliminary analyses suggest that islands with greater shade cover favored relatively small body size. Our on−going research will assess selection on second−generation hatchling/juvenile phenotypes to enable robust evaluation of spatio−temporal variation in, and consistency of, natural selection.

BART.1 WARNER, D.A.; University of Alabama Birmingham; *dawarner@uab.edu*

George A. Bartholomew Award Lecture: Fitness consequences of maternal and embryonic responses to environmental variation

Dan Warner, University of Alabama Birmingham, was selected as the 2014 Bartholomew Award winner and will give the Bartholomew Lecture on January 4, 2014 at 6 pm, followed by a social hosted by the Division of Comparative Physiology and Biochemistry (DCPB). Dr. Warner holds a B.S. degree in Animal Ecology from Iowa State University (1998) and a M.S. degree in Biology from Virginia Tech (2001). After receiving his Ph.D. from the University of Sydney (2007), he returned to Iowa State University as a postdoctoral researcher in the Department of Ecology, Evolution and Organismal Biology. Starting in fall 2012, he is currently an Assistant Professor in the Department of Biology at the University of Alabama at Birmingham. Dr. Warner's research seeks to understand the ecological and evolutionary processes that shape organismal responses to their environments across different life−history stages (from embryo to adult). His research uses lab and field experimental approaches and integrates aspects of ecology, physiology, genetics and behavior to empirically test theoretical predictions of adaptive evolution. His primary areas of interest are environmental sex determination, developmental plasticity, and maternal effects. His research uses reptiles as models to address these topics.

P3.114 WARRAICH, TN*; WYNEKEN, J; Florida Atlantic University; *twarraic@fau.edu*

Getting Hooked: A study to understand sea turtle longline bycatch

Loggerhead and leatherback sea turtles are often caught as longline bycatch in fishing industries worldwide. These two species of sea turtle differ greatly in their life histories and morphologies. Leatherbacks tend to be foul hooked, hooked externally in the shoulder or flippers, while loggerheads tend to be hooked in the mouth or they swallow the bait and get hooked in the esophagus or stomach. Although the number of loggerheads and leatherbacks caught decreased after the switch in gear type, leatherbacks mouth hooking increased while foul hooking decreased. We studied the prey approach and attack behavior of both species. The increase in leatherback mouth hooking may be explained by the reduced availability of hooks that snag the turtles' flippers and shell (circle hooks) and the tendency to re−approach and ingest the baits if they missed their target on the first attempt. We compared prey attack and behavior and accuracy in the presence of visual targets. Waterborne squid and jellyfish odors were used to elicit feeding behavior in the two species. We found that loggerheads have exceptionally good aim and almost always make contact with their intended target while feeding. Leatherbacks frequently overshoot and miss their intended target then have to re−approach the target multiple times before making contact.

45.6 WATANABE, A.*; BALANOFF, A.B.; NORELL, M.A.; American Museum of Natural History, New York, Stony Brook University, Stony Brook; *awatanabe@amnh.org*

From Archaeopteryx to modern Aves: testing the impact of allometry and phylogeny in shaping bird brain evolution

Brain anatomy is thought to be highly reflective of the major functional abilities of an organism, such as locomotory mode. Among birds (Aves), this association implies that the disparate morphological and ecological factors underpinning flight performance may correspond to specific brain morphologies. Yet, recent findings spanning volant and non−volant birds and mammals suggest that neuroanatomy (e.g., relative lobe size and shape) is not directly concomitant with flight performance. Instead, these results point to other possible drivers of morphological and functional evolution of the avian brain. Here we integrate three−dimensional geometric morphometric approaches and comparative phylogenetic methods to test whether allometry and phylogeny account for shape variation in this system. Digital endocranial models were constructed from CT−scanned images of over 20 species, including *Archaeopteryx*, broadly sampling the ecological, phylogenetic, and size ranges of Aves. Landmark and semi−landmark points were then digitally mapped to model surfaces to characterize the morphology. Our data show that neither phylogeny nor size alone significantly accounts for brain shape in birds. These results imply that brain evolution along the avian line has been guided by a more complex interplay of selective factors than previously realized. Additional considerations, such as social behavior or constraints of skull morphology, should be tested in the future to better elucidate this evolutionary problem.

84.1 WATERS, J. S.; Princeton University; *jswaters@princeton.edu*
Modeling the collective dynamics of metabolic allometry
Social insect colonies are model systems to investigate the mechanistic basis for the complex emergence of patterns across levels of biological organization as well as spatial and temporal scales. In the absence of hierarchical control, social insect colonies exhibit many features suggestive of a collective intelligence including the organization of their foraging behavior, nest construction, ventilation, bridge building, house hunting, and ritualized warfare. Recently it has been demonstrated that the metabolic rates of whole social insect colonies exhibit a nonlinear allometry with colony size so that mass−specific demands decrease with increasing colony size. This hypometric pattern is also observed for individual organisms, though no single theory has been able to reliably explain a mechanism whereby individual cells integrate information about body size and demands for activity and regulate their metabolism accordingly. In social insect colonies, communication between workers takes place through dynamic chemical and physical interaction networks. These interactions provide the link between an individual and her colony and may provide the foundation for assessing colony size and influencing response thresholds in decision−making processes. To investigate this hypothesis, we are developing individual based models for switching between inactive and active states, which may be evaluated with respect to the structure of interaction networks observed between workers in seed harvesting ant colonies. In this way, we can examine the relative roles of spatial distribution, activity cycles, and connectivity in generating complex patterns in animal groups.

P3.32 WATTS, H. E.*; VILGALYS, T. P.; Loyola Marymount University , Loyola Marymount University; *hwatts1@lmu.edu*
Effects of temperature on the transition from reproduction to molt in house finches
The transition from reproduction to molt is a key life history transition in the lives of birds. In this study we investigated the role of temperature as an environmental factor influencing the timing of this transition. Understanding the effects of temperature on the timing of life history events is of particular importance because ambient temperatures experienced by wild animal populations are changing as a result of global climate change. In this experiment, wild caught male house finches (*Haemorhous mexicanus*) were captured in April and housed from May onwards under two different temperature regimes, simulating cooler (mean max = 23.5 °C) and warmer (mean max = 30.6 °C) summer temperatures. Birds were then monitored as they transitioned from reproduction to molt. By the end of July, most birds (85%) had initiated molt, though not all birds had regressed the gonads. We found that males in the warmer treatment initiated molt earlier than did males in the cooler treatment. Circulating testosterone levels declined over the course of the experiment, but we found no difference in testosterone between the treatment groups. There was also a trend for males in the warmer treatment to delay gonadal regression compared with males in the cooler treatment. Our results suggest that warmer summer temperatures can advance the breeding−molt transition in male house finches.

34.5 WEAVER, MJ*; MCGRAW, KJ; MOUSEL, MM; Arizona State University; *melinda@pawspartners.com*
Avian anthrophobia? Stress response of house finches across an urban gradient in the presence of humans.
Urban environments present animals with many novel experiences, not the least of which is the physical presence or threat of humans. Cities are typically thought to harbor fewer predatory threats to wildlife because many native predators are not found in human−impacted areas. However, most studies on urban predation do not take human presence into account. In this study, we examined behavioral and physiological responses to human presence in house finches (Haemorhous mexicanus), a species that is abundant in both desert and urban areas, captured at six sites across an urban gradient during two different seasons: molt and non−molt winter. We captured birds in live traps and recorded breath rate (an indicator of stress). House finches were then allowed to acclimate to a cage at the field site where captured and then approached by a person. We recorded various behavioral responses (activity, stress behaviors, time eating) to human presence and found that urban birds showed lower activity levels and fewer stress−related behaviors than rural birds. However, rural birds showed a lower breath rate than urban birds. These results suggest that physiological stress responses to humans do not mirror behavioral ones in this cosmopolitan species and birds cope with human and/or confinement stress in unique ways.

S7.1−2 WEBSTER, J.P.*; KAUSHIK, M; Imperial College London Faculty of Medicine; *joanne.webster@imperial.ac.uk*
The impact of Toxoplasma gondii on host behaviour: can this parasite play a role in some cases of human schizophrenia?
Recognition of the role of infectious agents in a range of both acute and chronic diseases is increasing. One key example is the potential epidemiological and neuropathological association between some cases of schizophrenia with exposure to the protozoan Toxoplasma gondii. T. gondii establishes persistent infection within the CNS and can alter host behaviour. Altered dopamine levels have been reported for both T. gondii infection and schizophrenia. Moreover, several of the medications used to treat schizophrenia and other psychiatric disease demonstrate anti−parasitic, and in particular anti−T. gondii, properties in vitro. Furthermore, it appears that the parasite itself may actually be a source of this neurotransmitter. T. gondii was found to encode a copy of the mammalian enzyme tyrosine hydroxylase (TgTH), which represents the rate−limiting step in dopamine synthesis, through synthesis of L−DOPA, the precursor to dopamine. Using the epidemiologically and clinically applicable rat−T. gondii model system, we demonstrated that, whilst T. gondii appears to alter the rats' perception of predation risk, turning their innate aversion into a suicidal' feline attraction, anti−psychotic drugs proved as efficient as anti−T. gondii drugs in preventing such behavioural alterations and parasite establishment in the CNS in vivo. Furthermore we have identified a role of the T. gondii−produced TgTH in increasing activity levels, which in turn is correlated with reducing generalised anxiety. We have also established that T. gondii differentially alters activity levels depending on proximity to feline odour, causing more active rats to decrease activity when near a feline thereby providing further evidence for sophisticated selective manipulation to increase risk of predation by the definitive host.

27.2 WEBSTER, M.R.*; SOCHA, J.J.; DE VITA, R.; Virginia Tech; *mwbstr@vt.edu*

Nonlinear Elasticity of Tracheal Tubes in the American Cockroach

In some insect species, diffusion−based respiration is supplemented with convection. For insects that use rhythmic tracheal compression, convective ventilation is produced by the periodic collapse and re−inflation of various tracheae in the respiratory system, a phenomenon that is dependent on the unique structure and material properties of the tracheal tissue. To understand the underlying mechanics of this method of gas transport, we are studying the microstructure and material properties of the primary thoracic tracheal tubes in American cockroaches. In previous tensile tests, we found that these tracheae sustain large strains and exhibit a nonlinear elastic behavior. Although these tests provided crucial information about the mechanical behavior of the tracheal tubes, they were insufficient to fully describe the complex three−dimensional loading conditions experienced *in vivo* by these tubes. Inflation−extension tests, in which the trachea is pressurized while being stretched in the longitudinal direction, provide mechanical data that are more physiologically relevant. For this reason, we design and built an inflation−extension testing system that is able to measure low axial forces, internal pressures, and surface deformations of tracheal tubes of ~500 µm diameter. Images collected with two synchronized CCD cameras were analyzed using the digital image correlation method to compute the strain field. In addition, we also developed a constitutive equation that can capture the finite strains and nonlinear elasticity of the tracheal tubes. Our ultimate goal is to formulate a three−dimensional model that can be implemented into finite element methods to reproduce the complex mechanical response of tracheal tubes under *in vivo* loading conditions. Supported by NSF 0938047.

P2.18 WEDEMEYER, KR*; BERNARDO, J; PLOTKIN, PT; Texas A and M University; *kwedemeyer@bio.tamu.edu*

Ecological niches as underlying mechanisms of L. olivacea female alternative reproductive tactics

Alternative reproductive tactics are well studied in males, but poorly known in females. An important but understudied question is: What selection pressures cause divergent female behavior and/or morphology? We hypothesize that *Lepidochelys olivacea* (olive ridley sea turtles) female alternative reproductive tactics (solitary vs. mass−nesting behaviors) relate to an ecological dimorphism − differential foraging strategies (neritic vs. pelagic). We are investigating this idea using morphometrics, stable isotopes and satellite tracking.

P2.143 WEHRLE, BA*; GERMAN, DP; Univ. of California, Irvine; *bwehrle@uci.edu*

Testing the Adaptive Modulation Hypothesis: Physiological Changes in in a Newly Herbivorous Lizard

Few studies of diet incorporate analyses of what an animal is actually digesting. Knowing what an animal digests (as opposed to only what it ingests) allows us to understand if its physiology and morphology are optimized for its nutritional source. According to the Adaptive Modulation Hypothesis, dietary specialization should lead to gut specialization. We investigated potential digestive specializations in a lizard species that has shown rapid evolution of feeding and digestive tract morphology. A population of the Italian Wall Lizard (*Podarcis sicula*) in Croatia has become primarily herbivorous and morphologically distinct from its insectivorous source population in <30 generations. Though some morphological changes have been documented, it is unknown if gut function has shifted with this diet change. We compared the gross morphology of the intestines of both groups of lizards, compared their diets, and measured performances using digestive enzyme activities and concentrations of fermentation end products (short chain fatty acids, SCFAs). In a common garden experiment, we measured digestive efficiency of lizards from the herbivorous and source populations on different diets. Experiments are in progress, but we expected that the plant−eating population would have more plant material in their guts and a hindgut chamber in their distal intestines. Moreover, we expected to find differences in enzymatic activities among the populations, with the herbivores showing elevated carbohydrase activities. We also anticipated that the plant−eating population will have slower food transit times, increased microbial fermentation, and increased digestibility of a plant diet than the insectivorous population. Overall, this study will test whether rapidly evolving morphological features can translate into changes in animal performance.

S7.1−1 WEINERSMITH, K.L.*; HANNINEN, A.F.; SIH, A.; EARLEY, R.L.; University of California Davis, University of Virginia, University of Alabama; *klsmithbio@gmail.com*

Euhaplorchis californiensis, a brain−infecting trematode parasite, is associated with changes in physiology and behavior in its killifish second intermediate host

The trematode parasites *Euhaplorchis californiensis* (EUHA) and *Renicola buchanani* (RENB) infect California killifish (*Fundulus parvipinnis*) as second intermediate host. Infected killifish exhibit conspicuous behaviors, and infection is associated with a 10−30 times increase in predation rates by birds, the parasites' shared definitive host. EUHA is also associated with changes in neurotransmitter activity, which could result in downstream changes in steroid hormone release rates. In this study we explore associations between stress hormones (cortisol) and sex hormones (11−ketotestosterone and estradiol) and EUHA and RENB density in wild−caught California killifish. We find that the interaction between duration of handling stress and the density of EUHA influences release rates of cortisol and 11−ketotestosterone. We discuss the implications of these findings, and plans to further explore these relationships using controlled infections.

111.2 WEINSTEIN, S.B.; Univ. of California, Santa Barbara; *sara.weinstein@lifesci.ucsb.edu*

Transmission of Raccoon Roundworm, Baylisascaris procyonis, through the deer mouse, Peromyscus maniculatus

Parasites frequently move through a specific sequence of hosts in order to complete their lifecycles. Unlike many other parasites with complex life cycles, *Baylisascaris procyonis* can infect its final host raccoon either directly, via eggs in the environment, or through predation by raccoons on infected intermediate hosts. Infective eggs are concentrated in the environment at raccoon latrines. We monitored these sites to identify species with increased exposure risk. The deer mouse, *Peromyscus maniculatus* was frequently observed foraging in raccoon feces. Seventy percent of mice trapped were infected with larval *B. procyonis* . In 40% of these infected mice larval worms were found in the brain, with a higher infection prevalence observed in larger animals. In other rodents migrating worms in the brain are debilitating or fatal, potentially increasing transmission to final hosts. However, the effects of *B. procyonis* on *P. maniculatus* are unknown and thus it is unclear whether the cerebral migrations undergone by the parasite are adaptive or incidental. We address this question by using a combination of work in the field and lab, and modeling, to quantify the relative contribution of trophic transmission to the population dynamics of *B. procyonis* .

112.4 WEISS, T.M.*; VLACHOS, P.P.; JUNG, S.; SOCHA, J.S.; Virginia Tech, Purdue University; *talcat@vt.edu*

A kinematic analysis of water−surface locomotion in cricket frogs

Multiple species of frogs in the Ranidae family have been observed to 'skitter' across the water surface to escape, but little is understood about the biomechanical or physical mechanisms that underlie this behavior. Reports of this unique interfacial locomotion have been documented in literature since the 1950's, but the best description of this behavior is anecdotal, asserting simply that the frogs can cross the water surface without sinking. The force that propels these frogs several body lengths in the air may originate from the thrust of feet slapping on the water surface, as with basilisk lizards running on water, or it may arise from drag of the webbed feet in the water. To improve our understanding of the biomechanics of this interfacial locomotion, we recorded high speed video of two species of cricket frog (*Acris crepitans* and *Acris gryllus*) skittering across the water surface using a glass enclosure and two Photron APX−RS cameras. Contrary to expectations based on anecdotal knowledge of the Indian skipper frog *Euphlyctis cyanophlyctis*, we found that cricket frogs do not maintain an above−surface orientation throughout the locomotor cycle. Instead, the frogs are almost completely submerged during both the launching and landing phase of a jump cycle. Preliminary analyses of hindlimb extension show that the launch time is very short, ~32 ms (n=13 jumps). Consequently, the thrust required to propel the frog to a height of 1.5 − 2.0 body lengths is generated *entirely underwater* during a relatively small time frame. These underwater kinematics suggest that the frog propels itself using the drag produced by stroking the feet, a mechanism that differs from the impulse−slap force employed by the basilisk lizard. Supported by NSF PoLS #1205642.

P3.13 WEITEKAMP, C. A. *; HOFMANN, H. A.; UT Austin; *chelseaweitekamp@gmail.com*

Keeping Your Enemies Close: Neural and Hormonal Mechanisms of Cooperative Defense in a Cichlid Fish

Neighboring territorial males of many species exhibit less aggression toward each other than toward strangers ("dear enemy effect"). To maintain this relationship and avoid the costs of renegotiating boundaries with a new neighbor, a territorial male may actively display aggression toward a male intruding on the neighboring territory. While such defensive coalitions are thought to be widespread in nature, they have rarely been observed nor are the underlying neuroendocrine mechanisms known. Using the African cichlid fish *Astatotilapia burtoni*, we first show that upon repeated exposure to a territorial neighbor, levels of aggression, androgens, and cortisol quickly decrease over time. We then demonstrate that the presence of a novel intruder in one of two adjacent territories results in joint territorial defense in a manner that depends on the size and behavior of the resident partners and thus implies cognitive processes. To gain functional insight into this behavior, we manipulated the dopamine D2 receptor system in the resident male. Treatment with a D2 agonist causes aggression to be directed toward the neighbor, while blocking D2 signaling directs more aggression toward the intruder. Using immunohistochemical detection of the immediate−early gene c−Fos, we identified neural activity in nodes of the Social Decision−Making network. For example, neural activity in a subregion of Dm (putative basolateral amygdala homolog) and the parvocellular preoptic area correlates with both intruder size and aggression. To further investigate the neural correlates of these behaviors, we are co−localizing c−Fos with the dopamine system. Our results provide the first evidence of defensive coalitions in a vertebrate, and provide novel insights into the neuroendocrine basis of cooperative behavior and social cognition in general.

86.4 WEITZMAN, C.L.*; SANDMEIER, F.C.; SNYDER, S.J.; TRACY, C.R.; University of Nevada, Reno, Lindenwood University, Belleville, IL; *weitzman.chava@gmail.com*

Comparative microbial community diversity in the upper respiratory tract across Gopherus tortoise species

Of the five *Gopherus* tortoise species, all but the Texas tortoise are federally listed, in some capacity, by the U.S. Fish and Wildlife Service. An upper respiratory tract disease (URTD) has been implicated as a cause of population declines in both the gopher tortoise (*G. polyphemus*) and Mojave desert tortoise (*G. agassizii*), and URTD has been detected in the other three Gopherus species (*G. morafkai, G. berlandieri*, and *G. flavomarginatus*). URTD is associated with mycoplasmal and *Pasteurella* bacteria (as well as other pathogens), and it is unknown if disease is associated with co−infections. Additionally, very little is known generally about the microbial communities present in Chelonians. Here, we report on a study using nasal flush samples from each species of North American *Gopherus* tortoise in a large−scale comparative study on microbial communities. Next−generation sequencing was used to quantify diversity of bacteria and archaea, as well as presence of specific disease−related bacteria. Results presented will include comparisons in upper respiratory tract microbes among tortoise species and between individuals in a species, in addition to presence of pathogens associated with URTD.

113.5 WELCH, KC*; CHEN, CCW; University of Toronto Scarborough; *kwelch@utsc.utoronto.ca*

Glucose, fructose, and sucrose use in hovering hummingbirds

Hummingbirds have specialized on a diet consisting almost exclusively of a mixture of sucrose, glucose and fructose found in floral nectar. Previous studies have shown that hummingbirds can fuel energetically expensive hovering flight almost exclusively using recently ingested sucrose. However, the relative capacities for the direct utilization of glucose and fructose remain unknown. We investigated the use of each monosaccharide as a fuel by feeding separate ^{13}C−enriched fructose, glucose, or sucrose solutions to ruby−throated hummingbirds (*Archilochus colubris*). We collected breath samples from hovering hummingbirds using feeder−mask respirometry to determine the isotopic signatures of exhaled carbon dioxide. We found that hummingbirds transition from exclusively oxidizing endogenous fatty acids when fasted, to oxidizing newly ingested carbohydrates when given access to any of the above solutions. The percentage of hovering metabolism supported by exogenous sugar increased from 0% to near 100% in some individuals, averaging 81% and 88% for exogenous glucose and fructose treatments, respectively. Every measure of carbon turnover kinetics, energy intake and expenditure was similar between glucose and fructose treatments. By foraging frequently and fueling hovering flight directly with ingested monosaccharides hummingbirds avoid the energetic tax associated with the cost of synthesis of fats from these sugars prior to their oxidation. Remarkably, hovering hummingbirds are able to utilize fructose and glucose equally, a physiological feat which no mammals are thought to match, and one that suggests novel physiological capacities for the oxidation of fructose by active muscle tissues in hummingbirds. These findings indicate hummingbirds enhance net energy intake though specialization of diet, behaviour, and, uniquely, metabolic physiology.

94.2 WESTERMAN, E.L.*; MONTEIRO, M.; University of Chicago, National University of Singapore; *ewesterman@uchicago.edu*

Sexually dimorphic learning in a butterfly: learning biases, mate choice, and sexually dimorphic ornamentation

Mate preferences are learned in a wide variety of taxa with sexually dimorphic ornamentation. However, it is unclear what role sexual dimorphism in mate preference learning plays in the evolution of sexually dimorphic traits. Here we explore sexual dimorphism in preference learning using the butterfly *Bicyclus anynana*. Naïve female *B. anynana* butterflies prefer males with wild type forewing ornamentation (two dorsal eyespots) to males with more forewing ornamentation (extra dorsal eyespots), and learn preferences for more, but not less, forewing ornamentation. Number of eyespots varies on dorsal hindwings in both sexes, and is sexually dimorphic. We tested naïve preference and mate preference learning for dorsal hindwing eyespot number (DHSN) in both males and females. Neither sex exhibited naïve mate preferences. Males, but not females, learned preferences for DHSN. Male preference learning is biased, and biased in a different direction from female forewing preference learning − males learn preferences for females with less, but not more, DHSN. Female behavior during the learning period influences male hindwing mate preference learning, while male behavior during the learning period does not influence female forewing mate preference learning. We therefore demonstrate that mate preference learning in *B. anynana* is sexually dimorphic in terms of what traits are learned, direction of learning biases, and what premating experience influences preference learning. These findings illustrate the potential for sexual dimorphism in learning ability to influence the evolution of sexually dimorphic ornamentation.

P1.176 WEST, J.; University of Houston; *jwest5@trinity.edu*

Nuclear Dualism as an Evolutionary Capacitor in Tetrahymena thermophila

Tetrahymena thermophila has two distinct nuclei: a diploid germline micronucleus, which is transcriptionally silent during vegetative growth, and a polyploid (45C) somatic macronucleus, which determines the phenotype of the cell. During vegetative growth, the micronucleus stores genetic variation without it being exposed to selection. This variation is revealed via sexual reproduction, which is induced by environmental stress. Evolutionary capacitors are mechanisms that transiently express stored genetic variation. These mechanisms possess the following three characteristics: 1) genetic variation is hidden from selection, 2) hidden variation is revealed when it is most likely to be beneficial, and 3) revelation of variation is reversible. The dualistic nuclear architecture of *Tetrahymena thermophila* possesses these three characteristics, and may promote evolvability by functioning as an evolutionary capacitor.

P2.89 WESTLAKE, HE*; PAGE, LR; Univ. of Victoria; *hannahew@uvic.ca*

Comparative neuromuscular morphology of a scyphozoan and a staurozoan

The recent reclassification of Staurozoa as sister group to all other medusozoans upsets their classical interpretation as derived medusae with secondarily acquired stalked morphology. Their phylogenetic position suggests Stauromedusae are better interpreted as polyps that have developed novel medusoid features at their highly differentiated oral end. To identify stauromedusan neuromuscular features that are likely precursors of medusoid characters, we compared the stauromedusa *Haliclystus "sanjuanensis"* to polyps and ephyrae of the scyphozoan *Aurelia aurita*. Both species were treated with antibodies against FMRFamide, glutamate, taurine, and tyrosinated tubulin to label the nervous system and phalloidin to label the muscles. *Haliclystus* has both polypoid and medusoid neuromuscular features. *Haliclystus* and *Aurelia* ephyrae share a similar organization of manubrial muscles and both have a marginal circular muscle. The eight−part coronal muscle of *Haliclystus* is a possible homologue to the adult swimming muscle of *Aurelia*, but the coronal muscle of *Haliclystus* is composed entirely of smooth muscle whereas the swimming muscle of *Aurelia* is composed of both smooth and striated fibers. Polypoid features of *Haliclystus* include the four longitudinal muscle cords extending from pedal disc to tentacles. In *Haliclystus* these muscles are not innervated by FMRFamide−immunoreactive neurons as they are in *Aurelia* polyps. A single FMRFamide immunoreactive nerve net similar to the diffuse nerve net (DNN) of *Aurelia* polyps is present in *Haliclystus*, but the glutamate immunoreactive giant fiber nerve net (GFNN) of *Aurelia* ephyrae is absent. We conclude that precursors of novel medusoid musculature are more apparent in *Haliclystus* than precursors of novel medusoid neural characteristics.

P1.124 WESTNEAT, M.*; GEORG, M.; SCHLESER, A.; Field Museum of Natural History; *mwestneat@fieldmuseum.org*
The Machine Inside: A Biomechanics Museum Exhibit
A new traveling museum exhibition on Biomechanics will open in March 2014 at the Field Museum of Natural History, Chicago. The exhibit will travel widely over the next few years. Entitled The Machine Inside: Biomechanics, the exhibit makes extensive use of museum specimens to illustrate morphology and mechanical principles, and is rich with interactive elements to reveal organismal function. The goal of the exhibit is to present the view that biomechanics is a way of looking at living things as machines built by evolution. There are 7 main thematic areas of the exhibit. The first section focuses on biomaterials and organic shapes, with the message that living things must be able to withstand the forces of the world− wind, waves, and weight− so they must be made of the right materials for the job. The second focus of the exhibit is on circulatory mechanisms, highlighting the ways that organisms use hydraulic pressure, pumps, and capillary action to transport nutrients within their bodies. Next is thermoregulation, with principles of heat generation, insulation, extreme survival, and the impacts of body size on temperature control. The fourth section is on muscle mechanisms and the biomechanics of jaws and claws, with a focus on biting, crushing, slicing and grasping to capture prey. Then comes locomotion, with section 5 on terrestrial locomotion and section 6 on swimming and flying. From the number of legs and gait transitions in walking and running to effects of body size and walking robots, visitors learn how legged creatures push against the ground for propulsion. For aquatic and aerial locomotion, the exhibit explores propulsion modes, wing and flipper shapes, and hydrodynamics. Finally, the exhibit concludes with sensory systems, highlighting how living things have repeatedly evolved mechanisms to detect light, sound and other variables in the environment.

8.9 WESTNEAT, M.; Field Museum of Natural History; *mwestneat@fieldmuseum.org*
Simulating the Universe of Possible Functional Designs
Musculoskeletal systems are often arranged in ways that allow computational modeling of force, motion, work and power across systems and across species. Such modeling can aid in examining trade−offs between force and speed, making broad phylogenetic comparisons of function based on morphometric data, and studying the relationship between form and function across diverse evolutionary designs. Of great interest in this area is an ability to compare the range of living forms (and their functions) with the universe of all possible biomechanical configurations, in order to see what parts of morpho−mechanical space are not viable, which are occupied, and which perhaps could be occupied but are not. Computational simulation models are presented for simple musculoskeletal levers and linkage systems from vertebrate feeding systems, with comparisons to several large clades of vertebrates to explore what parts of theoretical morphomechanical space are occupied.

12.6 WHAM, DC*; LAJEUNESSE, TC; Penn State; *wham@psu.edu*
Estimating the Frequency of Sex in Symbiodinium
The amount of sexual recombination in the genealogy of partially clonal organisms can be highly variable. This rate, however, can have a large effect on the tempo and mode of evolution in these organisms. The process of sexual recombination facilitates the combination and spread of favourable mutations, rapidly creating new genotypic variability. Alternatively, clonal reproduction allows for the rapid proliferation of successful genotypes allowing for genetic stability over multiple loci without the need for physical linkage. Here we apply a method based on coalescent theory to estimate the population sexual reproduction rate, 4NeSe, from multi−locus genetic data from the symbionts of reef−building corals. Our results suggest that rates of sexual reproduction are highly variable within and between the examined taxa. We suggest that the mode of symbiont acquisition plays a primary role in driving the rate of sexual reproduction in Symbiodinium.

26.5 WHITCOME, K/K*; DYER, R/E; University of Cincinnati; *katherine.whitcome@uc.edu*
Plantarflexion component of stride length in bipedal walking
Because energy for locomotion in the form of muscle force production is necessary to support the body and swing the limbs, increase in stride frequency per distance and speed will increase the cost of locomotion. Routine walking should therefore favor low stride frequency and long strides. The effects of swing−limb rotations on stride length in human bipedal walking are well understood. During swing phase limb segments reach peak sagittal plane rotations placing the swing foot well ahead of the center of mass. Although stance limb segments also rotate during contralateral swing, their effect on stride length is less well known. Our aim was to investigate the kinematic link between terminal stance plantarflexion and travel distance. We focused on the period of lag foot heel rise milliseconds before the lead foot heel strike. We expected greater angular rotations of the stance limb v lead limb, generating a greater percentage of stride length as the swing limb prepares for ground contact. We captured 3D kinematics of 23 healthy adults at treadmill speeds of 1.25 m/s and 1.50 m/s. We calculated sagittal plane angles of both limbs including the thigh, knee and foot and the spatiotemporal components of stride length and proportion of stride duration. We found that heel rise of the stance limb occurs during only 7−8% of stride duration, yet is associated with 20% of total stride length. Although swing limb kinematics produce modest rotations that contribute little to stride length late in swing phase (1° thigh extension, 2° knee extension, 1° plantarflexion), stance limb rotations are significantly greater (7° thigh extension, 2° knee extension, 11−13° plantarflexion). In particular, because the stride lengthens as the lead hip, knee and foot are statically positioned for touchdown, it appears that support limb rotations in late terminal stance contribute markedly to overall stride length.

P1.167 WHITE, ME*; COHEN, CS; Macalester College, Romberg Tiburon Center, Biology, San Francisco State University; *mwhite2@macalester.edu*

Positive selection and recombination in the MHC of mainland and island killifish

Analyses of genetic variation at the antigen−binding sites of the adaptive immune loci in vertebrates often show strong signals of positive diversifying selection, and the study of wild populations subject to differing environments can be used to examine the processes that generate and maintain this diversity. We compared genetic variation in 10 *Fundulus* populations from Bermuda and from mainland locations in southern New England. The 3 mainland populations are associated with a strong pollution gradient, while 5 island *F. heteroclitus* populations, and a narrowly distributed island endemic *F. relictus* (2 populations) show evidence of genetic bottlenecks. Intron analysis revealed two phylogenetically distinct lineages that are interpreted to reflect distinct loci allowing estimation of recombination rates in exon sequence within and between duplicated loci. Mainland and bottlenecked island populations of *F. heteroclitus* show strong signals of positive selection in the PBR region of Class II MH DB. All populations of both species show higher variation in the exon in comparison to the intron, however island *F. heteroclitus* show lower exon and intron haplotype and allelic diversity than mainland populations. Comparison of recombination rate estimates among populations suggests recombination as an important contributor to MHC diversity. In particular, higher recombination rates and non−synonymous substitution rates are associated with higher pollution levels in a comparison among the three mainland populations studied. These results suggest that the bottleneck event experienced by the Bermuda fish resulted in a significant lack of diversity, a diversity which is generated and maintained in a large part by microrecombination and gene conversion.

P3.59 WHITE, A E*; OLSON, J R; Kenyon College; *whiteae@kenyon.edu*

Plasticity of pigmentation and thermoregulation of the harlequin bug, Murgantia histrionica, in response to developmental temperature

Sustaining homeostasis in a changing environment relies on an organism's ability to maintain an internal temperature within a specific range through thermoregulation. When temperatures fall outside an optimal range, metabolic, reproductive and behavioral functions can be impaired. As poikilothermic ectotherms, insects must rely on mechanisms other than metabolic heat production to protect themselves from extreme temperatures. Many insects, such as the harlequin bug (*Murgantia histrionica*), demonstrate phenotypic plasticity in body color, possibly taking advantage of solar radiation to warm and cool their bodies. On its dorsal side, the harlequin bug displays geometric patterns resulting from a juxtaposition of black and either yellow, red, or orange, and this ratio of black to color can have substantial variation among individuals. In order to investigate the impact of temperature on pigmentation patterns, we reared harlequin nymphs in two thermal environments, mimicking the seasonal temperatures observed in their natural geographic range. We then quantified the black to color ratio using digital imagery. As predicted, adult phenotype varied between treatments. In order to assess thermoregulation capabilities of each phenotype, we also monitored the temperature of adult harlequin bugs in dark and basking conditions, both before and after altering their pigmentation. Our results showed that individuals with a darker pigmentation were able to raise their body temperature to greater extent. These results suggest that colder temperatures experienced late in the season may induce the development of a darker phenotype, potentially improving the insect's immediate and over−winter survival.

P2.62 WHITWORTH, K; RAKES, C; LEUPEN, S*; BUSTOS, M; University of Maryland Baltimore County; *leupen@umbc.edu*

Use of Modeling as a Pedagogical Tool in an Undergraduate Biology Teaching Laboratory

Biology students tend to have an overly contextualized understanding of learned concepts, having difficulty applying those concepts to new systems. Further, they have difficulty understanding how quantitative models apply to biological systems. Our objective was to use rigorous, quantitative computer simulations as tools to teach biological concepts and improve quantitative literacy. We developed stochastic modeling laboratory supplements for two enzyme experiments performed in our introductory experimental biology laboratory class and designed a study to examine the efficacy of the simulation in enhancing student learning. In the control group, students collected all data through the traditional hands−on laboratory procedures. In the treatment group, students explored the model outcomes instead of doing the traditional hands−on laboratory procedures. In Week 1, course sections were randomly assigned to the treatment or control conditions. In Week 2, treatment and control sections were switched. We found that the use of computer simulated experiments for either enzyme lab neither enhanced nor detracted from student understanding of enzyme kinetics. Students who used simulations changed their views of the use of simulations and modeling in teaching labs, and teaching assistants were more enthusiastic about the simulations than about the standard wet labs. In conclusion, exposure of students in an introductory teaching lab to modeling techniques that partially replace hands−on laboratory procedures increases student and teaching assistant engagement without harming conceptual understanding of enzyme physiology.

P2.145 WIESSNER, G*; STEWART, J R; HEULIN, B; ECAY, T W; East Tennessee State University, Johnson City, Station Biologique de Paimpont, France; *gwiessne@gustavus.edu*

Developmental calcium uptake and chorioallantoic membrane expression of calbindin−D_{28K} by viviparous Zootoca vivipara embryos under manipulated ex utero calcium provision.

Zootoca vivipara is a reproductively bimodal lizard with geographically distinct oviparous and viviparous populations. Viviparous neonates contain only 75% of the calcium of oviparous hatchlings. A possible explanation for this difference is greater efficiency of shell calcium uptake by oviparous embryos compared to placental calcium uptake by viviparous embryos. To test the hypothesis that viviparous embryos are responsive to variation in calcium availability, we developed an *ex utero* culture system for viviparous *Z. vivipara* embryos and assayed embryonic calcium uptake and chorioallantoic membrane expression of calcium transport proteins. Embryos cultured at stage 37, prior to significant placental calcium uptake survive to stage 40 just prior to hatching but calcium accumulation is significantly greater for embryos cultured in 2 mM calcium media than in nominally calcium free media suggesting that embryonic calcium transport is maintained in culture. Assay of media calcium reveals that calcium uptake occurs at stage 40. Chorioallantoic membrane expression of calbindin−D_{28K}, a marker for calcium transport activity, is significantly greater at stage 40 for embryos cultured in 2 mM calcium than in the absence of calcium. Furthermore, calbindin−D_{28K} expression is maintained in media supplemented with calcium, but declines in the absence of available calcium. These results demonstrate that: 1) *ex utero* culture is a new experimental system to study viviparous *Z. vivipara* embryonic calcium metabolism, 2) chorioallantoic membrane calbindin−D_{28K} expression is sensitive to culture media calcium, and 3) embryonic calcium uptake is a very late event in *Z. vivipara* development.

P1.94 WIJESENA, N*; SIMMONS, D; ROTTINGER, E; MARTINDALE, M.Q.; Whitney Laboratory of Marine Bioscience, Institute for Research on Cancer and Aging, Nice, France; *naveenw@whitney.ufl.edu*

Investigating the cis−regulation of the cnidarian endomesoderm GRN

A characteristic feature of metazoan development is the formation of distinct germ layers that subsequently differentiate in to specialized adult tissues. The fate of the cells that gives rise to these different germ layers is determined by the transcriptional activators/repressors whose activity is governed by the inputs of intracellular and/or extracellular signals. Canonical Wnt/ß−catenin (cWnt) pathway provides crucial inputs during germ layer specification in metazoans. A recent study in the basal metazoan *Nematostella vectensis* has characterized the NvTcf/cWnt signaling inputs in to this cnidarian endomesodermal gene regulatory network (GRN). A detailed understanding of transcriptional control by inputs of NvTCF/cWnt during mesendoderm formation requires a cis−regulatory analysis of key genes in the network to identify transcription factor binding sites. We have used a combination of experimental and bioinformatic (phylogenetic footprinting using the *Acropora digitifera* genome) approaches to isolate the cis−regulatory modules controlling the expression of two genes in the endomesodermal GRN, *NvFrizzled10* and *NvStrabismus*. Genomic DNA fragments upstream of the start codon of both these genes were cloned into a transgenesis vector driving the expression of the reporter protein mCherry. Injecting these constructs in to zygotes results in the transient expression of mCherry in developing embryos. The functional importance of these identified sites will be validated by generating mutagenized cis−regulatory sequences and testing their activity by transient transgenesis assays. This approach will provide critical information for a detailed understanding of the architecture of the *Nematostella* endomesodermal GRN.

41.3 WILCOX, S.C.*; LAPPIN, A.K.; California State Polytechnic Univ., Pomona; *swilc002@ucr.edu*

The role of burst−swimming performance in relation to cannibalistic interactions of Green Poison Frog larvae (Dendrobates auratus)

Whole−animal performance characteristics are important in determining the outcomes of agonistic interactions, particularly intraspecific interactions. Cannibalism is an intraspecific agonistic interaction for which winners may be expected to exhibit superior performance in characteristics relevant to such behavior. The larvae of the Green Poison Frog (*Dendrobates auratus*) exhibit cannibalistic behavior in which "fast−starts" (i.e., high velocity and acceleration from a resting position) are used in attempts to bite and avoid being bitten by conspecifics. We tested the hypothesis that superior fast−start swimming performance is related to winning cannibalistic interactions between similarly sized individuals. Fast−starts by larvae were imaged with a high−speed camera, and pairs of size−matched individuals then underwent interaction trials to determine whether swimming performance is associated with winning a cannibalistic interaction. Linear acceleration of the snout tip, approximating the position of the mouthparts used to attack an opponent, was significantly greater in winners than losers. At the estimated center of mass, generally representing a target for an attacking opponent, linear velocity and acceleration were significantly greater in winners than losers. Understanding the role of performance in intraspecific interactions can help elucidate how such interactions contribute to drive morphological and behavioral evolution.

10.1 WILCOXEN, TE*; HORN, DJ; HUBER, SJ; HOGAN, BM; HUBBLE, CN; KNOTT, MH; PLANTS, S; WASSENHOVE, SJ; Millikin University, Millikin University, Univ. of South Florida, Millikin University, Des Moines Univ., Millikin Univeristy, Millikin University, Univ. of Illinois−Springfield; *twilcoxen@millikin.edu*

How many measures are enough: using a broad approach to examine health in a community of free−living birds.

Ecophysiologists are regularly searching for effective ways to determine the impacts of variable environmental conditions within habitats on the physiology of animals living in those habitats. Concerns surround the use of a single or small−set of metrics given the vast number of physiological processes with important regulatory functions in the body. Further, the repeatability of many of these measures within free−living individuals is often unknown and the time−course over which changes in environmental conditions are reflected in changes in physiology is often species and context specific. We conducted a 2−year, community−level study of over 2,200 free−living birds from 10 species of passerines and near−passerines and utilized many metrics to assess the health of the birds. Included in this assessment were measurements of baseline corticosterone, a body condition index from structural size and mass, hematocrit, feather quality, leukocyte counts, plasma protein levels, total antioxidant capacity, and four assays of innate immune function. There were many strong correlations among these metrics, allowing us to construct a consistent health profile' for many birds. In addition, among the many birds for which we had more than one capture record, repeatability was high for some measures but not for others. These correlations among multiple physiological products further our understanding of interacting physiological systems within free−living animals in variable environmental conditions.

82.3 WILGA, C*; DUQUETTE, D; FICARRA, L; Univ. of Rhode Island; *cwilga@uri.edu*

Coordination of Ventilation and Feeding in Elasmobranchs

Ventilation behavior must function independently of and cooperatively with other behaviors that are critical to the life history of the fish, such as swimming, feeding, and mating. The coordination of ventilation with feeding is investigated in three species of suction ventilating elasmobranchs to determine how the transition to feeding from ventilation occurs. Cranial morphology influences the ventilatory mechanism, and determines what prey can be captured and ingested. Three elasmobranch species (spiny dogfish, bamboo shark, and skate) are compared to evaluate the influence of torpedo vs flattened shaped heads, subterminal vs ventral mouth location, and epipelagic vs benthic species. Cranial movements and pressure generation were measured to determine how the ventilation mechanism is altered to capture prey. Sonomicrometry and pressure recordings of the oral, hyoid, and pharyngeal cavities during normal ventilation, prey capture, and the gape cycle prior to the capture event are compared. Suction feeding appears to be amplification of the suction ventilation mechanism with a shorter duration. Ventilatory gape cycles are longer than that of captures with smaller pressure changes. Hyoid and pharyngeal depression are the primary means of volumetric change during ventilation, in contrast to captures where changes in width also contribute to total volumetric change. Pharyngeal cavity changes also comprise a larger percentage of total volumetric change during feeding compared to ventilation, presumably to move the prey as well as the larger volume of water. Head shape, mouth position, and habitat differences among the species indicate that the elasmobranch ventilation mechanism is flexible. Whether the gape cycle prior to the capture event is an interrupted ventilatory cycle or a preparatory feeding phase is discussed.

P1.126 WILKES, AA*; BROWNING, Z; LENOX, M; JAQUES, J; MACKENZIE, DS; Texas A and M, College Station, Texas A and M Institute of Preclinical Studies, Texas Veterinary Medical Diagnostic Laboratories; *awilkes@bio.tamu.edu*

High Resolution Functional Imaging of Fish Endocrine Glands and Target Tissues Using Positron Emission Tomography−Computed Tomography

Positron Emission Tomography−Computed Tomography (PET/CT) is a sophisticated imaging technique combining high resolution functional images of PET with anatomical three−dimensional imaging of CT. Our objective was to determine whether PET/CT imaging would be applicable to studies of endocrine function in fish. To determine whether PET/CT could effectively image endocrine organs, we injected eight individuals of two fish species with 135.2 microcuries I^{124} and performed whole body PET/CT on anesthetized animals. Four fish per species were imaged six and 24 hours after injection. Although most teleosts are believed to have dispersed thyroid tissue, our images found a localized region of iodine concentration in the lower jaw. CT imaging enabled identification of anatomical coordinates allowing for histological confirmation that radiolabelled tissue was thyroid. PET/CT should thus be useful to characterize the structure of thyroid glands across diverse species. To evaluate potential uses of PET/CT for characterizing hormonal actions at target tissues, we imaged several species of fish following injection of F−fluorodeoxyglucose (FDG). FDG uptake was readily detectable in all species. Standard uptake values were similar to reported values for the same tissues in mammals. Our results suggest that it may be practical to utilize PET/CT to investigate the effects of hormones on tissue−specific glucose utilization. Overall, our results indicate that this PET/CT instrument has sufficient sensitivity and precision to be applicable to structural and functional endocrine studies in diverse fish species.

17.6 WILKINSON, K.C.*; NELSON, B.; NISHIKAWA, K.C.; UYENO, T.A.; LEE, D.V.; Northern Arizona University, Valdosta State University, University of Nevada Las Vegas; *wilkinso@unlv.nevada.edu*

Inter−environmental ballistic locomotion: A kinematic and kinetic analysis of a frog launching from water

Locomotion from one environment to another is essential for any animal that encounters more than one media. Anurans are exceptional examples of animals that are able to move from land to water and vice versa, but do not seem to have a design conflict to perform the two locomotor modes. A handful of frogs are known to skitter, or leap from the water into the air. Anuran skittering is not well understood, but stands as an important locomotion for species that possess the ability. The American Bullfrog was previously unknown to skitter. The frog has been shown to skitter in the case where the main food source in the wild is aerial prey, or to escape water−filled depressions. Few studies have analyzed skittering kinematics, and no known study has attempted to analyze the kinetics of this rare locomotion. Here, land leaping and skittering are compared in terms of joint extension durations, take−off velocities, and kinetic energies to evaluate whether skittering is a land leap applied to water. Biplanar, high−speed videography was used to record land leaping and skittering kinematics. From these videos, the parameters described above could be calculated. However, when a frog leaps from water, water is moved, thus the kinetic energy of the water must be calculated. Using digital particle image velocimetry, an elliptical ring vortex was shed from each from foot, and the velocity and mass were calculated. The results showed that the joints extend one and a half times faster in water and the joint extension sequence was the same. The take−off velocities and overall kinetic energies of both leaps were the same, thus concluding skittering in the American Bullfrog is a land leap applied in water, but in less time.

89.5 WILLIAMS, TD; Simon Fraser Uni., Burnaby; *tdwillia@sfu.ca*

Exactly when do female birds make their timing of breeding' decision, and what cues do they use?

Current models for control of timing of breeding suggest that day length provides reliable initial predictive information' for seasonal breeding but that non−photoperiodic supplemental factors' (temperature, food, social behavior) fine−tune the actual timing of egg−laying. Nevertheless, the cues and physiology controlling when birds decide to lay remain obscure. Past and current research on this problem has been based on the assumption that, "*physiological processes do not happen instantly*" (Dawson 2007), suggesting that non−photoperiodic cues are more likely to modulate the timing and rate of photoperiodically−induced gonadal maturation over a relatively long time window prior to onset of egg−laying. The alternative: that supplemental cues modulate the exact time of laying only within a short period of full gonadal maturity, has rarely been considered, and then mainly in males. Here I, firstly, propose a model for female birds of "constrained ovarian development" and "release" by non−photoperiod cues immediately (days) before egg−laying. This model suggests that a) even though food and social behaviour might not have long−term predictive value, these could still be key, *proximate* factors for timing of egg−laying (as proposed by some earlier work, e.g. Perrins 1970), and b) that we need to use different experimental approaches in future work. Secondly, I review data for female European starlings (*Sturnus vulgaris*) in captivity which suggest that the metabolic switch, from generic VLDL to yolk−targeted VLDLy synthesis, might be the critical component of gonadal maturation to focus on in future experiments in order to identify early on when a female has made her "decision" to proceed with egg−laying.

78.7 WILLIAMS, CT*; LANE, JE; HUMPHRIES, MM; MCADAM, AG; BOUTIN, S; Univ of Alaska Anchorage, Univ of Saskatchewan, McGill Univ, Univ of Guelph, Univ of Alberta; *ctwilliams@uaa.alaska.edu*

Reproductive phenology of a food−hoarding mast seed consumer: resource− and density−dependent benefits of early breeding in red squirrels

The production of offspring by vertebrates is often timed to coincide with the annual peak in resource availability. However, capital breeders can extend the energetic benefits of a resource pulse by storing food or fat, thus relaxing the need for synchrony between energy supply and demand. Food−hoarding red squirrels (*Tamiasciurus hudsonicus*) breeding in the boreal forest are reliant on cones from a masting conifer for their nutrition, yet lactation is typically completed before the annual crop of cones is available for consumption. We investigated the phenological response of red squirrels to annual variation in environmental conditions over a 20−year span and examined how intra− and inter−annual variation in the timing of reproduction affected offspring recruitment. Reproductive phenology was strongly affected by past resource availability with offspring born earlier in years following large cone crops, presumably because this affected the amount of capital available for reproduction. Early breeders had higher offspring survival and were more likely to renest following early litter loss. However, this only occurred under conditions of high population density, perhaps because late−born offspring are less competitive in obtaining a territory when vacancies are limited. Early breeders were also more likely to renest after successfully weaning their first litter, but renesting predominantly occurred during mast years, when recruitment into the population is high. Because of their increased propensity to renest and the higher survival rates of their offspring, early−breeders contribute more recruits to the population but the advantage of early breeding depends on population density and resource availability.

P3.172 WILLIAMS, C.D.*; BIEWENER, A.A.; Harvard University; *charleswilliams@fas.harvard.edu*

Taking evasive action: response to looming objects during forward flight

Flight involving unintentional mid−air collisions is rarely desirable. Successful identification and accurate location of approaching obstacles are essential to collision−free flight. The effects of looming and receding stimuli on tethered and hovering insect and bird systems have been frequently studied. This prior work has demonstrated that optic flow information from such stimuli modulates flight direction. Here we present results from a flight corridor permitting the display of variable looming and receding stimuli to freely flying hummingbirds (*A. colubris*). Differential avoidance response to towards−bird and away−from−bird object motion is described.

P3.102 WILLIAMS, L.E.*; DEFUR, P.L.; Environmental Stewardship Concepts; *environsc@gmail.com*

PCB contamination in Yadkin River NC fish: potential human and ecological impacts

We reviewed fish contamination data collected by the North Carolina Department of Natural Resources on the Yadkin River Basin following reports that PCB (polychlorinated biphenyl) concentrations are elevated above levels considered safe by the NC Department of Health. The Yadkin R. sampling was designed to cover a wide spatial extent from the farthest upriver location to the most downriver collection site. Looking only at the average PCB concentrations in fish tissue sampled (range: 10.9 − 35.9 ppb), none of the locations sampled along the Yadkin River have PCB levels above the NC standards of 50 ppb (but are above EPA's 1.5 ppb). However, many of the individual fish samples (range: 4.2 − 129 ppb) from the upper sampling locations, High Rock Lake, and the two sampling locations just downriver from Badin Lake have PCB concentrations that exceed the PCB levels used by NC to determine fish advisories. Indeed, some of the fish had PCBs at more than twice the 50 ppb. These PCB levels are high enough to cause reproductive impairment in several aquatic animals and potentially in people consuming fish from the Yadkin. The results for these locations indicate a pattern of change in PCB levels as a function of location from upriver to downriver. The highest concentrations were recorded in fish from the Yadkin River just below Badin Lake at the Narrows Dam and at the Falls Dam. The lowest PCB levels in fish occurred in the farthest downriver area, indicating an increase at Falls Reservoir and then declining fish tissue PCB levels downriver. This pattern suggests that at least primary PCB sources are upriver of Falls Reservoir, and fewer or no sources downriver. This pattern is repeated upriver at High Rock Lake, where high PCB levels exist in the two uppermost sampling locations but then drop downriver.

S9.1−5 WILLIAMS, C.M.*; SUNNY, N.; EDISON, A.S. ; MORGAN, T.J.; HAHN, D.A.; U. Florida, Gainesville, Kansas State U., Manhattan; *carolinewilliams@ufl.edu*

Nutrient flux through glycolysis and gluconeogenesis and the evolution of cold−stress tolerance in Drosophila melanogaster.

Ectotherms must maintain energy homeostasis in rapidly changing thermal conditions; a considerable challenge given that metabolism comprises a complex suite of processes that differ in their thermal sensitivities. Cold−adaptation on a broad phylogenetic scale involves changes to enzymes and pathways that allow them to function more effectively at low temperatures, but we lack an understanding of the microevolutionary variation in energy metabolism segregating within populations that may contribute to cold−stress tolerance. Without an integrative understanding of this naturally segregating variation, from the genomic through the physiological to the organismal levels, we cannot predict the evolvability of cold−stress tolerance, an important component of predicting the impacts of global climate change. We hypothesize that susceptibility to cold stress is set by an imbalance between energy supply and demand incurred at low temperatures, and that resistance may be conferred by reorganizing metabolic networks to maintain energy balance more effectively at low temperatures. Using complementary resources of the *Drosophila melanogaster* Genetic Reference Panel (192 fully−genotyped isogenic lines), and *Drosophila* lines selected in the laboratory for fast or slow recovery from a cold−induced coma, we show that tolerant flies have higher metabolic rates, maintain metabolic homeostasis more effectively during cold exposure, and show considerable restructuring of metabolic networks. Using stable isotopes, we demonstrate a reallocation of nutrients among core energetic pathways. These alterations to nutrient flux may rebalance energy supply and demand in the cold, and assist in maintaining energy balance in the face of changing temperatures.

36.1 WILLIAMS, M.B.*; POWELL, M.L.; WATTS, S.A.; Univ. of Alabama at Birmingham, Birmingham, AL; *micwilli@uab.edu*

Combinatorial effects of Corexit EC 9500A with abiotic and biotic stressors in the rotifer Brachionus plicatilis

Corexit EC 9500A (Corexit) is a surface acting agent that was implemented to facilitate ecosystem recovery following the recent Deep Water Horizon oil spill. Corexit acts to destabilize and disperse oil rafts, leading to enhanced degradation by naturally−occurring microbes. The direct chemical action of Corexit may also affect lipid components of living cells in lower trophic level marine fauna, endangering their populations. Toxic effects of Corexit dispersant on these primary producer/consumer populations can affect higher trophic level dynamics by altering carbon and energy transfer, thereby influencing ecosystem stability. Therefore, we examined the effects of Corexit on *Brachionus plicatilis*, a representative species of zooplankton in marine and estuarine ecosystems. Corexit exposure at standard husbandry conditions (17.5ppt salinity, 23 C, 200 rotifer/mL density) produced an LC50 value of 113 ppm for cultured *B.plicatilis* (probit analysis). At temperatures above annual Gulf coast shallow water medians (>22 C), the susceptibility of cultured populations to Corexit was substantially increased with the populations reaching an upper thermal survival temperature at lower temperatures as Corexit concentrations increased. In addition, increases in acclimation salinity and increases in rotifer population densities resulted in reduced survivorship when exposed to Corexit. These data suggest that outcomes associated with the exposure of wild populations of zooplankton to dispersant will vary depending on physical factors and community structure. These data can also be used to develop policies regulating the application of dispersants in future spills.

97.3 WILLIS, M.A.*; AVONDET, J.L; BROWN, K.; MILLIGAN, J.M.; Case Western Reserve University, Case Western reserve University; *maw27@case.edu*

Odor plume tracking behavior may be locomotion dependent.

Animals that track odor plumes while suspended in air or water usually generate very different looking movement paths than those that track plumes while walking or crawling on substrate. It is possible that these differences arise from: (1) differences between the odor plume and flow conditions in the boundary layer near the substrate and the free stream above it, (2) differences in the speed of movement through the environment generated by different types of locomotion (e.g., walking vs. flying or swimming), or (3) differences in the control rules used to steer the animal's movements. One piece of information plume tracking animals might use to steer and maintain contact with the plume is the distribution of the odor in the plume's cross section. They could get this by simultaneously comparing the concentration of the odor between their two antennae (spatial sampling) or by comparing successive sampling points along their track (temporal sampling). We have begun testing these ideas by comparing male oriental fruit moths, *Grapholita molesta*, with one antenna removed (either left or right) to intact controls as they transition from tracking an odor plume in flight to landing and tracking the same plume while walking. We observed no differences between intact controls and moths with one antenna when they tracked plumes in flight, but once they landed many males with one antenna generated upwind walking tracks that looped in the same direction as their intact antenna. These results suggest that oriental fruit moth males change the way they use odor to track plumes from temporal sampling when flying to spatial sampling when walking. This project was supported by NSF grant IOS−1121498.

122.5 WILSHIN, S*; REVZEN, S; Royal Veterinary College, University of Michigan; *swilshin@rvc.ac.uk*

Phase driven models of unperturbed locomotion

A major paradigm in contemporary biomechnics is the use of perturbation studies to probe animal movement. Such studies either implicitly or explicitly compare perturbed animal motions to some estimate of how an unperturbed animal would move. For cyclic motion, often encountered in locomotion studies, a common Null hypothesis is that animals continue moving as before. Our ability to resolve changes is often limited by the predictive capabilities of our Null model, themselves dependent on our ability to capture inter−individual variation and cycle to cycle variability. The mathematics of dynamical systems teaches us that a model based on the "asymptotic phase" of the cyclic motion should have superior statistical properties. Such models have been used for perturbation studies [Revzen−SICB−2005, Revzen−BioCyber−2013], and have used phase estimation techniques designed with the assumption that animal motions are close to some idealised cycle. In attempting to study the responses of animals to large perturbations, and the transition between different animal gaits [Wilshin−SICB−2012] we encounter the need to estimate phase for motions far removed from this idealised cycle. We present a method for obtaining the phase of cyclic movement which does not require the testing data be close to the limit cycle. Training data may consist of cycle fragments of any length, provided they cover the range of motions to be analysed. We show how this results in tighter confidence intervals on estimates of unperturbed animal motions. We argue that this approach can be used to provide a better description of phase during a gait transitions and in the study of multistable oscillators.

122.4 WILSON, R S*; BROWN, C; WHEATLEY, R; University of Qld; *r.wilson@uq.edu.au*

The soft serve: What tennis players can tell us about optimal performance in vertebrates

Intuitively, we expect animals to use their maximum locomotor capabilities during key survival, reproductive and foraging behaviours − yet observations in the field show that animals rarely, if ever, use maximal efforts in nature. Why is this? Biomechanical constraints on movement make mistakes more likely to happen at high speeds − a natural trade−off between speed and control. In the wild, where mistakes can be fatal, movement speeds should therefore be based on a compromise between speed and control, even during extreme situations like escaping predation. In humans, we expect elite sportsmen and women to also balance the competing demands of speed and accuracy, optimizing their efforts for specific tasks and contexts in order to enhance outcomes. We tested this idea by examining the serving speeds of 53 male tennis players during more than 13,000 serves whilst competing in the 2013 Australian Open Tennis Championship. The tennis serve is ideal for such an investigation because it is a motor task that requires both speed and accuracy to maximize success − in this case, winning the point. We first developed an optimality model of serving speed that assumed there was an underlying trade−off between serve−speed and −accuracy. Our model predicted that players should serve at 90% and 75% of their maximum capabilities on the first and second serves, respectively. As expected, player serve−speed affected accuracy − greater serve speeds decreased the likelihood that the serve would land inside the service area. But greater serve speeds also improved the probability of winning the point when the serve did land in − clearly demonstrating the benefits of high serve speeds. We will discuss the relevance of these results for improving serve success in elite tennis players and the development of a similar optimality−based approach for understanding of performance efforts of other animals in natural environments.

98.7 WILSON , W*; BAUMGARNER, B; WATANABE, W; ALAM, S; KINSEY, S; University of NC in Wilmington ; *wnw2488@uncw.edu*

Effects of resveratrol on the growth and muscle physiology of juvenile southern flounder

Dietary resveratrol has been widely studied in mammals, where it increases aerobic capacity, serves an antioxidant function, and may extend lifespan. In fish, resveratrol has been demonstrated to increase the longevity of a short−lived species. However, the effects of resveratrol on growth have not been examined in fishes. We tested the hypotheses that resveratrol supplementation in Southern flounder, *Paralichthys lethostigma*, would decrease protein carbonylation (indicator of oxidative damage) and ubiquitination (indicator of protein degradation) and would lead to an increase in growth and mitochondrial density. 144 fish were obtained and divided into a control and resveratrol treatment with 3 tanks per group. Fish within the resveratrol treatment were fed 600 µg resveratrol per g of food for 16 weeks. Body length and food consumption were recorded weekly for each group. Carbonylation and ubiquitination were measured in muscle and liver tissues using dot blots. Transmission electron microscopy and stereology were used to determine mitochondrial volume density within the muscle tissue. Fish treated with resveratrol had a 9% greater length than control fish after 16 weeks, and this was associated with a 16% increase in food intake. However, there was not a difference in carbonylation or ubiquination within the muscle and liver tissues. Mitochondrial volume density was nearly 2−fold higher in fish fed resveratrol. These results suggest that resveratrol has positive effects on growth that may be independent of its antioxidant properties.

92.5 WILSON, J.K.*; WOODS, H.A.; University of Montana; *keatonwilson@me.com*

Host−searching tactics in two groups of parasitoids that attack the hawkmoth Manduca sexta.

Insect parasitoids face the immense problem of finding an appropriate host in the complex natural world. Signals that parasitoids might use to find hosts are noisy, with insects being bombarded on all fronts in the olfactory, visual and auditory media. In particular, insects have incredible olfactory capabilities, and many parasitoids use olfaction to find hosts. Though some parasitoids cue in on scents given off directly by hosts, those signals are far weaker than those produced by plants. For this reason, parasitoids often use the volatiles emitted by plants as host−finding cues. Additionally, if herbivores cause significant fitness reductions in plants, it is in the plants' best interest to attract parasitoids as defenders, and there has been a great body of work in recent years uncovering plant volatiles that are emitted in response to herbivory. Here, we explore the host−searching tactics of two parasitoids of the sphingid caterpillars *Manduca sexta* and *M. quinquemaculata* in southeastern Arizona − a larval parasitoid, the tachinid fly *Drino rhoeo*, and a set of species that parasitize *Manduca* eggs. We tested both groups for olfactory and visual responses to host−plants as well as host eggs and larvae. Small hymenopteran egg parasitoids in particular appear to use airborne plant volatiles to find hosts, while larger larval−parasitoid flies rely on both visual and olfactory stimuli. Understanding how insect parasitoids find hosts is important for two reasons. First, parasitoids can clearly have strong evolutionary and population−level forces on herbivorous insects in natural systems, so host−finding and its connected physiological systems represent the method by which these forces act. Second, because insect parasitoids are often used in bio−control, basic research on host−finding can lead to better and more cost−effective techniques for rearing and releasing them.

P3.194 WILSON, RC*; BARRIGA−HERNANDEZ, J; NELSON, MB; LOUPY, KM; YOUNG, KM; BARNO, AR; STRAND, CR; Cal Poly State University, San Luis Obispo, Allan Hancock College, Santa Maria; *cstrand@calpoly.edu*

Neurogenesis and the expression of doublecortin in the cortex of Sceloporus occidentalis

In reptiles, plasticity of the medial and dorsal cortices (MC and DC) is related to spatial memory and spatial ecology. Furthermore, adult neurogenesis occurs in these regions, especially the medial cortex. However, little is known about the relationship between spatial learning and the proliferation or survival of newly born neurons in these regions. In order to investigate these processes, we need more information about neurogenesis in lizards. In other vertebrates, doublecortin (DCX) is a protein expressed in immature neurons and staining for this protein can be used to quantify neurogenesis. In this experiment, we injected adult male *Sceloporus occidentalis* with Bromodeoxyuridine (BrdU), a cell birth marker, and sacrificed them 2 days or 1, 2, 4 or 6 weeks after injection. Coronal sections were double−stained via immunofluorescence for BrdU and DCX to determine the time course of DCX expression and how long it takes new neurons to migrate to the cell layer of the MC. As expected, cells are born along the ventricles and migrate through the inner plexiform layer (IPL) and into the cell layer (CL) of the MC. The number of double−labeled cells is initially high in the ventricular zone and IPL (2d−2wks), increasing in the CL later (4−6wks). However, the total number of BrdU−labeled cells decreases by 6 weeks, indicating that many of the newly born cells die by this time. This information will be used to help design experiments to determine how spatial learning may affect different aspects of neurogenesis in the reptile brain, from proliferation to migration and survival.

9.6 WILSTERMAN, K*; WILLIAMS, CT; BUCK, CL; Bucknell University, Department of Biology, University of Alaska Anchorage, Department of Biological Sciences; *kew023@bucknell.edu*

Fair−weather Friends: Environmental constraints on ground squirrel activity in the arctic summer

Unique among resident arctic vertebrates, the arctic ground squirrel maintains a well−described diel rhythm of activity across the Polar Day despite 24−hour sunlight. We hypothesize that the rhythmic above−ground and below−ground activity patterns within a 24−hour day are driven by environmental factors which influence thermoregulation and energetics. To understand how the physical environment affects rhythms of activity in free−living arctic ground squirrels, we established a local weather station with sensors to measure and record environmental variables (air temperature, precipitation, wind speed and direction, and solar radiation) and outfitted female ground squirrels with collar−mounted light loggers to record above− and below−ground activity patterns. We collected environmental and activity data between 2 June and 2 July 2013 near Toolik Field Station in the northern foothills of the Brooks Range, AK. Individual activity datasets with matching environmental data ranged from 6 to 27 days in length with a median of 21 days. Paradoxically, though daily above−ground activity increased with solar radiation and ambient temperature, squirrels reduced activity levels during peak solar radiation on hot days. Thus, female ground squirrels appear to utilize burrow attendance to buffer exposure to thermal extremes. By going below ground when temperatures are either too high or too low, ground squirrels reduce thermoregulatory costs when ambient temperatures are low and eliminate the risk of overheating when both solar radiation and ambient temperatures are high. These results have implications for how changing weather patterns in the Arctic may constrain ground squirrel foraging opportunities.

P3.98 WINTERS, GC*; KOHN, AB; STERN, N; HOCHNER, B; WALTERS, ET; DICOSMO, A; MOROZ, LL; Whitney Lab, Neuroscience Dept, UF, Whitney Lab UF, Hebrew Univ. Jerusalem, Hebrew Univ. Jerusalem, UT Houston, Univ. Naples; *gabrielle.winters@gmail.com*

Cephalopods Do It Differently: Insights from Neurogenomics

Cephalopods (*Nautilus, Loligo, Octopus*, and *Sepia*) serve as powerful models for comparative biology. The complexity of their organizations ranges from relatively simple nervous systems in *Nautilus* to one of the most complex brains in *Octopus*. The remarkable morphological, behavioral, and physiological novelties found in cephalopods are either the result a common "genomic toolkit" that supports the development of a complex brain across taxa, novel gene/molecular mechanisms unique to the cephalopod lineage, or some combination thereof. We have sequenced neuronal transcriptomes of model cephalopods and compared them to the sequenced genome and transcriptomes of the gastropod mollusc, *Aplysia californica*. This approach allowed us to identify both evolutionarily conserved neuronal genes and numerous genomic innovations. We have characterized >50 neuropeptides, which are involved in locomotion, feeding, and defensive circuits. Next we localized their expression, including those that may be markers of homologous neural populations across molluscan classes. Obtained expression profiles support a hypothesis that there has been expansion of potentially homologous neural cell lineages between gastropods and cephalopods. We also found remarkable diversity in genes unique to cephalopods. This combined comparative data provides the unique opportunity to reconstruct ancestral neuronal lineages, identify specific cell homologies across species, and reveal trends in evolution within neural circuits. Our molecular resources are presented in the newly developed database of annotated neural genes, generated to test new hypotheses about the independent origin of complex brains and evolution of various developmental and neuronal systems. Supported by NSF, NIH and NASA grants to LLM

P3.111 WINZELER, M.E.*; LANCE, S.L.; LOVE, C.N.; NUNZIATA, S.O.; SCOTT, D.E.; Savannah River Ecology Lab, Univ. of Georgia, Aiken, SC, Dept. of Biology, Univ. of Kentucky, Lexington, KY; *meganwinzeler@gmail.com*

Prevalence of Ranavirus in Contaminated and Uncontaminated Sites on the Savannah River Site

A variety of natural and anthropogenic stressors have been hypothesized to increase the emergence of ranaviruses in amphibians via increased host susceptibility. On the Savannah River Site (SRS), multiple heavy metal contaminants are mitigated through retention wetlands used by native amphibians for breeding and habitat. However, no studies to date have explicitly examined the linkages between metal contaminants and the disease ecology of ranavirus in amphibians. We sampled adult and larval amphibians from three contaminated and two reference wetlands on the SRS for Ranavirus infection. We examined 215 individual representing 4 frog and 1 toad species. Ranavirus was not detected in the 80 samples collected from uncontaminated reference sites. There was also no difference at contaminated sites versus uncontaminated sites (3%). Nonetheless, our preliminary data indicated that while Ranavirus occurred at low prevalence on the site, it was only detected at heavy−metal contaminated wetlands. In total, Ranavirus was found in 2 species at contaminated sites on the SRS.

P2.97 WIRGAU, R.W.*; SWEET, E.; COOPER, W. J.; Washington State University; *rachel.wirgau@email.wsu.edu*

A comparative study of damselfish cranial development (Family Pomacentridae)

The damselfishes represent an extremely successful lineage of near−shore reef fishes that have a high abundance on all coral reefs. The embryos of damselfishes with diverse skull shapes and feeding ecologies can be obtained from both captive rearing and from the wild, which presents a unique opportunity to examine how changes in skull development have produced different adult damselfish head shapes. Here we present a comparative examination of embryonic skull development (fertilization−hatchling) in 12 species of damselfishes that occupy a range of adult feeding niches. Our objective is to understand how early developmental patterning determines larval and adult jaw shape, and to determine how larval jaw shape is connected to adult jaw shape. We used in situ hybridization labeling of the gene dlx2a, which is expressed in the cranial neural crest cells that form the pharyngeal arches, in order to visualize the formation of the first pharyngeal arch (i.e., visualize initial jaw patterning). We combined this developmental work with morphometric analyses of larval jaw shape using hatchlings of the same species. It is at the hatchling stage that first feeding (first jaw use) occurs. We used a similar approach to examine skull form in adults. Our research examined the developmental factors that shape cranial divergence using a larger number of species than has been previously examined in this context.

95.3 WOFFORD, S.J.*; EARLEY, R.L.; MOORE, P.A.; Bowling Green State University, Ohio, University of Alabama, Tuscaloosa; *sjwofford1@gmail.com*

Battle of the Sexes: Male and female crayfish (Orconectes virilis) use the same type of assessment strategy in different ways

Agonistic behaviour is an important social aspect of animal behavior and the outcome of agonistic interactions is critical to the acquisition of resources such as food, shelter, and mates. During agonistic interactions, individual participants make behavioral decisions based on energy and time investment such as escalating the intensity of the interaction and whether to end the interaction by retreating. Each of these decisions can be informed through self−assessment (i.e., energy reserves, fight capability, size), cumulative assessment (i.e., components of self−assessment in addition to the effects of opponent−inflicted injury) or through some form of mutual assessment (i.e., comparative energy reserve, size differential). Female and male individuals can be expected to exhibit different assessment strategies due to contrasting energetic needs and resource values. In this study, we are examining the assessment strategies that crayfish (*Orconectes virilis*) employ during same and mixed sex fights. After a brief acclimation, two individuals (male−male, female−female, or male−female) were allowed to interact for 15 minutes. Video analysis was used to calculate fight duration and times spent at various intensity levels. Analysis indicates that male and female crayfish both appear to employ a type of self−assessment strategy. However, significant differences between the two groups indicate dissimilar types of self−assessment in place or, at least, differential information gathering during agonistic contests.

P3.84 WOJCIECHOWSKI, M.S.*; VOIGT, C.C.; JEFIMOW, M.; MCCUE, M.D.; Nicolaus Copernicus Univ., Torun, Poland, Leibniz Institute for Zoo and Wildlife Research, Berlin, Germany, St. Mary's University, San Antonio, Texas; *mwojc@umk.pl*

Thermal acclimation affects the postprandial oxidation of exogenous nutrients in Siberian hamsters

During acclimatization to winter, changes in morphology and physiology combined with changes in diet may affect how animals use the nutrients they ingest. To experimentally verify this possibility, we studied how thermal acclimation affects the rates at which Siberian hamsters (*Phodopus sungorus*) oxidize different types of dietary nutrients. We conducted $^{13}CO_2$ breath−testing experiments on hamsters ^{13}C−labeled glucose, leucine or palmitic acid tracers gavaged orally. We predicted that under cold stress (2 °C) hamsters previously acclimated to cold temperatures (10 °C) would have higher resting metabolic rate (RMR) and would oxidize a greater proportion of dietary fatty acids than animals acclimated to 21 °C. Both groups of hamsters were kept under long photoperiod. Hamsters acclimated for 3 weeks to cold and subjected to near−freezing temperatures for 3 hours exhibited thermal conductance and RMR higher by ~10% than control animals, and oxidized dietary palmitic acid more extensively during the postprandial phase than animals acclimated to 21 °C. This indicates that 14d acclimation to cold leads to the upregulation of the mechanisms of heat production, but it is not enough for the increase in the insulation. We conclude that cold acclimated hamsters were able to direct more exogenous resources toward thermoregulation than those acclimated to 21 °C and that indeed, the thermal history results in significant changes in the extent to which animals oxidize dietary nutrients during the postprandial period.

21.2 WONG, K.K.W.*; TSANG, L.M.; HUI, J.H.L.; CHAN, B.K.K.; CHU, K.H.; School of Life Sciences, The Chinese University of Hong Kong, Institute of Marine Biology, National Taiwan Ocean University, Biodiversity Center, Academia Sinica, Taiwan; *wkwkaren83@yahoo.com.hk*

Physiological responses of two intertidal barnacles (Tetraclita japonica and Megabalanus volcano) to heat stress

Inhabitants of rocky intertidal zone are subjected to periodic tidal emersions and enormous thermal stress during daytime low tides. *Tetraclita japonica* and *Megabalanus volcano* are two common intertidal barnacles found in Hong Kong, with *T. japonica* occupying mid to high intertidal zone and *M. volcano* occupying low intertidal to subtidal zone. In this study, body temperature, hemolymph osmolality, and responses to thermal challenge were compared between the two species. 1) Measurement of body temperature in the field revealed contrasting thermal profiles. *T. japonica* at the upper shore experienced greater thermal stress than *T. japonica* and *M. volcano* at low shore. 2) Aerial exposure of barnacles was found to be associated with the increase in hemolymph osmolality. *M. volcano* with lower body temperature showed a more significant increase than *T. japonica* at a similar shore level. 3) When the two species were thermally challenged at 40 °C rock temperature for 5 h, *T. japonica* entered coma state much earlier than *M. volcano* and 94% *T. japonica* lose irritability in comparison to only 36% *M. volcano* did. However, all individuals of *T. japonica* resumed activity when immersed into water, and *M. volcano* in coma did not show any activities and died within 24 h. Given these results, we suggested the loss of irritability during the early stage of acute heat stress could be a strategy for *T. japonica* to cope with thermal stress. Transcriptomic analysis is now being carried out to dissect the differential gene expression of the two species upon heat stress.

P2.102 WONG, J. *; VON DASSOW, M.; Willamette University, Duke University Marine Lab; *jwong@willamette.edu*

Salinity variation and the mechanics of echinoderm gastrulation

We seek to understand how the physics of morphogenesis modulates environmental effects on development. Here we ask how salinity affects the sensitivity of sand dollar (*Dendraster excentricus*) embryos to inducers of exogastrulation, a defect in which the archenteron evaginates rather than invaginates. Salinity variation is common in near−shore marine environments and has a clear physical effect: swelling or shrinking cells. We hypothesized that if the apical extracellular matrix resists cell swelling, the pressure inside the embryo will rise, promoting archenteron evagination. However, if the blastocoel matrix resists embryo expansion, the pressure will drop, promoting invagination. If neither the blastocoel nor apical matrix resists embryo expansion, the internal pressure will not change, so salinity should not affect sensitivity to exogastrulation. Exogastrulation can be induced by many treatments. We used low calcium (10% of normal) artificial seawater as an inducer because it is non−toxic. We compared its effects in normal (32 ppt) and low (25 ppt) salinity, a range that *Dendraster* embryos can experience in nature. Preliminary observations indicate that low salinity alone did not cause exogastrulation, but low salinity made embryos more sensitive to exogastrulation induced by low calcium treatment. The similarity of blastocoel to cell volume ratio among treatments, combined with gross similarity in blastula shapes, suggests that the internal pressure did not change greatly. While further quantitative analysis is necessary, this appears inconsistent with our predictions, tentatively suggesting that effects of salinity on exogastrulation are not due primarily to internal pressure changes.

130.1 WOOD, HM*; WAINWRIGHT, PC; University of California, Davis; *woodhannahmarie@gmail.com*

Evolution of a novel trait in pelican spiders (Archaeidae)

Archaeid spiders, commonly known as pelican spiders, are an ancient group that may have existed since Pangean times with their diversification on Madagascar and Australia possibly relating to the continental break−up of Gondwana. Archaeids are cursorial hunters unique in their extreme modification of the cephalic area (or frontal region) and chelicerae (or "jaws"), giving them the appearance of a "neck" and "head." This novel morphology directly relates to their predatory behaviors: archaeids are specialized to prey only on other spiders and their highly modified cephalic area and chelicerae are used to attack prey at a distance. Among different species there is a great amount of variation in the shape and elongation in these morphological traits. Here, from a phylogenetic framework, we attempt to examine the nature of diversification of these traits in relation to habitat and biogeography. The findings from this study are important for understanding diversification patterns of novel traits.

116.2 WOODIN, SA*; WETHEY, DS; DUBOIS, S; Univ. of South Carolina, Columbia, IFREMER, Brest, FR; *woodin@biol.sc.edu*

Range Extensions: Larval Dispersal, Assisted Migration or Both

The tube−building polychaete *Diopatra biscayensis* has a 400 km gap between populations in the Bay of Biscay and the English Channel. Alternative hypotheses for establishment of the English Channel population are: 1) larval transport by ocean currents and 2) human intervention. A second question is whether the population in the English Channel is self−sustaining and capable of expansion northward. Records of movement of shellfish culture materials between the Bay of Biscay and the English Channel support the hypothesis of assisted migration of juvenile *Diopatra*. Shellfish operators often work at both sites, moving materials between the two, collecting mussel juveniles on ropes and oyster juveniles on tiles in the Bay of Biscay in areas with large populations of *Diopatra*, and transporting them to the Bay of Mont−Saint−Michel. Size distributions of populations were used to estimate growth and natural recruitment over a three year period. Results of Lagrangian particle tracking do not support the hypothesis of transport solely by ocean currents over the gap in distribution. Lagrangian transport of larvae could account for no more than 40 km during the larval period (<6 d). Size distributions of populations in the Bay of Biscay in 2010 to 2013 reveal a range of size classes with recruitment evident in most years. In contrast in the English Channel, more than 850 individuals were measured in 2011−2013 but only one juvenile (tube ID < 5 mm) and very few small individuals were seen and only in one population. The populations within Mont−Saint−Michel Bay appear to have very limited expansion capability. The unanswered question is how often successful reproduction or transport by humans occurs since some of the populations are large but without evidence of recruitment. The data are consistent with human assisted migration.

P2.61 WOODLEY, SK*; SHOBER, L; PATEL , P; Duquesne University; *woodleys@duq.edu*

SLURP: Service Learning in an Undergraduate Research Program

Service learning combines formal instruction with a related service in the community with the goal of promoting discipline−specific learning. This summer, we combined a formal summer undergraduate research experience with a service learning project. Goals for the undergraduate researchers were to increase outreach and communication skills as well as discipline−specific knowledge by having students translate concepts from their research projects into activities accessible to school age children. Student partnered with a non−profit community organization offering a free summer camp for 1−8th graders from an economically−depressed neighborhood. One goal of the camp was to improve the scientific literacy of campers and inspire them to consider science careers. Eighty percent of the undergraduate students' time was spent on their individual research project and 20% of their time was spent on the service−learning project. The service−learning component involved preparing and sharing STEM−related activities with over 80 campers. Undergraduate students reported that the experience reinforced their discipline−specific knowledge, increased their ability to work collaboratively, and increased their problem solving skills.

P2.4 WOODS, H. A.*; WILSON, J. K.; Univ. of Montana; *art.woods@mso.umt.edu*

Real, live chest−bursters and vomiting caterpillars: Alien flies meet Exorcist caterpillars in the American Southwest

A key source of mortality for caterpillars worldwide is parasitoid flies in the family Tachinidae, which deposit eggs or fully−developed larvae onto the cuticles of caterpillars. Once hatched, fly larvae burrow through the cuticle and live in the caterpillar's hemocoel, where they feed on hemolymph and host tissues even as the caterpillar continues to grow. Eventually the fly larvae kill the caterpillar, consume most of its internal tissues, and pupate inside the husk that remains, or just outside it. For the host caterpillar, parasitization by tachinid larvae is almost always a death sentence, and we hypothesized that caterpillars would show strong defensive behaviors against flies and their eggs. In a study of wild *Manduca sexta* and *M. quinquemaculata* in southeastern Arizona, we showed that caterpillars (field−collected fourth and fifth instars) were parasitized at rates exceeding 30%, and that caterpillars used at least eight distinct defensive behaviors, including camouflage, biting, several kinds of grooming, regurgitation, secretion of anal fluids, and increases in hemolymph pressure. We examined in more detail the defensive roles played by regurgitation, showing that it defended caterpillars from unembryonated eggs (fertilized but requiring additional development on the host) laid by one fly species, but not ovalarvaposited eggs (containing a fully developed first−instar fly larva) laid by another, which hatched within 10 minutes of deposition on the caterpillar. We hypothesize that these defenses evolved in response to the high risk that any one defense would fail, and in response to the physiological and behavioral diversity shown by tachinid flies.

55.1 WOODS, H. A.; Univ. of Montana; *art.woods@mso.umt.edu*

Mosaic physiology from developmental stochasticity: an alternative to phenotypic plasticity

A key problem in organismal biology is to understand the origins of functional diversity. Modern biology proposes two general mechanisms. The first is developmental programs, by which single cells diversify into the organized diversity of cell types, tissues, and organs that we see in almost all multicellular organisms. The second general mechanism is phenotypic modification stemming from interactions between organisms and their environments − known as phenotypic plasticity or phenotypic flexibility. I propose a third fundamental mechanism: stochastic events during development that give rise to mosaics of physiological diversity within individual organisms. In biological systems, stochasticity stems from the inherently random actions of small numbers of molecules interacting with one another. Although stochastic effects occur in many contexts, available evidence suggests that important kinds of stochasticity can arise in gene networks specifically as a consequence of low transcript numbers in individual cells. I briefly review mechanisms by which organisms control such stochasticity, and how they may use it to create adaptive functional diversity. I then fold this idea into modern thinking on phenotypic plasticity, proposing that multicellular organisms exhibit *mosaic physiology*. Mosaic physiology refers to sets of diversified phenotypes that carry out related functions at the same time, but that are distributed in space, within individual organisms. Mosaic physiology arises from stochasticity−driven cell differentiation, early during cell diversification, which is then amplified by cell division and growth into macroscopic phenotypic modules making up the physiological systems of later life stages. Mosaic physiology provides a set of standing, diversified phenotypes, within single organisms, that raise the likelihood of coping well with novel environments.

P2.21 WORD, KR*; WINGFIELD, JC; University of California, Davis; *krlizars@ucdavis.edu*

Allostatic Load: Heart Rate and Corticosterone in Free−living Gambel's White−crowned Sparrows (Zonotrichia leucophrys gambelii)

Previous investigations have shown that heart rate is correlated with oxygen consumption in white−crowned sparrows, *Zonotrichia leucophrys gambelii*. Here, we apply that relationship to estimate and analyze total energy expenditure in free− living birds, using heart rate as a proxy for VO_2. Regulation of energetic expenditure, considered here as allostatic load, is central to organism−environment interactions, and the value of responses that modify behavior or physiology is often measured in terms of energetic benefits. In addition to total energy expenditure, real−time measurement of heart rate offers the opportunity to examine daily activity patterns, night−time energetic expenditure, and responses to weather and other environmental stimuli. Furthermore, these investigations can address whether corticosterone secretion is directly related to these patterns. Although baseline corticosterone, proposed to mediate physiological responses to variation in allostatic load may not be correlated with corticosterone titers in captive animals under constant conditions, the relationship to individual variation in energetic profiles under natural conditions may be more meaningful.

106.4 WORTHINGTON, A.M.*; KELLY, C.D.; Iowa State University, University of Quebec, Montreal; *aworthin@iastate.edu*
Do females gain direct benefits from immune−boosting ejaculates in the Texas field cricket?
Promiscuity is ubiquitous in nature and females often mate more than is necessary to ensure reproductive success. Although mating multiple times generally increases female fecundity and offspring quality, it can impose significant costs to survival. Mate searching, courtship, and copulation can result in physical injuries and drastically increase rates of parasitism, predation, and disease, thereby reducing overall female fitness. In crickets, however, multiply mated females have greater longevity relative to once−mated females. The functional mechanism underlying this mating−related increase in longevity is not known, but some evidence suggests that mating boosts female immunity. We used the Texas field cricket, *Gryllus texensis*, to test whether mated females receive direct benefits from males in the form of immune−boosting ejaculatory compounds or whether copulation increases female investment in immunity. In our laboratory−controlled experiments, females were assigned to one of four treatments where they experienced: 1) physical contact with a male; 2) male courtship but no ejaculate; 3) received a partial ejaculate from a castrated male containing only the accessory fluids; or 4) received an intact ejaculate containing sperm and accessory fluids. Two days after mating, females were subjected to host resistance tests comprising an LD_{50} dose of the bacteria *Serratia marcescens*. We predict that if males provide females with immune−boosting ejaculatory products, then females that receive an ejaculate will exhibit increased disease resistance. Alternatively, if mating causes females to invest more in immunity, then physical contact or male courtship will elevate female disease resistance.

12.2 WRIGHT, R.M.*; MATZ, M.V; University of Texas, Austin; *rachelwright8@gmail.com*
Fundamental molecular components of coral immunity revealed through comparative analysis of gene coexpression networks
Understanding innate immunity in reef−building corals would benefit conservation efforts to restore rapidly declining reefs worldwide. Here, we took a gene coexpression networks approach to compare the disease response in adults of *Acropora hyacinthus* with the response to viral challenge in the larvae of *Acropora millepora* with the goal of dissecting the most fundamental mechanisms of coral immunity conserved among species and operating in all life cycle stages. Fragments of diseased and healthy *A. hyacinthus* were collected in the field, while larvae of *A. millepora* were challenged with concentrated field−collected virus−like particles as well as heat stress in the lab. Tag−based RNA−seq data were processed by means of weighted gene coexpression networks analysis (WGCNA) to identify groups (modules) of co−regulated genes, assess the degree of coherence ("preservation") of these modules across diverse experimental samples, and identify genes serving as regulatory network hubs. Two of the three significantly preserved modules correlated with heat stress, thus partitioning out the genes related to general stress response. The third preserved module correlated specifically with virus treatment/disease state. The most highly connected genes within these three modules represent hubs of gene regulatory networks and are thus the key elements of coral stress response and innate immunity. This knowledge is critical for understanding corals' susceptibility to disease. Furthermore, exposing conserved characteristics of innate immunity in basal metazoans such as corals could lead to broader biomedical insights.

P2.37 WRIGHT, R.M*; ROSALES, S.M; WELSH, R.M; VEGA THURBER, R.L; MATZ, M.V; University of Texas, Austin, Oregon State University, Corvallis; *rachelwright8@gmail.com*
The transcriptional response of coral larvae to viral challenge in the context of thermal stress
The global decline of coral reefs has been simultaneously attributed to rising ocean temperatures and the increasing prevalence of disease. While the agents of these diseases remain largely unidentified, there is increasing evidence that viruses play a role in infection. We challenged larvae of the reef−building coral *Acropora millepora* with virus−like particles (VLPs) isolated from seawater and with temperature stress (31C). Larval cultures were maintained at control (27C) or elevated (31C) temperatures either in the presence or absence of VLPs, resulting in four experimental treatments with five biological replicates per treatment. Global gene expression analysis was then completed using tag−based RNA−seq. Gene coexpression network analysis identified groups of co−regulated genes (modules) corresponding to the effects of virus and heat individually, as well as correlating with the combined effect of the two stressors. These differentially expressed genes included some of the key players in innate invertebrate immunity, genes previously implicated in response to thermal stress, and a number of novel candidates. This knowledge and the assays based on such genes will improve our ability to evaluate the risks of viral infection in corals in the context of warming oceans.

18.5 WRIGHT, C.W.*; MOELLER, K.T.; HOLDEN, C.; DEMARE, G.; DENARDO, D.F.; Arizona State Univ., Tempe; *cdwright729@gmail.com*
Exploring the energetics of foraging behavior in Gila monsters, Heloderma suspectum
Although predation risk and food availability strongly influence foraging decisions, so too can physiological condition and the energetic costs associated with searching for a meal. The interaction between physiological condition, energetic costs of searching for a meal, and foraging decisions is often referred to as state−dependent foraging (SDF). Although SDF is well studied in organisms with high−energy budgets (e.g., mammals), studies examining SDF in infrequently feeding organisms with low−energy budgets are rare. To better understand the interaction between condition, foraging behavior, and energetic costs associated with foraging, we examined how varying energy intake effects the foraging expenditures and behavior of a low−energy organism by supplementally feeding free−ranging Gila monsters, *Heloderma suspectum*. We used doubly labeled water to estimate field metabolic rate and implanted temperature loggers to record hourly body temperature and to estimate surface activity using temperature−based activity estimation (TBAE). As one determinant of foraging decisions is the energetic cost of searching for a meal, whereby high energetic costs may reduce the time an organism will dedicate to foraging, we used our field data in conjunction with lab−based measurements of the thermal sensitivity of standard metabolic rate to distinguish energetic expenditures during refuge use and surface activity. Here we present the results of our study and discuss how the foraging behavior of this low−energy organism compares to those of high−energy organisms.

97.8 WRIGHT, J/E*; UKHANOV, K; ACHE, B/W; KIMBALL, R/T; University of Florida, Gainesville; *jwright1855@ufl.edu*

Olfactory Sensory Neurons in New World Vultures (Cathartidae) Demonstrate Physiological Responsiveness to Biologically Relevant Odorants

Birds have long been thought to be anosmic, relying on visual and acoustic cues over olfaction. However, some birds have been shown to rely on olfaction for a variety of activities, including foraging, mate recognition, home site navigation, and predator avoidance. Turkey vultures (*Cathartes aura*) are known for their olfactory capabilities to locate food using only their sense of smell. In contrast, other genera of cathartid vultures are not thought to have well−developed olfactory abilities. We collected neuroepithelial tissue from the nasal cavities of turkey and black (*Coragyps atratus*) vultures and performed calcium imaging analysis on dissociated olfactory sensory neurons (OSNs). Results reveal that both species demonstrate an ability to bind biologically relevant odorant mixtures at the peripheral olfactory system and show little response to non−relevant odorant mixtures. Additionally, percent responses to odorant mixtures by cathartid OSNs appear to be just as robust as similar studies in mammals, indicating at least some birds are capable of a similar level of olfactory ability to mammals.

P1.153 WRIGHT, AM*; HILLIS, DM; University of Texas at Austin; *wright.aprilm@gmail.com*

Utilizing likelihood models for phylogenetic reconstruction from discrete phenotypic characters

Rate heterogeneity among characters presents challenges for the estimation of phylogenetic trees. This statement has been validated in many molecular studies to date, and we present results here exploring the issue of rate heterogeneity in morphological data sets. The issue of estimating topology when rate heterogeneity is present is exacerbated by missing data. In paleontological data sets, artifacts of preservation often lead to highly−structured missing data. Structured missing data can lead to biases in the information content of a data matrix when rate heterogeneity is present. For example, systemic lack of preservation of labile characters in a clade of interest can lead to misestimation of the rate parameters in phylogenetic estimation, leading to error in the tree. In this talk, we will explore the effects of structured missing data in morphological data sets. Using simulated data with varying degrees of rate heterogeneity, we will examine how model parameters and topologies estimated from data sets are affected by structured missing data. We will present results displaying the effectiveness of likelihood and parsimony methods for topology estimation under a range of simulation conditions and propose suggestions for mitigating the effects of structured missing data in topology estimation.

S5.3−3 WUNDERLICH, R.E.*; MILLER, C.E.; TONGEN, A.L.; SCHMITT, D.; James Madison University, Duke University; *wunderre@jmu.edu*

Dynamics of locomotor transitions from arboreal to terrestrial substrates in Verreaux's sifaka (Propithecus verreauxi)

Sifakas are indrid primates whose primary mode of locomotion is arboreal vertical clinging and leaping. On the ground, they use bipedal galloping gait characterized by asymmetrically sequenced limb contacts, a single re−direction of the center of mass and an aerial phase. Bipedal galloping and leaping in sifakas share kinematic features, yet the energetics and loading regimes of these two forms of locomotion are poorly understood. We used triaxial accelerometry to quantify dynamic body accelerations during a variety of locomotor behaviors. Accelerometers were mounted on free−ranging animals for whom locomotor behavior was recorded over 4 hours. Acceleration (100Hz) was recorded by datalogger, smoothed, and components summed to produce overall dynamic body acceleration (ODBA). Peak ODBA values over 20 Hz were identified as leaps. Leaping could be clearly identified compared to all locomotor behaviors other than bipedalism, which exhibited similar ODBA. A single leap or bipedal gallop consists of take−off and landing ODBA peaks. In both leaping and bipedalism, sifakas regularly use repeated or richochetal movements in which the landing ODBA of one leap is the takeoff ODBA of the next, resulting in one fewer ODBA peaks than would be expected from a series of single leaps. By using the landing acceleration to accelerate for the next take−off, sifakas minimize collisional energy losses by reducing the number of center of mass redirections by 1 each leap. Arboreal leaping and terrestrial bipedal galloping are dynamically similar locomotor patterns that use similar mechanisms for minimizing energetic costs.

118.6 WYGODA, J.A.*; BYRNE, M.; MCCLAY, D.R.; WRAY, G.A.; Duke University, University of Sydney; *jaw61@duke.edu*

Shifts in the Expression of Developmental Regulatory Genes Involved in the Evolution of a Novel Life History Difference

Developmental mode can influence dispersal, gene flow, speciation and extinction rates in marine taxa and thus can have important consequences for micro− and macroevolutionary processes. While the ancestral developmental mode of sea urchins is indirect through a feeding larval stage (planktotrophic), non−feeding development (lecithotrophic) has evolved independently multiple times. In order to identify evolutionary changes in gene expression underlying this ecologically significant shift in life history, we used Illumina RNA−seq to measure expression dynamics across 6 developmental stages in three sea urchin species: the lecithotroph *Heliocidaris erythrogramma*, the closely related planktotroph *Heliocidaris tuberculata* (3 myr), and an out−group planktotroph *Lytechinus variegatus* (50 myr). Our analyses draw on a well−characterized developmental gene regulatory network (GRN) in sea urchins to understand how the ancestral developmental program was altered during the evolution of lecithotrophic development. Our results suggest that changes in gene expression profiles were more numerous during the evolution of lecithotrophy than during the persistence of planktotrophy, and this contrast is even stronger when only GRN genes are considered. We found evidence for both conservation and divergence of GRN linkages in *H. erythrogramma*, as well as significant changes in the expression of genes with known roles in patterning the larval skeleton and gut, which are greatly modified in lecithotrophs. Collectively, these results indicate that the transition from planktotrophic to lecithotrophic development involved a surprising number of changes to key developmental processes over a short evolutionary timescale.

P1.92 WYGODA, J.A.; KOOP, D.*; YANG, J.; WRAY, G.A.; BYRNE, M.; Duke University , The University of Sydney; *mbyrne@anatomy.usyd.edu.au*

Developmental Transcriptome of Heliociaris erythrogramma − from bilateral larva to radial juvenile

Echinoderms possess bilateral larvae that give rise to a unique pentaradial adult organization. However, the genetic and cellular mechanisms underpinning the development of this body plan remains unclear. A key question is whether this pentamery involves axial patterning programs that are highly conserved in other organisms or is a novel feature, possibly evolved through co−option of gene function. In this study we use the sea urchin *Heliocidaris erythrogramma* with rapid development to the juvenile stage (5 days) as a model to identify genes specifically involved in juvenile formation and assess whether gene networks that pattern the early larva are redeployed in adult development. To address these questions, we used Illumina RNA−seq to measure the transcription profiles of 6 distinct stages of *H. erythrogramma*, from gastrulation through metamorphosis. These findings are expanded by assessing the expression patterns of key genes during the formation of the juvenile *H. erythrogramma*.

107.1 WYNEKEN, J; LOLAVAR, A; TEZAK, B M*; Florida Atlantic University; *jwyneken@fau.edu*

Temperature, Moisture and Male Production in Marine Turtle Nests& Oh What a Maze

The incubation environment determines the sex of marine turtles and temperature is the major factor thought to direct sex determination. In nature, most marine turtle hatching sex ratios are samples are limited in size and in the numbers of mothers represented. Sex ratios often are inferred temperature−sex ratio response curves derived in lab studies. The relationship between the temperature and sex ratio response is reasonably well documented in controlled temperature studies, yet typically the numbers of clutches and samples are limited. In the field, the temperature−sex ratio relationship differs from that in the lab so that female biased sex ratios are common at male−producing temperatures and male−producing temperatures are rare or do not occur in many field situations. Here we identify key uncertainties left by previous studies lab studies of sea turtle sex ratios based solely on incubation temperatures. We describe our large, multi−year field−based incubation temperature−sex ratio results and the sex ratio results of a series of controlled temperature and moisture conditions using a reasonably large numbers of nests samples. Both sets of studies suggest that high humidity modifies sex ratio responses of marine turtle eggs incubated near pivotal temperatures so that male−biased sex ratios occur more frequently. Both temperature and humidity can influence the sex ratios in experimental nest conditions so that normally female−biasing temperatures can produce male−biased sex ratios in high moisture conditions.

2.6 YAMASE, N. *; SMITH, C.; Chaminade University of Honolulu, University of Honolulu at Manoa; *nicole.yamase@student.chaminade.edu*

Unknown but common: The ecophysiology of the green alga Microdictyon setchellianum

Understanding how physical factors affect the photosynthesis and growth of macroalgae are crucial to estimating their ecological success and the health of the reef community. The macroalga *Microdictyon setchellianum* is a common plant in many reefs as a component in the understory or as a principal element of reef cover, as in the Northwestern Hawaiian Islands. Despite its abundance, rates of growth and photosynthesis for this alga were unstudied. We began initial characterizations, using three approaches; manipulation of irradiance from ambient to 350 µmol photons m^{-2} s^{-1} in mesocosm setup; a controlled nutrient experiment again using mesocosms; and determination of light response curves for the base, center, and outer edge sections of the alga, for freshly collected materials. There was no significant difference in growth rates between the shaded and unshaded samples; plants attained significant growth in a two week period ($p<0.005$). There was no difference in growth between the control and nutrient treatments. Photosynthetic parameters ETR_{max} and E_k remained unchanged throughout the experiment. Growth rate decreased significantly in the experimental group ($P<0.001$) when nutrient amounts were doubled. Finally, photosynthetic performance parameters documented differences between the base of blades and center of the plant ($P<0.011$), suggesting self−shading is a common occurrence *in situ*. *M. setchellianum* appears to be a shade−tolerant alga, which allows it to grow in both low and moderately high irradiance regimes. Finally, in oligotrophic conditions, this plant can sustain growth comparable to other well−known native species.

P1.107 YANAGITSURU, Y.R.*; AKANYETI, O; LIAO, J.C.; University of California, San Diego, Whitney Laboratory for Marine Bioscience; *yyanagit@ucsd.edu*

The Effects of Self Motion on the Pressure Difference Across the Head of Rainbow Trout (Oncorhynchus mykiss) During Locomotion

The self−generated pressure gradient across a fish's head during locomotion affects both hydrodynamic efficiency and the ability to sense flow signals. By head−mounting pressure sensors and synchronizing them to high speed video cameras recording lateral and ventral views, we simultaneously measured the head kinematics and hydrodynamic pressure gradients for rainbow trout during steady swimming (L=18.7±1.1 cm, 2−7 L s^{-1}, n=5 fish). We find that the pressure gradient increases quadratically as steady swimming speed increases, which correlates with the inability of the fish to sustain steady swimming above 4 L s^{-1}. We have also begun to look at the pressure gradients generated by other motor behaviors such as Karmán gaiting in a vortex street behind a cylinder, bursting, and C−starting. Preliminary data shows that for a fish Karmán gaiting among vortices in a cylinder wake, the pressure gradient is ten times that of steady swimming and also increases quadratically with flow speed. For transient behaviors such as bursting the pressure gradient depends upon burst speed, and is always higher than that of steady swimming. Remarkably, during a C−start the pressure gradient is over one thousand times that of steady swimming. We find that, overall, the intensity of the self−generated pressure gradient is inversely correlated with the duration of a behavior. Our study lays the groundwork to better understand the effects of self−motion on both locomotor efficiency and sensory functions.

49.3 YANG, P.J.*; PHONEKEO, S.; XU, K.; CHANG, S.K.; HU, D.L.; Georgia Tech, Georgia, National Sun Yat−sen University, Taiwan; *peijyang@gatech.edu*

Flying fish accelerate at 5 G to leap from the water surface

Flying fish can both swim underwater and glide in air. Transitioning from swimming to gliding requires penetration of the air−water interface, or breaking the "surface tension barrier," a formidable task for juvenile flying fish measuring 1 to 5 cm in length. In this experimental investigation, we use high−speed videography to characterize the kinematics of juvenile flying fish as they leap from the water surface. During this process, which lasts 0.05 seconds, flying fish achieve body accelerations of 5 times earth's gravity, achieving gliding speeds of 1.3 m/s, an order of magnitude higher than their steady swimming speed. We rationalize this anomalously high speed on the basis of the hydrodynamic and surface tension forces and torques experienced by the fish. Specifically, leaping fish experience skin friction forces only on the submerged part of their body, permitting them to achieve much higher speeds than in steady underwater swimming. We also perform experiments using a towed flying fish mimic to determine optimality of various parameters in this process, including body angle and start position with respect to the water surface.

49.1 YANOVIAK, S P*; FREDERICK, D N; Univ. of Louisville, Univ. of Arkansas, Little Rock; *steve.yanoviak@louisville.edu*

Surface swimming in tropical canopy ants

Wingless arthropods (e.g., ants) regularly fall from tropical forest canopies to the ground below. The flooded, fish−inhabited understory typical of many tropical forests presents an especially high probability of mortality for fallen insects. Here we show that several canopy−dwelling ant species use rapid, directed surface swimming to escape from water. We tested the hypothesis that swimming ability is associated with an arboreal lifestyle in tropical ants by dropping workers of a broad range of arboreal and epigeic species individually into natural and experimental aquatic settings. We used Image−J software to quantify swimming velocity and directionality for each species. We similarly quantified leg kinematics for selected species. We conducted experiments with workers of *Odontomachus bauri*, a common species that swims well, to determine if their aquatic locomotion is directed toward emergent objects (black or white pipe). Swimming ability varied greatly among the species tested. Many simply struggled on the water surface (e.g., *Cephalotes atratus*), while others were very effective swimmers (e.g., *Gigantiops destructor*, velocity = 12 cm s^{-1}). Directional swimming of *O. bauri* was biased toward dark objects, suggesting that these ants use skototropism for orientation toward tree trunks when on water. Although swimming behavior has been described for ant species associated with specific habitats (e.g., mangroves and phytotelmata), we provide the first evidence that aquatic locomotion is a widespread phenomenon among tropical rainforest ants.

P1.158 YAO, A*; CLARK, F; TEMKIN, M; SCHREIBER, A.M.; St. Lawrence University, NY, Bard College, NY; *aschreiber@stlawu.edu*

Effects of thyroid hormones and glucocorticoids on lung development in metamorphosing Xenopus laevis tadpoles

Prior to metamorphosis, the primary respiratory surfaces of X. laevis tadpoles are the skin and gills. Although tadpoles do have functional lungs as early as hatching, their contribution to respiration at this developmental stage is thought to be minor. However, following the abrupt loss of the gills and thickening of the skin during metamorphosis, the lungs rapidly take on a more prominent respiratory role. Thyroid hormone (TH) and glucocorticoids (GC) are known to play important roles in mammalian post−natal lung development, and have also been shown to work synergistically to mediate most, if not all, aspects of amphibian metamorphosis. In order to determine the influence of these hormones on metamorphic lung development, pro−metamorphic tadpoles (Nieuwkoop−Faber stage 54) were treated with TH (5nM T3) or dexamethasone (DEX, 2 uM), either separately or in combination, for 4 days. Lung cross−sections were then examined using hematoxylin−eosin histology, and immunohistochemically using an antibody against epithelial cadherin, and the actin−specific label, phalloidin. The appearance of e−cadherin−containing cells did not vary among treatments. However, compared with either untreated or DEX−treated tadpoles, the lung walls of tadpoles treated with TH−alone had significantly thicker cross−sections, more pronounced blood vessels, and a much higher proportion of actin−rich cells. Interestingly, DEX+TH lungs contained more actin than untreated or DEX−treated lungs, but less compared with TH−alone. These findings suggest that these two hormones exert different effects on lung development, with TH promoting the growth and/or proliferation of actin−containing cells in the lung, and GC inhibiting actin−containing cell development.

P2.26 YEE, A.K.*; VAN ALSTYNE, K.L.; PADILLA, D.K.; Stony Brook University, Shannon Point Marine Center, Western Washington University; *alison.yee@stonybrook.edu*

Chemical Signaling In An Inducible Offence

Inducible phenotypic plasticity is the ability of an organism's genotype to express different observable traits, or phenotypes, such as morphology, over and individual's lifespan. The snails *Lacuna vincta* and *L. variegata* are found in two habitats, eelgrass and macroalgae where produce two different radular tooth morphologies, blunt or pointed, depending on their diet. We tested whether there are different chemical cues from macroalgae, a kelp in this case, diatoms, or eelgrass (*Zostra marina*) that trigger different tooth morphologies in these two species of Lacuna to understand what induces the change in phenotype. Changes in tooth morphology during the experiment was different for snails from two source locations, False Bay, an eelgrass bed, and Pile Point, dominated by macroalgae, which may reflect different prior environmental variability or stability. Furthermore, the lag time of phenotypic change was different between species originating from the same source. *L. vincta* from False Bay changed phenotype more quickly than *L. variegata* from False Bay, which may also be due to different prior environmental variability or stability. Most animals of both species produced pointed teeth on the neutral diet of lettuce, as well as when fed kelp or eelgrass, suggesting this is a default morphology, and blunt tooth production requires a cue for production.

P1.3 YETSKO, K.L.*; FORLANO, P.M.; SISNEROS, J.A.; College of Charleston, South Carolina, City University of New York, Brooklyn College, University of Washington, Seattle; *klyetsko@g.cofc.edu*

Does the mating call of the plainfin midshipman reflect mate quality?

For signals in nature to be honest in a reproductive context, they have to convey accurate information about the sender's value as a potential mate. The plainfin midshipman (*Porichthys notatus*) is a good model to investigate vocal−acoustic behavior and honest signaling because acoustic communication is essential to its social and reproductive behavior. In this study, we tested the hypothesis that larger nesting males produce louder and lower frequency advertisement calls than smaller nesting males. Males were collected from intertidal nesting grounds in Hood Canal, WA , transported to Friday Harbor labs, and took up residence in artificial nests in large indoor communal tanks. The calls were recorded at night during the months of June and July 2013. Overall, loudness, or amplitude, of the male's advertisement call was positively correlated with body size and swim bladder volume. Swim bladder volume and body size were also correlated with the dominant frequency components (first five harmonics) of the male advertisement call; however this correlation was much weaker. The fundamental frequency (1^{st} harmonic) of the male advertisement call was negatively correlated with body size and swim bladder volume, supporting our initial hypothesis; however the frequencies of the 2^{nd} through the 5^{th} harmonics showed a positive correlation. The amplitude of the 2^{nd} and 3^{rd} harmonics relative to the 1^{st} harmonic also increased with body size and tends to be of greater amplitude or equal to the fundamental frequency of the advertisement call of larger males. Based on preliminary data, the plainfin midshipman does seem to convey honest information about the male's size and potential mate quality, especially in regards to amplitude.

67.1 YOUNG, V.KH.*; BLOB, R.W. ; Clemson University; *vkhilli@clemson.edu*

In vivo Femoral Strains in Swimming Turtles: Influence of Locomotor Medium on Limb Bone Loading

Many terrestrial vertebrate lineages have members that have returned to aquatic habitats. Such taxa often show characteristic changes in limb bone shape, such as flattening of the shaft. The basis for evolutionary modifications in skeletal structure is often assumed to relate to changes in the loads that bones experience. Shifting to aquatic habitats would be expected to alter the loads to which limbs are exposed, lowering body support demands but retaining muscle forces from cyclic activity. No experimental data are available to evaluate such predictions, however, or to specify changes in load magnitude or regime between habitats. We tested how limb bone loading changes between use in terrestrial and aquatic habitats by recording *in vivo* strains from femora of swimming turtles, and comparing these data to strain recordings from turtle femora during terrestrial walking. We predicted that peak load magnitudes would be lower during swimming than walking, but that nearly equal load peaks, indicating bending in opposite directions, might occur during each of the thrust and recovery phases of the limb cycle. Preliminary data indicate our first prediction was met, with average peak strains in swimming less than half the magnitude of those during walking. Loading regimes were consistent between swimming and walking, with compressive axial strains experienced on the dorsal surface of the femur. Thus, our second prediction was not met, as single peaks of loading were consistently experienced during the thrust phase, whereas loads during recovery were more variable and typically much lower in magnitude than the strains recorded during thrust. These results indicate the strong role that limb muscles play in producing bone loads even after the reduction of environmental forces.

39.4 YOUNG, B.A.*; MOST, M.G.; DUMAIS, J.; JOHN, N.; LYONS, B.; MACDUFF, A.; REISER, P.J.; A.T. Still University, University of Massachusetts Lowell, Ohio State University; *byoung@atsu.edu*

Multiple perspectives of the functional divisions within the swimming muscles of the Asiatic water monitor (Varanus salvator)

Varanus salvator is a semi−aquatic species in which aquatic propulsion is produced by undulations of the tail base. This study examined the functional contributions of three muscles that insert on the tail base; Caudofemoralis, Longissimus (an epaxial muscle), and Iliocaudalis (a hypaxial muscle). For consistency all of the work was performed on juvenile specimens with total body lengths between 90 − 130 cm. To explore the functional roles of these muscles, we performed bipolar emg coupled with high−speed digital videography, whole muscle physiology, work loops, enzymatic fiber typing, and molecular analysis of the contractile proteins. The temporal pattern of the emg signals, combined with their relationship to swimming speed, suggests that the Iliocaudalis is the primary propulsive muscle while caudofemoralis functions more in stabilization. This inferred functional split was supported by other findings: caudofemoralis has a significantly different contractile rate and force output profile, a different pattern of fatigue, and more slow−type MHC than the axial muscles. The longissimus and iliocaudalis have similar molecular composition and physiological properties; the activity pattern of the longissimus indicates that it is not playing a major role in tail propulsion. Examining this locomotor system using these diverse analytical approaches may provide insight into the physiological properties of reptilian muscle. Comparative analyses within *Varanus* could illuminate the pattern of physiological evolution within this functional system.

67.3 YOUNG, J. W.*; RUSSO, G. A.; ROSE, J. A.; BUTCHER, M. T.; SMITH, G. A.; NEOMED, Youngstown State Univ., Youngstown State Univ, Univ. of Akron; *jwyoung@neomed.edu*

Ontogeny of locomotor performance in Eastern cottontail rabbits: II. Hindlimb joint work during acceleration

Due to small size and ecological inexperience, juvenile animals are often under greater predation risk than adults. Although previous studies of several taxa have identified specific musculoskeletal growth trajectories that may alleviate juvenile risk by improving locomotor performance, few have measured age−related changes in performance, particularly in mammals. We used high−speed video and force platforms to quantify how growing cottontail rabbits (*Sylvilagus floridanus*), a species that experiences high predation at early ages, modulate hindlimb mechanics during acceleration. We collected 38 trials from a cross−sectional series of six wild−caught rabbits (mass: 0.23−1.3kg; age based on published growth curves: 37−184d). Overall, accelerations ranged from −0.6 to 8.6ms^{-2}, corresponding to a −0.57 to 0.95 ms^{-1} change in velocity during stance. Increasing acceleration was associated with linear increases in total hindlimb joint work (R^2=0.76, p<0.001), and was primarily powered by increases in hip (R^2=0.67, p<0.001) and ankle work (R^2=0.80, p<0.001). Although measured accelerations slightly increased with age (R^2=0.16, p=0.01) this effect disappeared when the youngest (and slowest) individual was removed from the dataset (R^2=0.07, p=0.15). Moreover, multiple regressions showed that age, controlling for acceleration and mass, was not significantly associated with either total limb work or individual joint work (all p>0.05), suggesting similar capacities for power output in juveniles and adults. When combined with the results of previous morphological studies, our findings support the hypothesis that musculoskeletal growth in rabbits is optimized to increase performance at early ages. Supported by NSF IOS 1146916, 1146851 and 1147044.

P2.53 YOUNG, R*; PERRY, SL; JENNINGS, KX; RODRIGUEZ, WB; BOUCHARD, SS; Otterbein Univ., Westerville OH, Otterbein Univ, Westerville OH; *sbouchard@otterbein.edu*

Compensatory growth in larval American Toads

Juvenile growth rate is an important life history trait that is linked to adult fitness in many organisms. After a period of limited resources, some organisms experience accelerated growth rates that allow them to compensate for periods of slow growth. For animals with complex life cycles, such compensatory growth could have carry over effects for future life stages. We assessed the capacity for compensatory growth in larval American Toads, *Bufo americanus*, and investigated effects on growth post−metamorphosis. Larvae were reared at high, medium and low densities in 410 L mesocosms. Each mesocosm was supplied with equal food rations, such that per capita food availability varied with density. Upon reaching an average mass of 1.3 g, a subset of larvae were removed from their initial densities and placed at low densities with high food availability. One week growth rates, as well as time to and size at metamorphosis were determined. Post−metamorphic growth rates were also measured for toadlets maintained in the lab on a fruit fly diet for five weeks. Initially, larvae did not demonstrate compensatory growth as one week growth rates of larvae from medium and high densities were lower than those of larvae from the low density. However, larvae from the medium density metamorphosed sooner than and at the same size as those from the low density. Larvae from the high density were slightly smaller and metamorphosed at the same time as those from the low density. There were no significant differences in post−metamorphic growth rates. These results suggest that the capacity for compensatory growth may vary with initial food restriction levels.

115.1 ZACHOS, L G; University of Mississippi; *lgzachos@olemiss.edu*

Holistic Morphometrics of Sand Dollar Echinoids Using Geographic Information Systems Technology

A mature individual of the Northern Sand Dollar *Echinarachnius parma* has a skeleton composed of approximately 1000 individual calcite plates. There are significant changes in number, size, orientation, and location of plates throughout ontogeny. There is also significant variation within populations of these echinoids, although it has been difficult to quantify. The flattened, relatively 2−dimensional architecture of a sand dollar offers a unique opportunity to test the use of Geographic Information Systems (GIS) technology for morphometric studies. All of the plates of individual specimens are manually digitized from scaled photographs and converted into topologically correct polygons. These polygons are labeled by plate type and indexed using an echinoid−centric numbering system. This permits the determination of plate cohorts and allows not only static measure of plate location and dimension, but also the ability to map the changes in size and relative position during growth. Such information is proving invaluable for development of computer models of growth in these organisms. Although the data are originally collected in a 2−D reference frame, GIS software facilitates overlay of upper and lower surfaces for visualization of vertical plate juxtaposition. With the addition of 3−dimensional information, obtained either by direct measurement or optical means, fully 3−D models can be created. GIS software functionality includes scaling, transformation, annotation, data conversion, and spatial analysis. Using GIS, it is possible to study plate development using every element of the echinoid skeleton, quantify individual plate growth, measure plate translocations, and correlate growth dependencies between oral and aboral plates.

P1.201 ZACHOS, L G; University of Mississippi; *lgzachos@olemiss.edu*

Developmental Reaction Norms in the Phenotypes of Scutelliform Echinoid Skeletons

Using a holistic morphometric method based on Geographic Information System technology, recurring themes (developmental reaction norms) in phenotypic expression of skeletal architectures are demonstrated for a group of scutelliform sand dollar echinoids. In particular, similarities in the expression of timing of imago to post−imago stage transitions, juvenile through adult plate growth, aboral−oral plate dependencies, translocation of ambulacral and interambulacral plates, and asymmetric radial expansion can be shown for the extinct Protoscutellidae and extant Echinarachniidae. Distinct morphotypes in a single population of *Echinarachnius parma*, defined using information from all the plates in the skeleton and complete ontogenetic trajectories, are compared with similarly examined morphospecies of protoscutellids. This information is critical to unraveling both the taxonomy and the phylogeny of the Protoscutellidae.

P2.137 ZAJIC, D.E.*; CRAMB, G.; GOTZ, M.; VILLASENOR, A.; YANCEY, P.H.; Whitman College, Univ. of St. Andrews; *zajicde@whitman.edu*

Novel osmolyte in Atlantic salmon (Salmo salar) as a potential biomarker of freshwater−seawater transition

Organic osmolytes are small solutes that increase osmolality inside cells to stop osmotic water loss without disturbing cellular functions and, in some cases, to stabilize proteins against denaturants like urea, salt and pressure. In recent years, some euryhaline teleosts, which as osmoregulators have been thought not to use such osmolytes, have been found to accumulate them in many tissues following freshwater (FW) to seawater (SW) acclimation. The current study was undertaken to examine the osmolyte profile of Atlantic salmon (*Salmo salar*). High−performance liquid chromatography identified osmotically significant levels of taurine and an unknown compound in fins and skin of *S. salar*, at levels (from highest to lowest) in: juveniles (6 mo old) acclimated 3 wks in SW > young adults (9 mo old) acclimated 3 mo in SW > juveniles (6 mo old) in FW > adults (30 mo old) kept 2 yrs in SW. Currently, gill Na/K−ATPase levels are measured at salmon farms to determine when S. salar should be moved from FW to SW. We suggest this unknown osmolyte might serve as a biomarker for the salmon industry as indicator of readiness for FW to SW transition. Nuclear magnetic resonance has tentatively shown the unknown compound as a possible di− or tri−peptide, perhaps containing isoleucine. Small peptides have only rarely been found to be osmolytes, and this would be the first known to contained isoleucine. Common osmolytes such as alanine, glutamine and proline were also observed to be highest in juvenile SW fish, though a complete age survey must be completed to ensure each compound's role as potential osmolytes and biomarkers. Funding: Whitman College and Natural Environment Research Council.

128.7 ZAKAS, C*; ROCKMAN, MV.; New York University; *christinazakas@gmail.com*
Dimorphic Development in Streblospio benedicti: Characterizing key morphological shifts between larval types using hybrid crosses
Mechanisms of early development can constrain body plan evolution, but the extent to which these developmental constraints shape larval morphology, and thus suites of life−history traits, remains unresolved. Poecilogonous species, such as the marine polychaete *Streblospio benedicti*, produce two distinct larval types and are ideal systems to study differentiation between contrasting developmental plans. *S. benedicti* has a population−level egg size dimorphism− a ~5 fold difference in egg size occurs between morphs− with cascading effects on larval development. Distinct morphological differences between the larval types are well described in some populations, including the presence of larval bristles, the ability (or need) for larval feeding, and the timing of emergence of adult features such as palps and branchiae. Here, we characterize these traits in a number of populations of both larval types to determine the amount of variation at the population and family level. We also cross adults of both morphological types to establish the extent that key larval features are maternally or zygotically controlled in the F1s, and thus begin to uncover the potential mechanisms that drive the evolution of larval mode.

S3.1−3 ZALLEN, J.; HHMI and Sloan−Kettering Institute; *zallenj@mskcc.org*
Shaping the embryo: Cellular dynamics in development
A major challenge in biology is to understand how large−scale changes in tissue structure are generated on a cellular and molecular level. In the fruit fly Drosophila, the characteristic elongated shape of the head−to−tail axis is achieved through the rapid and coordinated movements of hundreds of cells. We found that these movements are oriented by cellular asymmetries in the localization of the molecular machinery that generates contractile and adhesive forces between cells. Using quantitative imaging, we show that these asymmetries result in higher−order collective cell behaviors in which groups of cells assemble into multicellular rosette structures that form and resolve directionally, promoting efficient elongation. Rosettes form through a combination of biochemical and mechanical signals that spatially orient actomyosin contractile activity. An initial asymmetry in the localization of the myosin II motor protein is amplified by mechanical tension, promoting the formation of multicellular contractile networks that contract to promote efficient elongation. In addition, the dynamics of cell adhesion proteins are controlled by the spatially regulated activation of tyrosine kinase signaling at cell−cell junctions that are selectively targeted for disassembly, demonstrating an essential role for spatially regulated tyrosine kinase signaling in dynamic cell interactions during development. Multicellular rosette behaviors have since been shown to occur during epithelial elongation in vertebrates and may represent a general mechanism linking cellular asymmetry to tissue elongation. We are currently using molecular genetic and live imaging approaches to understand how genes encode the forces that generate polarized cell behavior, and developing biophysical methods to elucidate the mechanotransduction mechanisms that allow cells to modify their behavior in response to their mechanical environment.

19.1 ZELDITCH, M.L*; LI, J.; TRAN, L.A.P.; SWIDERSKI, D.L.; Univ. of Michigan, Ann Arbor; *zelditch@umich.edu*
The radiation of a living fossil: Jaw morphology of tree squirrels
The dynamics of adaptive radiations have captured much attention recently, but equally interesting are groups famed for their morphological conservatism, i.e., living fossils. Some living fossils are diverse and geographically widespread, such as the largely New World tree squirrels (Sciurini) which closely resemble the first known squirrel in postcranial morphology and jaw proportions. In this analysis, we examine jaw size and shape disparity of 90 species, 75 of which had sequence available for a phylogenetic reconstruction. We compare the evolutionary dynamics of three clades, Sciurini, its sister group, the Indomalayan flying squirrels (Pteromyini) and Indomalayan tree squirrels (Callosciurinae). As anticipated, Sciurini is least disparate in both size and shape; its subclade disparity is consistently high relative to the total disparity. In contrast, the within−subclade disparity of Pteromyini is initially no greater than expected from Brownian motion, but it increases dramatically, exceeding the total for the group because of the relatively large distances between close relatives in comparison to the average distances across all species. Size apparently evolves by Brownian motion in all three clades but shape is better explained by an Ornstein−Uhlenbeck model, with Sciurini being most constrained. The low disparity of Sciurini is thus not due to low rates of jaw shape evolution; in both evolutionary rate and average branch length, Sciurini does not differ from Pteromyini. Rather, Sciurini more densely fills a smaller morphospace, rarely expanding its morphological range and repeatedly converging, while its lineages accumulate and its geographic range expands from boreal to tropical forests.

P1.200 ZELDITCH, M.L*; LI, J.; TRAN, L.A.P.; SWIDERSKI, D.L.; Univ. of Michigan, Ann Arbor; *zelditch@umich.edu*
Diversification, species richness and rates of morphological evolution: Squirrel jaw morphology
Whether rates of diversification and morphological evolution are related is a central question in evolutionary biology. They could be related when speciation and morphological divergence are both driven by ecological opportunity. But the relationship between them might be weak when speciation is driven by geographical opportunity and species either track their habitat or are adapted to widespread environments. Even when lineage accumulation and morphological evolution are related, that relationship could be complicated by diversity−dependence of speciation rate or morphological evolution. In particular, when species diversification rates are bounded, species richness rather than speciation rate might be a better predictor of morphological evolutionary rates. Similarly, when morphological evolution is also bounded, disparity may be more strongly related to lineage accumulation than are evolutionary rates. To examine the relationships between rates of diversification, species richness, rates of morphological evolution and morphological disparity we analyze jaw shape and size in 168 species of squirrels (Sciuridae), representing 17 monophyletic groups. We find some correlations that are high but non−significant, especially between species richness and two measures of accumulation of size and shape differences: disparity and evolutionary rates. We also find high but non−significant correlations of species richness with clade age and evolutionary rate. The correlations are not significant because of outliers. In Sciuridae, the disparity in species−poor clades is highly variable, while species−rich clades are among the least disparate. Clades that are both species rich and very disparate are unusual.

24.4 ZENG, Y.*; LAM, K.; GONG, M.; CHEN, Y.X.; DUDLEY, R.; Univ. of California, Berkeley; *dreavoniz@berkeley.edu*

Biomechanics of asymmetric leg behaviors in aerial righting maneuvers of larval stick insects

The aerial capabilities of wingless invertebrates subjected to unsteady and perturbed conditions is largely unexplored. We studied the aerial righting maneuvers of first instar larval stick insects *Extatosoma tiaratum* (body length 1.7 cm) introduced to unintentional drops, catapulted ascent and midair perturbations. Three−dimensional high−speed filming and detailed motion reconstruction were applied to describe the whole−insect dynamics as well as the movements of all six legs. All insects responded with righting reflex to initiate rapid rotation by aerodynamic torque for orientation recovery, and then exhibited asymmetric leg behaviors during the transient phases after the major rotation. The coordination of leg postures and strokes was found to be responding to the instantaneous body rotation. Model−assisted analyses on the stroke movements of legs, which collectively hold 40% of total insect mass, showed a combination of inertia and aerodynamic effects for body reorientation. Our results demonstrated the biomechanical feasibility of controlled appendicular movements in aerial maneuvers at the size of larval stick insects, and provided insights for understanding the evolution of controlled aerial behaviors in invertebrates.

S9.3−1 ZERA, A.J.; University of Nebraska; *azera1@unl.edu*

Physiological, biochemical, and molecular bases of a nutrient allocation trade−off that underlies a life history trade−off in a wing−polymorphic cricket

Mechanisms controlling nutrient allocation trade−offs that underlie life history trade−offs have been an important topic of evolutionary and physiological research during the past few decades. Detailed studies of lipid and protein metabolism in morphs of wing−polymorphic crickets that trade−off flight capability and egg production have contributed significantly to this area of research Previous radiotracer and enzymological studies identifying morph−specific differences in lipid and protein biosynthesis, degradation, and allocation, in the context of production of lipid flight fuel and ovarian protein and lipid, will be briefly reviewed. Recent and ongoing transcriptome studies (RNA−Seq) which have identified morph differences in the expression of genes involved glyceride biosynthesis and hormone signaling will also be discussed. Studies mentioned above have largely been conducted on a single diet. Ongoing multi−diet studies of morph−specific intermediary metabolism conducted in the context of the geometric framework will also be discussed. Research was supported by grants from the National Science Foundation

63.1 ZHANG, Y.*; SWANSON, D. L.; University of South Dakota; *yufeng.zhang@usd.edu*

Cold and Exercise Training Produce Similar Increases in Maximal Metabolic Output in House Sparrows

Maximal metabolic output for both exercise and thermogenesis in birds presumably influence fitness through effects on flight and shivering performance. Because both summit (M_{sum} = maximum thermoregulatory metabolic rate) and maximum (MMR = maximum exercise metabolic rate) metabolic rates are functions of skeletal muscle, correlations between these measurement might occur, but this has been little studied in birds. We measured effects of 3−week experimental cold and exercise training protocols on body (Mb) and muscle masses, basal metabolic rate (BMR), M_{sum}, MMR, and citrate synthase (CS), ^{2}−hydroxyacyl CoA−dehydrogenase (HOAD) and carnitine palmitoryl transferase (CPT) activities in house sparrows (*Passer domesticus*). Both training protocols resulted in significantly higher M_{sum}, MMR, Mb, CPT and CS activities in pectoralis (PEC) with non−significant trends toward higher CPT and CS activities in supracoracoideus than in the control group. Exercise−training also significantly increased PEC and heart masses and cold−training also produced a nearly significant increase in PEC mass (P=0.058). BMR showed a trend (P=0.087) toward increasing with cold training, but BMR was significantly reduced by exercise training. These data indicate that both cold and exercise training modified the phenotype of house sparrows to similarly increase maximal metabolic outputs for exercise and thermogenesis. These increases are associated with increases in Mb, PEC and heart masses, and enzyme activities in both groups, suggesting that such changes are prominent drivers of metabolic flexibility. Correlation between the two measures of maximal metabolic output indicate that cross−training effects between cold and exercise may occur for birds. However, BMR varied differently with exercise and cold training, suggesting that other factors (e.g., changes in digestive organs) account for flexibility in BMR.

P3.9 ZHENG, DJ*; DEANGELIS, R; HARRIS, RM; HOFMANN, HA; UT Austin, Austin TX; *djzheng@utexas.edu*

Dissociating sex from choice: Deciphering the neural basis of female mating decisions

Across vertebrates social decision−making processes are regulated by a conserved set of brain regions that comprise a Social−Decision−Making (SDM) network. Female mate choice is one of the most important decisions affecting fitness, yet the neural underpinnings of this process are not well understood. To gain insight into female mate choice we probed the SDM network activity of two species of cichlids with different mating systems across different points of the female reproductive cycle: Astatotilapia burtoni, a polygynous lekking species, and Amatitlania nigrofasciata, a monogamous species. In a dichotomous choice paradigm, female A. burtoni show preference for the male they eventually mate with only on the day of spawning, while on all other days she avoids this individual. Conversely, female A. nigrofasciata show mate preference several days before spawning, when a pairbond is formed. We then compared induction of the immediate−early gene c−FOS, a marker for neural activity, across the SDM network in females of both species on the day of spawning, on a day when the female A. burtoni has yet to spawn, and on the day when A. nigrofasciata shows preferences. By comparing across these four time points we can dissociate the substrates that modulate mate choice from those underlying sexual behavior. Our results provide novel insights into the mechanisms of complex decision−making.

P2.41 ZHUANG, M*; HIGHAM, T.E.; Univ. of California, Riverside; *mzhua001@ucr.edu*

Foot use during arboreal locomotion in the Giant Day Gecko (Phelsuma madagascariensis)

By using adhesion, geckos can move in a variety of challenging habitats. The evolution of adhesion was accompanied by morphological changes in the foot, such as modifications for digital hyperextension and an average shortening and splaying of the toes. These changes are thought to facilitate adhesion. Given the importance of the foot in transmitting forces to the substrate, these changes in morphology are also likely to affect kinematics. *Phelsuma madagascariensis* has feet that are not symmetrical (within the foot) and not as shortened as that of other geckos, suggesting a constraint on the surface area in which the adhesive system can engage. This is important given the directionality of adhesion. In order to accommodate varying inclines and substrates, we expect *P. madagascariensis* to rotate its feet towards or away from the body and change the within−foot symmetry (angles between its toes). To test this, we obtained 3D movements (with high−speed video) of geckos running on a range of ecologically relevant inclines (0°, 45°, 90 °) and perch diameters (1.5cm, 10cm and flat). We focused on measuring instantaneous within−foot symmetry and foot alignment relative to the body across each condition. The modulation of within−foot symmetry and foot alignment suggests that aspects other than adhesion are important for moving on a variety of arboreal substrates. Behavior and morphology are highly integrated, although morphology defines behavioral limits. In addition to better understanding the unique morphology in *Phelsuma*, our study reveals foot usage in arboreal locomotion and the constraints of the adhesive system in geckos. This is essential to understanding how biomechanics responds to the evolution of novel adaptations and morphologies. Supported by NSF IOS−1147043.

131.1 ZIMMERMAN, L.M.*; CARTER, A.W.; VOGEL, L.A.; BOWDEN, R.M.; Illinois St. Univ.; *lmzimme@ilstu.edu*

Effect of age and temperature on B cell function in a long−lived ectotherm

Both endothermic and ectothermic vertebrates typically demonstrate a functional decrease in immune function with age. In ectotherms, temperature can also influence immune responses. Typically, ectothermic vertebrates can mount immune responses over a wide range of temperatures with a species−specific temperature at which responses are strongest, and impaired responses above and below this threshold. In long−lived ectotherms, aging could negatively influence the ability to respond to short−term temperature changes. This study examined the effects of this interaction on B cell function in a long−lived reptile, the red−eared slider turtle, *Trachemys scripta*. Sliders can produce both natural antibodies (Abs) in the absence of antigen stimulation and specific Abs in response to stimulation. Slider B cells are also capable of phagocytosis. Adult turtles were trapped and blood samples taken. Because sliders grow throughout their lifetime, plastron length was used as a proxy for age. Leukocytes were isolated and used in either an ELISpot assay to examine their ability to produce Abs spontaneously or when stimulated, or used in a phagocytic assay. The ELISpot was conducted at 27, 29, 33, and 37°C while the phagocytic assay was run at 25, 27, 29, 33, and 37°C. We found no interaction between age and temperature on any measure of B cell function. In all cases there was a significant effect of temperature, with impaired function at temperatures below 29°C and no impairment of function at higher temperatures. We also found little evidence of immunosenesce in any response. This study provides insight into the thermal preferences of sliders and provides an interesting connection between immunology, behavior, and ecology in this turtle.

P1.211 ZIMMERMAN, S*; CURRY ROGERS, K; Macalester College; *rogersk@macalester.edu*

Validity of Skeletochronology for Indicating Age and Growth in Egyptian Tortoise, Testudo kleinmanni

We assessed the accuracy of skeletochronology in the assessment of age and overall growth dynamics in a known−age skeleton of *Testudo kleinmanni* (Egyptian Tortoise). Skeletochronology is often utilized in the determination of the minimum age of an individual by enumerating the concentric growth rings within the cross section of a bone that record periodic slowing and/or cessation of growth. These lines of arrested growth (LAGs) are frequently utilized in age determination for fossil vertebrates including dinosaurs, for which other means of aging (e.g., cranial or vertebral suture, tooth replacement, body mass) are unavailable. However, little is understood about intraskeletal variation in LAG deposition and in other measures of growth rate (e.g., bone fiber organization, primary porosity, degree of remodeling). We analyzed a single zoo specimen that was euthanized at 15.0 years of age due to cancer. We sampled portions of the appendicular skeleton from the left side − femur, fibula, tibia, humerus, radius, and ulna. Skeletochronology and growth patterns among the six sampled elements are inconsistent. Some bones (e.g., femur) exhibit highly vascularized woven bone indicative of rapid growth, while others (e.g., tibia) are predominated by lamellar bone, indicative of slower growth. Secondary remodeling also varies, with some bones exhibiting high levels of remodeling (e.g., radius) while others (e.g., fibula) lack remodeling. Similarly, the number of LAGS varies among bones. The humerus and femur both record 4 LAGs, the tibia records 3 LAGs and the other elements record only 2 LAGs. None of the sampled bones accurately record the 15−year age of the specimen. Our results highlight the need for caution when applying skeletochronological methods, particularly among fossil taxa where only single elements are available to study.

115.3 ZINNA, RA*; MCCULLOUGH, EL; Washington State University, Pullman, University of Montana, Missoula; *Robert.Zinna@wsu.edu*

Sensilla Density Corresponds to the Regions of the Horn Most Frequently Used During Combat in the Giant Rhinoceros Beetle Trypoxylus dichotomus (Coleoptera: Scarabaeidae: Dynastinae)

In the giant rhinoceros beetle, *Trypoxylus dichotomus* (L.), males have a long forked head horn that they use in fights with other males over access to sap sites that attract females. Because of the high risk of injury from these contests, males should assess the fighting potential of their rivals before escalating to direct combat. Indeed, male rhinoceros beetles only escalate to intense fighting when matched with equal−sized rivals. Males often tap their opponents with their head horn before and during fights, so it is likely that beetles assess the size of their competitors via sensory input from their horns. Here, we used scanning electron microscopy to examine the density and distribution of sensory hairs along the length of the males' horn. To assess the potential functional significance of variation in hair density, we combined our microscopy observations with a behavioral analysis of how males use their horns during fights. We found a strong correlation between the density of sensory hairs and the regions of the horns that were used most during combat. The distal tips of the horns had the highest hair density, and were also the region of the horn most frequently in contact with an opponent. Given the shaft and socket morphology of these hairs, which is the characteristic morphology of mechanoreceptors, we expect that they provide mechanosensory input. Thus, although beetle horns are often described as dedicated weapons, our results suggest the head horns of *T. dichotomus* also play an important sensory role.

59.2 ZOHDY, S*; FRIED, I.R.; WRIGHT, P.C.; GILLESPIE, T.R.; Emory University, Stony Brook University; *sarah.zohdy@emory.edu*

Diarrheal Viruses in Humans and Lemurs in Madagascar: a One Health Approach

Diarrheal viruses are one of the most common causes of death in humans in developing nations; however, they have not yet been studied in lemurs, wild non−human primates (NHPs) endemic to the island of Madagascar. Over half of the pathogens listed as emerging in humans are viruses, and a majority of them have been isolated from wild NHPs. Due to a similar evolutionary history between human and NHPs, as well as the increasing proximity of human populations to shrinking NHP territories, an understanding of human and NHP disease has the potential to inform decision making for primate conservation and human health. In this study we screened human populations in rural villages near Ranomafana National Park, Madagascar and wild lemur populations in the rainforests that surround them for diarrheal viruses (Adenovirus, Enterovirus, Rotavirus, and Norovirus genogroups GI and GII). Fecal samples were voluntarily provided from human populations and non−invasively collected from lemurs in 2011 and 2012 (May−August). In both humans and lemurs Adenovirus was the most commonly exhibited virus found in 34% of human and 27.4% of lemur samples, followed by Enterovirus found in 9.6% of human and 20% of lemur samples. Further phylogenetic analysis of positive viral samples has the potential to reveal novel lemur adenoviruses, and zoonotic transmission events between humans and lemur species in Madagascar. Transmission of these viruses from humans to lemurs poses a serious conservation risk for these already endangered species, while transmission from lemurs to humans could become a serious public health risk.

78.1 ZYLBERBERG, M*; DERRYBERRY, EP; BREUNER, CW; MACDOUGALL−SHACKLETON, EA; CORNELIUS, JM; HAHN, TP; Univ. of California, Davis, Tulane University, University of Montana, University of Western Ontario; *xylberg@gmail.com*

Impacts of avian malaria and related parasites on lifetime reproductive success and survivorship of mountain white−crowned sparrows (Zonotrichia leucophrys oriantha)

Interactions between haematozoan parasites and their avian hosts are frequently used to model fundamental questions in ecology and evolution. However, the basic assumption that these parasites consistently reduce host fitness in the wild has yet to be conclusively addressed. To this end, we conducted a long−term study examining the relationship between naturally−occurring infection with *Haemoproteus* and *Plasmodium*, and lifetime reproductive success and survival of mountain white−crowned sparrows (*Zonotrichia leucophrys oriantha*). Specifically, we tested the hypothesis that birds infected with haematozoan parasites should have reduced survival and reproductive success (as determined by overwinter return rates and eggs laid, hatched, and nestlings fledged, respectively). We found no difference in lifetime reproductive success and survival of *Plasmodium* infected and uninfected individuals, or in *Haemoproteus* infected and uninfected males. Contrary to expectation, we found that *Haemoproteus*−infected females exhibited a trend towards increased annual reproductive success and had significantly higher overwinter return rates, with the result that these females fledged more than twice as many chicks during their lifetimes as did uninfected females. We discuss the impact of parasitic infections on host fitness in light of these findings and suggest that, in the case of less virulent pathogens, investment in excessive immune defense may decrease lifetime reproduction.

P3.109 ZOHDY, S.*; DERFUS, K. S.; MBOLATIANA, T. A.; WRIGHT, P. C.; GILLESPIE, T. R.; Emory University, University of Antananarivo, Stony Brook University; *sarah.zohdy@emory.edu*

Deforestation and Malaria: A Field Evaluation of a Synthetic Lure to Capture Mosquitoes in Madagascar

It is estimated that less than 6% of Madagascar's original forests remain intact. The common slash−and−burn agricultural (tavy) practices in Madagascar are accelerating the already devastating deforestation rates and threatening the endemic wildlife found on the island. The impact that this type of deforestation has on the environmental conditions could create enhanced environments for vectors of infectious disease, such as mosquitoes. To test this hypothesis, we surveyed mosquitoes in six villages and their surrounding agricultural sites and forests in and around Ranomafana National Park, Madagascar, while simultaneously evaluating a newly described synthetic attractant lure (Mukabana et al., 2012) to selectively capture malaria carrying mosquitoes (*Anopheles gambiae*.). This volatile (3−methyl−1−butanol) was originally isolated from human skin microbiota and was found to be one of the most attractive to *Anopheles gambiae*. When compared to non−odor baited light traps in the same habitats we found that the synthetic odor baited traps were more successful at capturing *Anopheles* mosquitoes in the forested and village sites, but not in the agricultural sites. In agricultural sites, traps set near livestock pens were more successful at capturing anopheline mosquitoes than the odor−baited attractant. In all habitat types the odor lure was more successful at capturing other mosquitoes with relevance to public health. Additionally, very few anopheline mosquitoes were captured in the forested areas in and around the national park, suggesting that increased deforestation activities and proximity to livestock may place humans at higher risk for malaria.