

P3.61 ADAMSKI, Alison V*; VILCHECK, Jeremy J; SURMACZ, Cynthia A; HRANITZ, John M; Bloomsburg University; csurmacz@bloomu.edu

Temperature-Induced Stress Responses in the Blackworm (*Lumbriculus variegatus*)

The aquatic worm *Lumbriculus variegatus* (blackworm) is an ideal candidate for toxicity testing and is being used increasingly to assess ecological risk. Blackworms are sensitive to sublethal doses of various toxins and display readily observable biological responses such as pulse rate and tactile responses. To better understand the relationship between environmental stress and biological responses in the blackworm, we seek to investigate whether or not a hormetic stress protein response predicts changes in physiological and behavioral responses by blackworms exposed to water pollutants. In this initial study, our objectives were to determine: 1) if blackworm HSP70 can be detected with commercially available antibody; 2) conditions that induce heat stress in blackworms (heat shock); and 3) an experimental design to detect changes in HSP70 concentrations in response to heat stress. Commercial anti-HSP70 detected a single 70 kD stress protein on Western blots after 10% SDS-PAGE. Two experiments described the temperature responses of blackworms. Based on tactile responses over a range of temperatures, blackworms acclimated to room temperature displayed bimodal critical thermal maxima (37.5 oC and 40.3oC). Worms exposed for three hours to temperatures ranging from 22oC to 39.5oC showed higher HSP70 concentrations at 34.5 oC ($p < 0.001$) compared to controls in ELISAs. These results show the potential for hormetic stress responses in *L. variegatus* and to further dissect relationships between physiological and behavioral responses and cellular stress proteins. Improved understanding of these relationships will assist aquatic biologists using blackworms as a bioindicator to more effectively predict sublethal population effects of pollutants in nature and to assess the health of aquatic ecosystems.

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Experience with photostimulation upregulates vasoactive intestinal polypeptide in the hypothalamus of female house finches

For many temperate breeding birds, reproductive output increases with age. Older birds tend to breed earlier and lay larger clutches than younger birds. Previous research suggests that first-year females that experience photostimulation for the second time upregulate several components of reproductive development more quickly or robustly than first-year females experiencing photostimulation for the first time. The hypothalamic neuropeptide vasoactive intestinal polypeptide (VIP) plays an important role in the photoperiodic regulation of avian reproductive development and behavior, principally by regulating pituitary secretion of prolactin (PRL). PRL increases in photostimulated birds and changes in PRL are correlated with different stages of the avian reproductive cycle. We tested whether prior experience with photostimulation influenced expression of hypothalamic VIP in the house finch (*Carpodacus mexicanus*). We predicted that VIP expression would be higher in first-year birds with prior photostimulation experience because early breeders would need elevated PRL levels earlier in the season. As predicted, first-year females with photostimulation experience had higher hypothalamic VIP immunoreactivity (VIP-ir) than first-year females that were experiencing photostimulation for the first time. Photostimulation experience did not influence VIP-ir in males, possibly because male house finches use other cues to time PRL release. These results suggest that VIP joins the list of reproductive factors that develop early or more robustly in females with photostimulation experience, which may explain the increase in reproductive output with age.

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Pectoral and forelimb muscle activity during landing in *Bufo marinus*

In toads, traversing a given distance is usually achieved by linking consecutive small hops together, which requires coordinated use of the forelimbs during each landing to rapidly decelerate the body and prepare the animal for the next hop. To better understand toad landing behavior we used high-speed video to characterize basic movements of hopping and implanted fine-wire electrodes into six muscles (two heads of the anconeus and pectoralis complexes as well as the deltoid and coracoradialis) to characterize their activity patterns in relation to locomotor kinematics. We divided hops into four phases. Takeoff phase one lasted from the onset of movement to when the forelimbs left the ground. Most muscles were quiescent in this interval except the anconeus, which occasionally exhibited small bursts associated with the onset of animal movement. Takeoff phase two was the time between when the forelimbs and hindlimbs left the ground. EMG activity typically began in all muscles during this phase. In the aerial phase, all but one of the muscles had their highest average EMG intensities. The exception was the long head of the anconeus, which was most intensely recruited in the landing phase, between forelimb and hindlimb touchdown during landing. All muscles are clearly important in resisting the impact forces when the forelimbs hit the ground, however, subtle differences in activity profiles suggest some degree of functional differentiation. For example, the coracoradialis and deltoid showed relatively high levels of recruitment in takeoff phase two implying a particularly important role in moving and positioning the forelimbs before landing whereas the long head of the anconeus had its highest recruitment after forelimb touchdown indicating a critical role in stabilizing the body during the landing phase.

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Radio controlled stimulation of abdominal flexion in *Manduca sexta* affects the flight path.

Control of flight in insects involves multiple actuators including wings, legs and the abdomen. While wing motions are thought to dominate flight forces, relatively little attention has been given to the role of abdominal motions in flight control – either as a rudder or way of shifting the center of mass relative to the center of lift. To understand the potential role of abdominal flexion in flight control, prior studies have focused on either tethered preparations or on observations of natural abdominal motions during flight maneuvers. Recent advances in radio technology, along with the development of stimulation methods for the ventral nerve cord of *Manduca sexta* permit remote control of abdominal motions and, thus, provide direct tests of the potential role of the abdominal motions determining flight trajectories. We used a microPIC controller combined with an ultra-miniature radio receiver mounted on the animal to deliver pulse-width modulated, bipolar stimulation (100 Hz, duty cycle 50%, $\pm 2.5 - 3V$) to freely flying moths. We stimulated the ventral nerve cord in three separate animals, placing tungsten electrodes in the connective between the last thoracic ganglion and the first abdominal ganglion in each case. All three animals showed a pitch upwards in response to that stimulation and resulting abdominal flexion. These results demonstrate that we can elicit abdominal movement remotely in freely-flying animals, and further indicate that such abdominal flexion can indeed affect the flight path.

P1.84 AMIEL, A.*; SEAVER, E.C.; Kewalo Marine Laboratory, Honolulu, Hawaii, USA; aamiel@hawaii.edu
Evolution of the Wnt pathway, insights from the annelid *Capitella teleta*

The Wnt pathway is crucial for orchestrating a number of events during metazoan embryogenesis, from early cleavage stages to tissue differentiation. Wnt genes are well conserved from cnidarians to vertebrates, and it is likely that they have important conserved developmental roles. The complexity of the Wnt pathway leaves a number of unresolved questions and current models are insufficient to explain the complex responses often observed in developing organisms. Within spiralian, investigations of the role of the intracellular mediator of the canonical Wnt pathway, β -catenin, have revealed substantial species-specific differences during early development. For example, in the nemertean *Cerebratulus*, β -catenin functions as an important factor in determining vegetal embryonic fates, and later in tissue layer formation. In contrast, in the annelid *Platynereis*, β -catenin functions in binary cell fate specification. In this study, we focus on *Capitella teleta*, a well-suited polychaete model to study developmental biology. Compared to some other protostomes, lophotrochozoan genomes appear to have retained a large complement of wnt gene subfamilies. In the *C. teleta* genome, there are 12 Wnt ligands, representing 12 of the 13 established subfamilies. Expression analysis of 5 Wnt ligands reveals distinct patterns during larval stages, suggesting diverse roles for each Wnt gene. We are currently focusing on characterizing expression and roles of the Wnt pathway members during early cleavage stages to understand the integration of signaling pathways during early development, which is generally not well understood in spiralian. Our results contribute to an understanding of the variation of early developmental roles of this signaling pathway has in different spiralian species.

P3.26 ANDERSON, R.A.; HOUSMAN, M.L.*; GRANT, L.J.; Western Washington University; Roger.Anderson@wwu.edu
The role of running in predation and antipredation by the leopard lizard, *Gambelia wislizenii*

The long-nosed leopard lizard, *Gambelia wislizenii*, as a mesocarnivore, is a predator on highly mobile insects and lizards and is potential prey for raptors and snakes. We sought to determine how leopard lizards use running to evade predators and pursue prey. We expected that anti-predatory responses of *Gambelia wislizenii* would depend on the type of predator, the type and speed of approach, and in which microhabitat. We measured velocities and distances run by *G. wislizenii* when they were chased in unrestricted field conditions and in raceways by "predators." We compared these speeds to those of *G. wislizenii* attempting to capture grasshoppers and model prey in unrestricted field conditions, and to the evasion speeds of the western whiptail lizards, *Aspidoscelis tigris*. Lizards were relatively unwary when approached by walking humans, and usually did not "evade" until approached within 1 m. Lizards chased by running humans entered larger and more foliage-laden shrubs and commonly ran along the perimeter of a shrub and out of sight before entering the shrub cover. Lizards usually sought refuge under the nearest shrub when approached by an ersatz aerial "predator." Pursuits after grasshoppers were quadrupedal, at less than 3m/sec, and often included leaping pursuits. Evasions in raceways sometimes were bipedal, at over 4m/sec, at the speeds required to capture *Aspidoscelis tigris*. Western whiptails tended to be faster than *G. wislizenii*, but whiptails simply may have been more motivated to sprint. The only obvious predators of *G. wislizenii* appear to be snakes, which are relatively slow pursuers. Hence, we infer that the sprinting ability in *G. wislizenii* is needed for prey capture and not antipredation.

P2.95 ANADOR, S.*; BROWN, C.; LICORISH, R.; CILLI, N.; FLEMING, R.; CARROLL, M.A.; CATAPANE, E.J.; Medgar Evers College, Brooklyn; catapane@mec.cuny.edu

Pharmacological and Immunofluorescence Identification of Dopamine D2 Receptors in the Lateral Ciliated Cells of the Gill of the Bivalve Mollusc *Crassostrea virginica*
 Lateral cell cilia of gill of *Crassostrea virginica* are controlled dopamine (DA) and serotonin (HT) nerves originating from the cerebral and visceral ganglia. DA slows down beating of lateral cilia and serotonin accelerates them. We undertook a pharmacological and immunofluorescence study of DA receptors. DA receptors are classified as D1-like and D2-like, each with subtypes. D1-like are coupled to G protein $G_{\alpha s}$ and activates adenylate cyclase. D2-like are coupled to the G protein $G_{\alpha i}$, and inhibits formation of cAMP by inhibiting adenylate cyclase. Beating of cilia were measured by stroboscopic microscopy. D1 and D2 agonists and antagonists were applied to gill to determine their efficacy in altering beating. D2 agonist were effective in mimicking DA, and D2 antagonists were effective in blocking the actions of DA. D1 agonist and antagonist did not alter the beating of the cilia nor block the effects of DA. We further examined the receptor by using a primary antibody against D2 receptors followed by an FITC linked secondary antibody to visualize them. Gill was exposed to antibodies and prepared for light microscope. Control sections without primary antibody exposure were similarly treated and viewed. Antibody treated sections showed bright FITC fluorescence in the lateral ciliated cells and other areas of gill. Control sections did not. The study shows postsynaptic DA receptors involved in the cilio-inhibitory response of the lateral cells of gill are D2 type. The study also shows this preparation is a good model for pharmacological studies of DA function as well as the pharmacology of drugs affecting biogenic amines. This work was supported by grants 2R25GM0600305 of NIGMS, 0516041071 of NYSDOE, 0622197 of NSF and P382A080040 of the USDE.

P2.126 ANDRIEUX, S.J.*; CHESTER, E.M.; DEMAS, G.E.; SUNY College at Old Westbury, Indiana University; sybandrew@yahoo.com

Prenatal Social Stress Affects Siberian Hamster (*Phodopus sungorus*) Offspring Social Behavior and Physiology

The in utero environment can exert profound influences on both mother and offspring, resulting in modified adult offspring physiology and behavior. The present study examined the effects of social stress on physiology and behavior in both mothers and adult offspring. We hypothesized that prenatal animals exposed to social stress would display increased behavioral (i.e., aggression, submission) and endocrine responsiveness, while suppressing immune activity. To test this, pregnant hamsters received either social interactions or a handling control. Social interactions involved placing an animal in a resident's home cage for five minutes for the last six nights of gestation. Control hamsters were placed in soiled resident cages for the same time. We monitored the mother's agonistic behavior (e.g., submission, grooming and attacks) as well as maternal behaviors and pup growth. We also tested the agonistic behavior of adult offspring, and measured serum cortisol and innate immunity. Social stress did not affect maternal behavior or pup growth. Prolonged prenatal social stress, however, affected submissive behavior toward a same sex conspecific in adult female offspring while male offspring were not affected. Grooming, number of attacks and serum cortisol levels were not significantly different between groups. These results suggest that prenatal social interactions can exert profound effects on offspring behavior that can persist into adulthood. Further, this study aids in our understanding about the effects of maternal environment on the immune and endocrine systems and behavior of both mother and offspring in hamsters and likely other species.

P2.29 ANDRILENAS, KK*; MOROZ, L; University of Washington, Seattle, Whitney Laboratory for Marine Biosciences, University of Florida, St. Augustine; andrik@u.washington.edu

The Neurogenic Effect of Injury and Regeneration in Ctenophores

Studying how nervous systems evolved requires a broad investigation of many phyla. Ctenophores, one of the most basal organisms (Dunn, 2008), are an under researched group of organisms. The signaling molecules used by their neurons have yet to be documented, and few immunohistochemistry (IHC) experiments have been done. In the ctenophores *Bolinopsis infundibulum* and *Pleurobrachia bachei*, anti-FMRFamide IHC labels injury induced neurogenesis. Ctenophores were collected at Friday Harbor Labs, Friday Harbor, WA and kept in sea tables at local sea temperature. Ctenophores were dissected and the tissue was allowed to regenerate with culture times from first incision to fixation. *B. infundibulum* and *P. bachei* tissue was cultured for 0-3, 6, 24, and 72 hours with longer cultures for *B. infundibulum*. Tissue was then fixed and stained using anti-FMRFamide IHC protocols developed for the ctenophores. Neuron density and nerve net organization increased with the length of culture time. Preliminary data in *P. bachei* suggests they have a slower regeneration time. *B. infundibulum* has an amazing regenerative capacity and regenerates a robust neural network in 72 to 96 hours. An assessment of *B. infundibulum* apical organ regeneration was done and it takes only four days to regrow the statocyst, but more time is required for regeneration of the aboral canals. The labeling of a FMRFamide-like compound in post-injury neurogenesis suggests it may be a signaling molecule involved in regeneration. Moroz (in press) suggests that recruitment of damage related secretory pathways may have been an avenue for the evolution of neurons. Further research may reveal whether exogenous FMRFamide-like compound can induce neurogenesis.

P1.10 AQUILINA-BECK, ALLISAN; MACDONALD, CARYN*; KAVANAUGH, SCOTT I.; SOWER, STACIA A.; University of New Hampshire, Durham, University of New Hampshire Durham; sasower@cisunix.unh.edu

Identification of Two Novel Type-II GnRH Receptors in the Sea Lamprey, a Basal Vertebrate

Gonadotropin-releasing hormone (GnRH) is a central regulator of reproductive function in vertebrates, and its function is mediated through a GnRH receptor (GnRHR), a class A 7-transmembrane GPCR. Previously, we identified a unique lamprey GnRH receptor (IGnRH-1) that shares several characteristics of both type-I and type-II vertebrate GnRH receptors (Silver et al., 2005). In this study, we have identified two additional novel GnRH receptors (IGnRHR-2 and -3) in the sea lamprey, a basal vertebrate via the trace files produced by the Genome Sequencing Center at Washington University School of Medicine, St. Louis. Lamprey GnRHR-2 was shown to activate the inositol phosphate (IP system): stimulation with either IGnRH-II or -III led to dose dependent responses in transiently transfected COS7 cells. However, there was no IP response of the transfected GnRHR-2 receptor when treated with IGnRH-I. The cloned receptors retain the conserved structural features and amino acid motifs of other known GnRH receptors and both receptors include a C-terminal tail. The phylogenetic placement, structural and functional features of the lamprey GnRH receptors support that these receptors have retained key ancestral residues and motifs. Further comparative studies on the lamprey GnRHs and respective receptors will help provide clues on the evolution of reproductive mechanisms and insights into our understanding of gene duplication, structure-activity relations, and the molecular evolution and functional diversity of these systems. Supported by NSF IBN-0421923, IOS-0849569, NSF REU Supplement, NH AES Hatch 332 and NIH 5R21RR024477-02 to SAS.

P2.55 ANSON, JA; University of Hawaii; jorg@hawaii.edu
Recruitment Sensitivity to Contaminated Substrata in Larvae of Coral Species: *Montipora capitata* and *Porites hawaiiensis*

The continued decline in coral populations is a concern in coral reef ecosystems throughout the Pacific region. As anthropogenic stressors increase globally, understanding the population dynamics and larval ecology of corals is central to developing management responses. Recruitment bioassays were performed by exposing planula larvae to substrata contaminated with copper, a common metal in the marine environment. Slides conditioned with biofilms and crustose coralline algae were exposed in various copper treatments for 2-3 days. Recruitment bioassays using the contaminated substrata tested responses in larvae of two coral species, *Montipora capitata* and *Porites hawaiiensis*. Settlement success was scored over 7 and 5 days, respectively. Copper exposure altered settlement success in both species. Larvae of *M. capitata* were more sensitive to copper exposure than those of *P. hawaiiensis*. A stress response was observed in recruitment assays in *M. capitata* in which settlement occurred earlier in high copper treatments. The settled larvae of subsequently bleached in less than 48hrs following exposure. Copper inhibited settlement in both species but a greater settlement success was observed in the *P. hawaiiensis* bioassay. Both coral species demonstrated larval sensitivity to substratum quality, indicating the importance of this parameter to the early life-history stages of corals and therefore broadening our knowledge on larval ecology for sound policy development and implementation purposes throughout Pacific island nations.

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Genetic Differentiation, Range Expansion, and Loss of Allelic Diversity Within the Western Fence Lizard (*Sceloporus occidentalis*) in the Basin and Range Province

The western fence lizard is distributed throughout the Basin and Range Province of western North America (800km X 500km) at intermediate elevations in isolated and semi-isolated mountain ranges. Based on a phylogenetic analysis of mtDNA variation, four distinct clades are present with > 5% sequence divergence between them. Two of these clades (central and western) exhibit extremely low levels of variability, consistent with a post-Pleistocene range expansion. Based on the degree of mtDNA differentiation within and between the clades, we predicted significant nuclear genetic differentiation between clades and a loss of allelic diversity progressing from south to north in two of them. We analyzed the geographical distribution of mtDNA clade variants using clade specific RFLP patterns and patterns of nuclear genetic differentiation and diversity using six microsatellite loci in populations sampled throughout the region. Overlap of mtDNA clades in the region was minimal; only isolated intergrade populations were found. Contrary to our hypothesis, we found a lack of genetic differentiation at microsatellite loci between adjacent mtDNA clades consistent with high levels of gene flow. However, we found significant genetic variation as follows: 1) southern clade populations were differentiated from others clades, 2) an isolation by distance effect within central and western clades (but not the others), and 3) a loss of allelic diversity from south to north in the central and western clades. The results support the hypothesis of northward range expansion of within two clades associated with post-Pleistocene climate changes. These are consistent with low levels of mtDNA variation found within the Central and Western clades, but not the Eastern or Southern.

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Molecular and morphological systematics of the precious corals (Cnidaria: Octocorallia: Coralliidae)

The intricate evolution of precious corals' axial characters and the monophyly of Coralliidae's genera (*Corallium* Cuvier and *Paracorallium* Bayer and Cairns) are unanswered aspects of the octocoral phylogeny. The diversity of colonial forms among the various species of coralliids corresponds to the diversity in shape of the supporting axis. The surface of the axis may be smooth, or distinctly marked by narrow longitudinal grooves underlying the coenenchymal canals or in some species additional pits are present. However, Coralliidae phylogenetic relationships are unknown and their taxonomic affinities are confusing. In order to fulfill the information gap about this family, material of the genus *Corallium* and *Paracorallium* from New Zealand, Taiwan and elsewhere in the Pacific and Atlantic oceans was revised. The phylogenetic hypotheses using ITS2 sequences and their secondary structures showed two strongly supported clades (using *Paragorgia* as outgroup). The *Corallium* clade included *C. ducale*, *C. regale* and unidentified species from New Zealand with smooth axis and short cylindrical calyces. The "*Paracorallium*" clade comprised species with the axis marked by narrow longitudinal grooves and some species with pits, such as *P. thrinax*, *P. tortuosum* and *P. inutile* but *Corallium rubrum*, the type species of the genus, together with *C. niveum* and *C. kishinouyei* were also members of "*Paracorallium*" clade. In contrast, 16S rRNA hypothesis showed discordance in the resolution of the clades. These phylogenetic results are an important step towards understanding the evolution of morphological features in Coralliidae towards a natural taxonomy of the groups. Although, it is essential to add other mitochondrial and nuclear sequences and to include the remaining species of the group.

P1.61 ARMFIELD, Brooke A. *; THEWISSEN, J.G.M.; VINYARD, Christopher J.; Department of Anatomy and Neurobiology, Northeastern Ohio Universities Colleges of Medicine and Kent State Biomedical Science; Rootstown, Ohio. ; bgarner@kent.edu

Protein expression of genes that may be involved in initiating and developing the secondary dentition in mammals

Limited tooth replacement is a defining trait of mammals, however, very little is known about the genetic pathways involved in the development of a second generation of teeth. Mice, the mammalian model for genetic studies, only have a single generation of tooth development and, therefore, researchers have not been able to determine the signals that initiate and generate the morphology of the second dentition in mammals. We examine *Sus scrofa* as a model for mammalian secondary tooth development. Pig embryos were chosen because they replace all their teeth (excluding their adult molars) and staged embryos are relatively easy to obtain. To explore gene expression patterns during formation of the second generation, we looked at an array of genes (*Bmp4*, *Fgf8*, *Fgf4* *Shh*, *Pax9*, *Msx1* and β -catenin) involved in primary tooth development or hypothesized to be involved in mammalian tooth replacement. Immunohistochemistry was used to define areas of protein expression during several stages of pig tooth development (gestation days 24-65). We found that several of the genes known to influence the first dentition, such as *Bmp4*, *Fgf8* and *Shh*, were present in the oral and dental epithelium during secondary tooth formation. We are currently investigating if their expression and that of β -catenin, a gene associated with inducing supernumerary tooth development, differ from patterns observed in mice. Given the functional and phylogenetic significance of the second generation of mammalian teeth, these results will contribute to our understanding of mammalian life history and evolution.

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Resolving the relationship among *Lamprophis lineatus* populations from the islands of São Tomé and Príncipe

The lined house snake (*Lamprophis lineatus* Duméril, Birbon, and Duméril, 1854) is common in western Africa, including the islands São Tomé and Príncipe in the Gulf of Guinea. The populations of *L. lineatus* on São Tomé and Príncipe have always been considered the same species. However, differences in aspect lead us to hypothesize that the form on Príncipe and the one on São Tomé actually represent separate species and demand further investigation. Morphological measurements (i.e scale counts) do not reveal any significant differences between the two forms. However, coloration and pattern are clearly different. Cytochrome B analysis appears to support our hypothesis and indeed each island population clades separately. Future work with a nuclear gene and analysis of tissues from mainland specimens may further clarify the relationship among the *L. lineatus* populations of São Tomé and Príncipe.

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The impact of incubation environmental stress on the Angiotensin II receptor density in tissues of embryonic American alligators (*Alligator mississippiensis*)

Embryonic reptiles are unique among vertebrates due to the virtual absence of parental care following oviposition in most species and the relatively high eggshell permeability in comparison to birds. Typically, reptile eggs develop in a nest that is either subterranean or in a mound structure in which the surrounding media can vary in abiotic stress. Nests of the American alligator (*A mississippiensis*) are subjected to a variety of conditions due to nest structure, periods of drought, as well as flooding conditions. These bouts of developmental stress have the capacity to alter gene expression and ultimately both physiological and morphological maturation of organs systems. While this is intuitive the impact of embryonic stress on the gene expression is largely a mystery. Therefore this study was undertaken to determine if Angiotensin II (Ang II) receptor density, a key CV regulatory component, is altered by developmental challenges in embryonic alligators. Acute dehydration, chronic hypoxic and temperature oscillation were used as stressors and Ang II receptor density was determined at 70% and 90% of incubation in the heart, lung, CAM and liver. Receptor density in the heart was highest in early development relative to the loading control. At 90% receptor density was highest in lung tissue relative to the loading control. Dehydration stress increased receptor density in heart tissue at 90% of incubation with little affects of the remaining stressors. The data indicate that this receptor exhibits marked plasticity during embryonic development and during periods of stress. Supported by NSF Career award IBN IOS-0845741 to DAC.

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Changes in Genetic Variation of Energy Metabolism and Life History Traits between Sexual and Asexual Phases of a Clonal Organism.

Cyclically parthenogenetic animals (i.e. that alternate sexual and asexual reproduction during its life cycle), such as aphids, represent a good model for studying the short-term evolutionary consequences of sex. In aphids, the sexual phase is induced by unfavorable environmental conditions, producing sexual forms (e.g. males and sexual females) besides parthenogenetic females. Moreover, both sexual as asexual forms can produce wingless and/or winged individuals associated to specific environmental cues. The production of these morphs could determine a differential investment between the two phases, which can also be traduced in trade-offs with other life-history traits. In this study we studied the quantitative genetic of life-history traits (age at maturity, total fecundity, number of winged and wingless forms, and males and sexual females) and energy metabolism (standard metabolic rate, SMR) in eight genotypes of the pea aphid *Acyrtosiphon pisum*, during both the sexual and asexual phase. We found larger and significant broad-sense heritability (H^2) for age at maturity, number of winged and wingless individuals, and SMR during the sexual phase. Moreover, H^2 of the males and sexual females was also significant. The differences in the genetic variation of the SMR between sexual and asexual phases would indicate that exist energy costs expressed only during sexuality, which could be associated to the sexual morphs production. On the other hand, the G x E interaction found in almost all traits indicate that the genotypes would respond independently to the selection in each phase. Acknowledgement: FONDECYT project (3080051), ANILLO project (ACT-38).

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Imperfect Detection, Lag Times and the Evolution of Phenotypic Plasticity

Several theoretical models of phenotypic plasticity have incorporated a lag time between detecting an environmental change and employing a new phenotypic state. In Padilla and Adolph's (1996) model, phenotypic plasticity can be disadvantageous if lag times are longer than a critical value. Other authors have suggested that imperfect detection of environmental change could likewise reduce the adaptive advantage of plasticity. Here, we extend the lag time model to include imperfect detection of the environment. We assume that organisms identify each of two environmental states with probabilities less than one; these probabilities may differ for the two environmental states. The effect of imperfect detection depends strongly on the relative frequencies of the two environments. Unequal occurrence of the two environments causes an asymmetry in the relative importance of detection accuracy in those two environments. Specifically, imperfect detection of the more common environment markedly reduces the critical lag time, narrowing the range of conditions under which plasticity would be adaptive. On the other hand, imperfect detection of the less common environment has a relatively weak effect, and can actually be slightly beneficial for individuals whose induction lag times are longer than the critical lag time.

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Effects of delayed hatching on energy reserves and survival of the California grunion, *Leuresthes tenuis*

The California grunion has the unique ability to both spawn terrestrially and extend embryonic incubation in the sand beyond the initial hatching period of 9-14 days post-fertilization (dpf). Maternally supplied proteins and lipids provide energy for embryonic development and may play a role in larval survival. Previous studies showed a linear decline in oil droplet size with time post-fertilization in grunion embryos, but how energy reserves change during extended incubation is not known. We quantified changes in both yolk and lipid as a result of delayed hatching in *L. tenuis*, and tested if delayed hatching results in reduced post-hatching survival. We measured yolk surface area, larval lipid content, and time to 50% mortality when starved, in larvae hatched after initial incubation (10 dpf) and extended incubation (28 dpf) at 20°C. We also measured notochord lengths (NL) of larvae from 8 batches of eggs, each from an individual female fertilized by sperm from one male. NL was significantly higher in 28-dpf larvae than in 10-dpf larvae from 3 of 8 batches, significantly lower in 2 of 8, and did not differ significantly in the other 3. This suggests maternal effects, which we plan to investigate in future studies. Yolk and lipid content were significantly lower in the 28-dpf larvae from all but one batch studied, and survival time was significantly reduced in 28-dpf larvae. Thus, because of reduced energy reserves and increased mortality when starved, larvae that must delay hatching are at a disadvantage when competing with those that do not. Future experiments will test if additional development during extended incubation results in increased swimming performance that may offset these negative effects.

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Cadmium exposure affects metabolic responses to acute temperature rise in eastern oysters *Crassostrea virginica*

Cadmium (Cd) and elevated temperatures are common stressors in estuarine environments affecting intertidal mollusks such as oysters. Sublethal Cd exposure raises metabolic demand of oysters, that (according to the concept of oxygen-limited thermal tolerance) can lead to a downward shift of the critical temperature of aerobic metabolism and restrict thermal tolerance limits of the organism. We tested this hypothesis by determining the onset of anaerobic metabolism, changes in the cellular energy budget and the extent of oxidative damage during acute temperature rise (from 20°C to 36°C) in eastern oysters *Crassostrea virginica* under control conditions and Cd exposure (50 µg Cd L⁻¹ for 30 days). In control oysters, levels of anaerobic end products (L-alanine, acetate and succinate) increased at 24 °C and above suggesting the critical temperature (T_c) of ca. 24 °C. In contrast, in Cd exposed oysters there was no accumulation of anaerobic end products during acute warming despite tissue hypoxemia indicating that Cd inhibits anaerobic pathways. There was a significant transient increase in ATP levels 24°C in control but not in Cd-exposed oysters; however, ATP levels were not significantly depleted even at the highest tested temperature (36°C) in either group. Elevated temperature elicited an increase of oxidative damage to proteins, which was similar in control and Cd-exposed groups, whereas lipid peroxidation was not affected by temperature or Cd. These data suggest that Cd exposure may delay or prevent the temperature-induced transition to anaerobiosis in oysters that may have important implications for determining T_c and for tolerance to the environmental conditions where survival solely depends on anaerobic metabolism (e.g. during oxygen deprivation). Supported by NSF and UNC Charlotte.

P1.101 BAKKEN, G.S.*; COLAYORI, S.E.; DUONG, T; Indiana State University, Indiana University School of Medicine; gbakken@indstate.edu

Optical characteristics of the facial pit of 4 pitviper species from different habitats

The facial pit of pitvipers is a flask-shaped cavity divided into two chambers by a membrane covered with warm receptors. Both the pinhole camera-like anatomy and neurophysiological studies indicate a thermal imaging function. While neural image reconstruction may improve the final image, geometry indicates that the temperature contrast images formed on the membrane by thermal radiation have poor angular resolution. Thus, there is considerable uncertainty as to what a snake can 'see' with this organ. Here we report membrane-temperature-contrast images of typical laboratory and outdoor scenes computed by applying first-principle optical and heat transfer models to the facial pit anatomy of 4 pitviper species, *Trimereseurus albolabis* (typical habitat moist tropical forest and bamboo), *Crotalus atrox* (arid grassland and scrub), *C. o. oreganus* (dry woodland), and *C. horridus atricaudatus* (temperate deciduous forest). Our results show that optical spread functions (the distribution of radiation from a source point over the image plane) vary greatly over the pit membrane and among species. This presents a challenge to neural image reconstruction. The nature of interspecific variation suggests facial pit anatomy might be functionally related to ecological factors. Our images indicate published behavioral observations are best explained by assuming membrane receptors are significantly more sensitive than is commonly believed. Our results also show that if body and average environmental temperatures differ significantly, background membrane temperature variation may exceed the reported dynamic range of the sensory endings. Thus, the facial pit system presents many challenges that may lead to significant advances in sensory physiology and perhaps new approaches to computational image reconstruction.

P3.29 BARTHELL, John F.*; CLEMENT, Meredith L.; GIANNONI, Manuel A.; LIU, Lucy; PRESKY, Miyeon E.; REDD, JeAnna R.; RICCI, Paige R.; STEVISON, Blake K.; FREEMAN, Brett; PETANIDOU, Theodora; HRANITZ, John M.; WELLS, Harrington; University of Central Oklahoma, University of Puerto Rico, University of North Carolina, Chapel Hill, SUNY College at Oneonta, Bloomsburg University of Pennsylvania, Oklahoma State University, University of Central Oklahoma, University of the Aegean, University of Tulsa; jbarthell@uco.edu

Differing foraging responses by bees to the invasive thistle species *Centaurea solstitialis* L. in native (Greece) and non-native (USA) island ecosystems

The honey bee (*Apis mellifera* L.) is among the most successful of terrestrial, multicellular invaders on the planet. As mutualists, honey bees also promote non-native plant species, including the noxious weed yellow star-thistle (*Centaurea solstitialis* L.), an invasive plant species that is common in the western USA. Honey bees and yellow star-thistle have not been studied from a biogeographic perspective as a means to understand their role as biological invaders. We have now done so in two island ecosystems: 1) the Northeast Aegean Island, Lesvos (Greece), where these species are native, and 2) Santa Cruz Island, California (USA), where honey bees and yellow star-thistle have been co-invasive species. We report herein on studies of foraging patterns of honey bees and solitary bees on Lesvos with reference to parallel studies on Santa Cruz Island (SCI). Our results show that yellow star-thistle is generally less attractive to honey bees on Lesvos relative to SCI, especially when in proximity to the competing flowering plant species *Vitex agnus castus* L. As shown in pairwise studies at these locales, yellow star-thistle is very effective in drawing bees from native plants in California but not so with honey bees in its native range in Greece. Our results therefore suggest that yellow star-thistle more effectively increased its range in California in the presence of honey bees and in the absence of natural enemies.

P2.5 BARNARD, M.E.*; STRANDBURG-PESHKIN, A.R.; YARETT, I.R.; MERZ, R.A.; Swarthmore College; mbarnar1@swarthmore.edu

The blue streak in *Uca pugnax*: fast, bright, and beautiful - but does it mean anything?

In fiddler crabs (*Uca* sp.), a male uses his display claw to signal his potential reproductive fitness to females and to threaten and fight with other males. In our study we explored whether the blue streak, a color bar located on the anterior carapace of both sexes of *Uca pugnax*, serves as another signaling device. *Uca* sp. are sensitive to the color blue and the streak is located in a position visible to interactive conspecifics. The presence of the blue streak is positively associated with two known sexually selected traits in males, claw length and carapace size, and it only appears as the crabs reach sexual maturity. Unlike claw length and carapace size, however, the color of the blue streak is dynamic and can vacillate between bright blue and nearly black in as little as 5 minutes. Laboratory experiments indicate that light but not temperature can mediate this response. When crabs displaying blue streaks in the daylight were moved into the dark but kept at constant temperature (31° C) they began to darken within 3 minutes and became nearly black in less than 12 minutes. Crabs exposed to a 10° C change in temperature (31 - 21° C) had no significant change in color when light was kept constant. In the field, the blue streak varies with the behavior of the crab; it is significantly brighter and bluer when the crabs are foraging away from their burrows or fighting and darker during waving displays or while the crabs are basking. The rapid changes in streak color in response to both abiotic and biotic factors strongly suggest the possibility that the blue streak could be used as a signaling mechanism in *U. pugnax*.

P2.117 BASIL, Jennifer*; CROOK, Robyn; GRASSO, Frank; Department of Biology, Brooklyn College, CUNY, Brooklyn NY, Department of Integrative Biology and Pharmacology, University of Texas Medical School, Houston, TX, BioMimetic and Cognitive Robotics Laboratory, Brooklyn College, CUNY, Brooklyn NY; fwgrasso@gmail.com

The evolution of flexible behavioral repertoires in cephalopod molluscs

Cephalopods are a large and ancient group of marine animals with a complex brain organization that supports a diversity of sophisticated and adaptive behaviors. Forms extant today are equipped with brains, sensors, and effectors that allow them not to just exist beside modern vertebrates as predators and prey; they also compete with marine vertebrates at every scale --- from small crustaceans to sperm whales. We discuss the evolution of the cephalopod nervous system, their learning capabilities, and their complex behavior. We also review recent evidence of learning and memory in chambered nautilus, considered to be plesiomorphic among cephalopods. While competition with bony fishes has left a deep impression on the brains and behavior of modern cephalopods, the original re-organization of their complex brains from their molluscan ancestors may have been forged in ancient seas, millions of years before the advent of bony fishes.

P1.19 BASTEA, L.*; WALKER, L.; VIRGILIO, A.; BRIX, KV; WADA, RH; WESSELS, F; HAHN, DA; HATLE, JD; Univ. of North Florida, Univ. of Miami FL, Univ. of Florida; jhatle@unf.edu
Mild life extension and reduced reproductive output in female flesh flies on dietary protein restriction

Dietary restriction (DR) extends lifespan in most organisms, usually while reducing reproduction. Fruit flies are widely used for aging research and eat yeast to obtain both protein and carbohydrate. In contrast, lab flesh flies obtain protein and carbohydrate separately, from liver and sugar respectively. Hence, flesh flies may be useful to distinguish between the roles of these two nutrients in DR. We tested various frequencies of protein availability on lifespan in flesh flies offered continuous sugar. Liver every 2nd, 3rd, 4th, or 5th day all significantly extended lifespan (Kaplan-Meier test; all $P < 0.05$), but the increase in median life span for these treatments was only $10.7 \pm 3.5\%$ over controls (fed liver continuously). Further, the percentages of life extension (median survival of DR cages / median survival of control cages) had 95% Confidence Intervals that overlapped zero, with one exception; flies on every 2nd day liver had weak but significant life extension (95% CI = 22.6-0.6%). Offering liver less frequently (i.e., every 6th, 9th, or 12th day) resulted in mass mortality after feeding, which likely was not due to senescence. Flies that were offered only sugar had moderate life extension (95% CI = 29.8-9.4%). In comparison, life extension in fruit flies on DR is ~50%. Similar to the mild life extension upon liver restriction, lifetime fecundity (73% of controls; $P < 0.0001$) and oocyte growth ($P = 0.009$ at day 5) were slightly but significantly reduced. In contrast to liver restriction, offering sugar every other day (but constant liver) reduced life span 30%. These data suggest that restriction of dietary protein can reduce reproduction and perhaps extend lifespan in flesh flies, but only slightly.

P1.91 BENOWITZ-FREDERICKS, M.*; LI, W. W.; KITAYSKY, A. S.; Bucknell University, University of Alaska Fairbanks; zmbf001@bucknell.edu

Effects of dietary restriction on the development of avian endocrine axes: Hormone receptor mRNA expression and response to GnRH challenges by captive rhinoceros auklet chicks (*Cerorhinca monocerata*)

Food availability during chick-rearing can be highly variable for seabirds. Chicks often experience food shortages, and the morphological and endocrine consequences of food restriction (particularly growth rates and circulating glucocorticoids) have been well documented in free-living and captive chicks. In this study, we assessed the effects of post-hatch food restriction on the expression of hormone receptor mRNA (androgen receptor, glucocorticoid receptor, and IGF-1 receptor) in brain and muscle, and on the response to GnRH challenges in captive rhinoceros auklets (*Cerorhinca monocerata*). Food restriction did not affect receptor mRNA expression, but it generated a larger increase in estradiol in response to handling (independent of GnRH treatment). mRNA expression was better explained by size and mass at hatching than treatment, suggesting that these aspects of endocrine physiology are determined prior to hatching, and not affected by post-hatching food intake

P2.93 BATEMAN, J. L.*; HEALY, J. E.; FLORANT, G. L.; HANDE, R. J.; Colorado State University, University of Arizona College of Medicine, Phoenix; jlbatemala@rams.colostate.edu
Investigation of seasonal AMP-activated protein kinase expression in golden-mantled ground squirrels (*Spermophilus lateralis*)

AMP-activated protein kinase (AMPK) is activated in response to high levels of AMP in a cell. Consequently, AMPK initiates catabolic and inhibits anabolic pathways. It is also implicated in the food intake pathway since increased AMPK activity leads to changes in hypothalamic arcuate (ARC) neuron activity. The golden-mantled ground squirrel is a mammalian hibernator which goes into torpor throughout the winter months. During this time, food intake is suppressed. Since AMPK plays a strong role in food intake regulation, it may also be important in food intake suppression during hibernation. We investigated whether AMPK expression in the ARC differs between the summer 3-day fasted and summer fed states using immunohistochemistry (IHC). We hypothesized that neurons of summer 3-day fasted animals would express more AMPK than neurons of summer fed animals. Our preliminary IHC results show a trend towards higher active AMPK levels in fasted animals, but significance was not reached. IHC has also been performed on brain slices from winter-state ground squirrels, including both torpid and euthermic animals. We hypothesized that torpid squirrels would show lower AMPK expression than winter euthermic animals due to suppressed enzyme activity during torpor. Our results show that the two groups were not significantly different. Finally, AMPK expression in summer state animals was compared to AMPK expression in winter. We found that there is more AMPK expression in summer compared to the winter state. We conclude that there are changes in AMPK expression between summer and winter, but once animals enter the winter state, AMPK expression is not altered by torpor. This work was supported by NIH NS039951 grant to RJH and NIH R25DK067017 to GLF.

P2.73 BENTLEY, S.E.*; MATLACK, C.L.; CHOW, J.; HAUSSMANN, M.F.; Bucknell Univ.; mfh008@bucknell.edu
A charmed life: in ovo supplementation of vitamin E and its effects on oxidative stress during early development in domestic chickens (*Gallus gallus*)

Rapid oxidative metabolism during early development results in the production of large quantities of free radicals in many tissues, making them particularly susceptible to oxidative damage. Antioxidants are a crucial defense against free radicals. In oviparous organisms, mothers may place their offspring at a fitness advantage through the allocation of dietary antioxidants to the yolk. The developing embryo may use these antioxidants to reduce the impact of free radicals, particularly in susceptible tissues such as the liver and brain. We propose that supplemental yolk vitamin E will result in decreased oxidative damage in the liver and brain, and that the latter may impact offspring behavior. To test this, we experimentally increased vitamin E concentration in the egg yolks of domestic Leghorn chickens (*Gallus gallus*). Groups received either control, low (12-18 $\mu\text{g/g}$ yolk), or high (24-36 $\mu\text{g/g}$ yolk) doses of supplemental vitamin E via direct injection into the yolks of unincubated eggs. Blood and tissue samples were collected during embryonic development and post-hatch to assess oxidative stress. Chick growth and behavior were monitored for the first two weeks of life. Eggs receiving high doses of vitamin E had higher hatchability than control or low dose eggs ($P = 0.04$). Chicks receiving the high vitamin E dose had higher growth rates ($P = 0.0004$) and showed more proactive behavior compared to control chicks in open field ($P = 0.05$) and tonic immobility tests ($P = 0.04$). These results indicate that supplemental yolk vitamin E is beneficial to early development and possibly results in chicks that are better behaviorally adapted to their environment.

P1.136 BERGAM, Brittany A.*; FRIEDMAN, Alex; SWANSON, Brook O.; Gonzaga University; bbergam@gonzaga.edu

Building a Biological Hammer

The stomatopod dactyl is a powerful spring-loaded appendage that is used for smashing hard shelled prey, producing point forces in excess of 1000 N and cavitations at the strike point. The dactyl cuticle can survive thousands of these strikes with minimal damage. Here we describe the unique biomaterial and structural features that allow this extreme material performance. The dactyl cuticle is much thicker and has much higher mineral content than other parts of the cuticle. We expect this higher mineral content to lead to increased stiffness and hardness at the expense of toughness. Nanoindentation and bulk impact toughness were used to describe the properties of the dactyl. Two species, *Odontodactylus scyllarus* and *Gonodactylaceus falcatus* were used in this study. In nanoindentation we find that the surface of the dactyl has high resistance to permanent deformation, hardness, and very high resistance to elastic deformation, stiffness. The hardness of the *O. scyllarus* was 2.028 ± 0.7616 GPa with a stiffness value of 84.12 ± 17.73 GPa while the *G. falcatus* averaged a 1.510 ± 0.7775 GPa for the hardness and a stiffness value of 66.06 ± 26.29 GPa. In both of these cases the property values drop precipitously with increasing depth so that the hard and stiff striking surface is backed with much more compliant material. Charpy impact toughness was used to determine the absorbed energy of dactyls under dynamic loading. It was found that the dactyl had an average toughness of 19.3 KJ/m². We hypothesize that this high toughness can be achieved because of the fibrous organic component in the low-stiffness interior of the dactyl. This combination of high surface stiffness (a bit higher than tooth enamel) and high toughness (a bit higher than wood) place the dactyl in the realm of metals instead of biomaterials.

P3.151 BHANDIWAD, AA*; JOHNSEN, S; Northeastern University, Boston, MA, Duke University, Durham, NC; bhandiwad.a@neu.edu

Now you see it, now you don't: the effects of salinity and temperature on the transparency of the ghost shrimp, *Palaemonetes pugio*

The ghost shrimp, *Palaemonetes pugio*, is a detritivore that plays a major role in nutrient recycling and is a primary consumer in Atlantic and Gulf coast estuarine systems. These systems experience rapid changes in salinity and temperature due to tidal cycles, evaporation, and runoff. Because *P. pugio* faces high predation pressure from visual predators such as killifish (*Fundulus heteroclitus*), summer flounder (*Paralichthys dentatus*), and post-larval decapod crustaceans, it is thought that its transparency has evolved to serve as a form of crypsis. In this study, we examined the effects of rapid, but ecologically relevant, changes in salinity and temperature on the transparency of *P. pugio* under laboratory conditions. Animals normally kept at a salinity of 15 ppt and a temperature of 20° C were placed into solutions with salinities of 0, 15, 25 or 30 ppt and temperatures of 12° C, 20° C, or 28° C for 12 hours. We found that at the control conditions of 15 ppt at 20° C (N = 43), $64\% \pm 2.8\%$ (Mean \pm SE) of incident light was transmitted through a 2 mm thickness of the tail muscle, whereas at the extremes of 30 ppt at 28° C (N = 10) and 30 ppt at 12° C (N = 29), the light transmission was only $0.03\% \pm 4.0\%$ and $4.5\% \pm 2.8\%$, respectively (ANOVA, $F=57.6$, $p < 0.0001$). Though both were significant, the effects of temperature were more pronounced than the effects of salinity. We believe that this loss of transparency is due to pooling of low index hemolymph between the high index muscle fibers, which increases light scattering. This induced opacification increases the visibility of the animal and thus may increase predation pressure during periods of salinity and temperature change, changing estuarial trophic dynamics and infaunal composition.

P3.70 BERGE, Kathryn A.*; BERENDZEN, Peter B.; GOLUBTSOV, Alexander S.; University of Northern Iowa, A.N. Severtsov Institute of Ecology & Evolution; kberge@uni.edu
Genetic connectivity between morphologically distinct populations of the Ethiopian fish *Barbus paludinosus*

Barbus paludinosus, the African straightfinned barb, is widely distributed throughout eastern and southern Africa. Within Ethiopia, the fish is found within the Omo, White Nile and Blue Nile systems as well as lakes in the Ethiopian Rift Valley. In these areas an interesting phenomenon occurs; the characteristic serrated dorsal spine of *B. paludinosus* is drastically reduced in the headwaters of the Blue Nile, White Nile and Omo drainages. However, downstream the fish have the normally prominent spine. This separation occurs in populations which are geographically isolated from one another by waterfalls where a predator is present below and absent above. The objectives of this study are: 1) to examine connectivity and population structure in isolated populations of *B. paludinosus* and 2) to determine the relatedness of individuals found in separate drainages. Three sources of data, mitochondrial and nuclear DNA sequence data and polymorphic microsatellites, will be used to examine genetic variation at different temporal and spatial scales. Early results from the mitochondrial data reveal that barbs are related by drainage and not ecophenotype. Preliminary results will be presented.

P1.28 BICKEL, R.; BELLETIER, N.; CLEVELAND, H.; STERN, D. L.; DAVIS, G.*; Univ. of Nebraska, Lincoln, Bryn Mawr College, Princeton University; gdavis@brynmawr.edu

A patterning difference underlying viviparous and oviparous development in the pea aphid

The pea aphid, *Acyrtosiphon 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). Oocytes and embryos that are produced asexually and develop within the mother develop more rapidly, are yolk-free, and much smaller than oocytes and embryos that are produced sexually. These overt differences suggest that there may be underlying differences in the molecular mechanisms of pattern formation. Indeed, our preliminary comparative gene expression work suggests that there are important differences in the terminal patterning system, involving the Torso pathway, between viviparous and oviparous development. We have so far examined the expression of homologs of *torso-like* and *capicua*, members of the *Drosophila* Torso pathway. We have detected clear differential expression of *torso-like* and possible differential expression of *capicua*. Establishing such differences in the expression of patterning genes between these developmental modes is a first step toward understanding how a single genome manages to direct patterning events in such different embryological contexts.

P1.156 BIKNEVICIUS, A.R.*; REILLY, S.M.; KLJUNO, E.; Ohio Univ. ; biknevic@ohio.edu

Modeling the consequences of non-steady speed locomotion on walking mechanics

Studies of walking mechanics are traditionally constrained to steady-speed locomotion even though the ecological relevance of steady locomotion is questionable for most terrestrial vertebrates. Yet intermittent locomotion (brief but frequent locomotor bouts) is common across vertebrates. In this study, we developed a computer-based model to assess the effect of acceleration (positive or negative) on the pendulum-like recovery of external mechanical energy during walking (recovery ratios). The model was based on a spring-mass inverted pendulum with a point mass (center of mass), a spring of specified stiffness, and a dashpot (damper). It also included a torque at the foot as the active element in the model, representing the source of energy needed to accelerate/decelerate the walking cycle. A separate model was developed for hypothetical small and large vertebrates (0.5 kg versus 30 kg). At steady locomotion (acceleration = 0 m/s), both models displayed a progressive decline in recovery ratios with speed but the decrease was more pronounced in the small model. Both models also displayed reductions in recovery ratios for non-steady locomotion compared with steady events, however, there were substantial differences between the small and large models based on initial speed. In the large model, accelerating from a slow initial velocity had a smaller degradative effect on recovery ratios than did accelerating from a faster initial velocity. In other words, the large vertebrate model was somewhat forgiving of non-steady locomotion when moving at slow to moderate speeds. By comparison, the small model showed the opposite pattern, namely, steeper declines in recovery ratios at the slower initial speed than at faster speeds. These results will be interpreted with an eye towards differences in the metabolic cost of walking in small versus large vertebrates.

P1.3 BLACK, M.P.; EZEOKI, C.B.*; SALEM, S.J.; SABULA, M.J.; WILCZYNSKI, W.; Georgia State University, Atlanta, Georgia Southern University, Statesboro; seawater@gsu.edu

Anolis carolinensis maleâ–...male agonistic encounters: a three year study of the best predictors for determining dominant/subordinate status

Agonistic encounters can play an important role in the allocation of reproductive resources and the consequent fitness of an individual. The green anole lizard has an easily recognizable suite of behavioral displays that allow the determination and establishment of dominance and subordination. To investigate the predictive value of different displays during the agonistic encounter, male *Anolis carolinensis* were paired with similar-sized males and observed as they established social status during a ninety-minute session. In real time, observers recorded bob A, B, and C, eyespot presence, dewlap displays, lateral displays, open mouth displays, wrestles, pushups, nips, and body color changes. Anole individuals that became dominant were green for a greater duration during the observation period. Dominant males also had a higher bob A and C count, longer latency to first bob A, more dewlap displays, and longer total duration of dewlap displays. In fights that escalated to open mouth displays, dominants had higher frequencies of open mouth displays. In contrast to previous reports, eyespot latency in this study was not predictive of winning or losing, and subordinates most often displayed aggressively first, usually as bob A displays. The latency differences between this study and others may be due to different geographic sources of anoles, smaller differences in size between competitors, or housing males with females as opposed to isolation before encounters. This suggests that displays that are predictive of outcomes may vary depending on the source populations and encounter environment.

P3.95 BLACK, Samuel J*; CRESPI, Erica J; Vassar College; sablack@vassar.edu

Does nutritional state affect immune function in frogs?

With emerging diseases threatening global amphibian populations, there is a need to understand the physiological mechanisms that influence susceptibility to infection in frogs and salamanders. Because variation in nutritional status is one of the main factors known to affect the immune system in other vertebrates, we investigated the effects of food restriction on immune function in juvenile *Xenopus laevis*. First, we compared red blood cell (RBC) and white blood cell (WBC) densities in hematological smears obtained from fed and 1-month food-deprived juveniles of three size classes. We also challenged both fed and food-deprived animals with the mitogen phytohaemagglutinin (PHA, 50 ug/g dose), which is known to stimulate proliferation in targeted cell types. Even though we did not detect a main effect of nutritional state on total RBC counts, we found that only fed animals experienced the stimulatory effect of the PHA, while food restricted animals experienced a decrease in RBCs after PHA injection. We also did not find overall effects of nutrition or PHA on total WBC counts. However, the ratio of heterophils to lymphocytes (H:L), which is particularly sensitive to stress, was increased in food-deprived animals. These findings suggest that nutritive condition may not affect baseline levels of RBC or WBC, but food restriction may impair the animal's ability to up-regulate RBC proliferation, potentially in situations when an increase in oxygen consumption may benefit the health of the animal. This impairment could be due to an overall reduction in metabolic activity in the food-deprived animals, or due to a down-regulation of mitogenic factors related to reduced energetic reserves. In addition, the increased H:L ratio in food-restricted frogs reflects some interaction between nutritional status and immune function.

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Patterns of muscle coordination vary with terrain during locomotion

Patterns of muscle coordination have been well studied in laboratory settings, yet conclusions and correlations to outdoor environments are limited by the ability of laboratory studies to recreate realistic variations in terrain. Few studies have ventured into the field to investigate how muscle coordination varies in a more natural setting. The purpose of this study is to identify correlations between muscle activation patterns and factors known to affect muscle coordination in the field. To accomplish this muscle activity was measured in human subjects while cycling outdoor on paved roads. Subjects cycled 20km (4 laps of 5km) in the shortest time possible. Muscle activity of 8 leg muscles was continuously recorded using surface electromyography (EMG) while power output, cadence, heart rate and rider location were recorded. The time-varying intensity of the EMG signals was calculated and the dominant coordination patterns were identified using principal components analysis. Coefficients for muscle coordination were statistically compared to the mechanical power output, cycle frequency, velocity, heart rate, course slope and lap number using analysis of covariance. The muscle coordination patterns significantly covaried with the power output, cycle frequency, heart rate, course slope and lap number. These results show that muscle coordination changes with altered locomotor demands and terrain, and highlights the importance of recording these parameters under field conditions.

P2.163 BOHÁRQUEZ-HERRERA, J.; KAWANO, S.M.*; DOMENICI, P.; Centro Interdisciplinario de Ciencias Marinas, Instituto Politécnico Nacional, Clemson University, CNR-IAMC; skawano@clemson.edu

Effects of prey capture on escape responses of the silverspotted sculpin (*Blepias cirrhosus*)

Predator evasion and feeding are both fundamental for the survival of organisms. Although a number of studies have assessed how these two activities interact and influence the overall behavior of organisms, little is known about the effect of feeding on escape performance in terms of the kinematics and the timing of the response. The present study investigated how engaging in feeding activities affected escape responses by comparing fast-start escape responses of silverspotted sculpins (*Blepias cirrhosus*) elicited in three conditions: (1) a control (no feeding involved), (2) during chasing of a prey, and (3) immediately after prey capture. Non-locomotory and locomotory variables were analyzed from high-speed videos (250 fps) using automated data analysis routines. Responsiveness was about two times lower when individuals were stimulated immediately after capturing a prey item compared to the other two treatments and latency performance was higher in the control treatment (as indicated by lower latency values) than in the other two treatments. Directionality was not statistically different between the treatments with all three treatments showing a high proportion of responses away from the threat. Locomotory variables were not statistically different among the three groups. Our results indicate that feeding behaviors can have a negative effect on the responsiveness and latency of escape responses, suggesting that engaging in feeding behaviors may decrease an individual's ability to successfully evade predators.

P2.66 BORCHERT, JD*; SHELDON, KS; TEWKSBURY, JJ; Indiana State University, University of Washington; jborchert@gmail.com

Differences in the thermal tolerances of isopods, from a temperate and tropical region, will buffer temperate isopods from the impacts of climate change

Organisms in tropic and temperate regions experience very different climatic regimes. This is particularly true in regards to the amount of seasonal temperature variation each of these regions experience, with tropical systems seeing mild levels of annual variation while temperate regions experience a large range of annual variation in temperature. As global warming continues to increase both of these regions are expected to see increased temperatures. However, temperate regions are expected to see a disproportionate increase in warming relative to the tropics. We hypothesized that temperate organisms are more capable of tolerating climate change, despite this greater increase in rising temperatures, since they are adapted to a wider range of temperatures than tropical species. To examine this we found the thermal optima and thermal maxima of an isopod, *Oniscus asellus*, in both the temperate climate of Seattle and the tropical climate of Ecuador. To find the thermal optimum we found the temperature at which isopods were fastest at righting themselves after being flipped over onto their back. The thermal maximum was defined as the temperature where the isopods were no longer capable of righting themselves. For each region we then compared the difference between the thermal optimum and maximum for the isopods and looked at whether the expected increase in global warming for each region was within this temperature range. We found that the temperate species has a substantially larger difference between its thermal optimum and maximum than the tropical species whose thermal optimum is very close to its thermal maximum. Based on this evidence we believe that the temperate isopod is much more capable of withstanding its expected temperature increase.

P2.8 BOORSE, GC*; LIBBON, JV; Arizona State University, West Campus; graham.boorse@asu.edu

Genomic characterization of two leptin genes and a leptin receptor gene in the Green Anole, *Anolis carolinensis*

Leptin is a type-I cytokine hormone secreted primarily by adipose tissue that is central to regulating food intake, energy balance and reproduction in mammals. Our knowledge of leptin evolution has been impacted by limited success in identifying leptin orthologs from vertebrate groups outside of mammals and fish. Debate over the validity of chicken leptin gene sequence has further clouded the molecular evolution of leptin. By analyzing the *A. carolinensis* genome, we have identified two leptin genes (LepA and LepB) and one leptin receptor (LepR) gene. Like fish and amphibian leptins, both lizard leptins show low amino acid similarity (~38%) but do show nearly identical predicted tertiary structures to mammalian leptins. Lizard LepA and LepB exhibited genomic synteny with human Lep (7q21) based on the limited gene arrangement information available from the current version of the Anole genome suggesting both are orthologous to human leptin. Molecular cloning of LepA by RT-PCR confirmed it was expressed in brain and spinal cord. Similar techniques failed to demonstrate expression of LepB in any tissue examined thus far suggesting this gene may not be expressed or expressed in low amounts. Using RT-PCR we have identified a 741bp fragment from testis with a deduced amino acid sequence that exhibits 57% similarity to human LepR; molecular phylogenetic analyses in conjunction with synteny mapping have clearly identified this molecule as the lizard LepR ortholog. Tissue distribution of leptin and receptor genes by RT-PCR and generation of full length clones by RACE-PCR are currently underway. Our characterization of lizard leptin and its receptor provides additional insight into our understanding of the structural and functional evolution of this important hormone.

P2.35 BOSTRÅ, M. J.*; FRANSSON, T.; HENSHAW, I.; JAKOBSSON, S.; KULLBERG, C.; ÅKESSON, S.; Lund University, Lund, Sweden, Swedish Museum of Natural History, Stockholm, Sweden, Stockholm University, Stockholm, Sweden, Stockholm University, Stockholm, Sweden; jannika.bostrom@zooekol.lu.se

Magnetically induced migratory fuelling in juvenile wheatears (*Oenanthe oenanthe*)

Most migratory birds are believed to rely on an endogenous migration program during their first autumn migration. This program tells them, among other things, when to fuel and how much fat to accumulate in preparation for the different flight steps. Recent studies have shown that external factors, such as the magnetic field experienced, can also influence fuelling decisions in naive migrants.

I will present data from a suite of experiments where naive wheatears have experienced magnetic displacements and their body mass increase and food intake have been monitored. One group was kept in the local geomagnetic field as a control, whereas other groups were exposed to shifted magnetic fields, corresponding to geographical locations either along their population specific migration route or parallel to the west of their natural route. Underlying causes of different fuelling responses will be discussed.

P2.4 BRANDLEY, N. C.*; SPENDEL, K.; GREIG, E. I.; Duke University, University of Chicago; ncb9@duke.edu
Evidence for widespread predator-elicited vocalizations in the Fairy-wrens: the Type II call in *Malurus lamberti*
 Predator-elicited vocalizations have typically been viewed as alarms to conspecifics or deterrents to predators however recent work has suggested that they may also function as sexual displays to conspecifics. It is believed that calling after a predator's vocalization adds additional danger to the call, which increases the caller's attractiveness to females. Within the Fairy-wrens, two different species (the Superb, *M. cyaneus*, and the Splendid, *M. splendens*) are known to give songs in response to the vocalization of a predatory bird (referred to as the 'Type II song'). Recent work in *M. splendens* has shown that these songs serve little alarm function and most likely function as sexual displays. Here we demonstrate the Type II song in a third species of Fairy-wren, the Variegated Fairy-wren (*M. lamberti*). We conducted a series of ten playbacks from each of five avian species (three predators and two non-predators) to *M. lamberti* in the Brookfield Conservation Park, South Australia. Only the predatory Grey Butcherbird (*Cracticus torquatus*) elicited a Type II response, which occurred in 70% of their playbacks (n=10, two tailed Fisher's Exact test: p=0.003). This represents the third case of a song-like vocalization induced by predators in the genus *Malurus*, and is the first example in the Variegated Fairy-wren's 'Chestnut-shouldered' clade. Although the function of the Variegated Fairy-wren's Type II song was not examined, its similarities in structure and usage to the Splendid Fairy-wren's Type II song suggest further widespread predator-elicited sexual display vocalizations in the genus *Malurus* than previously believed.

P2.134 BRAZEAL, K. R.*; DECASTRO, D. M.; WATTS, H. E. ; HAHN, T. P.; Univ. of California, Davis; krbrazeal@ucdavis.edu
The effect of social cues on the timing of the breeding-molt transition in House Finches (*Carpodacus mexicanus*)

Transitions between annual cycle stages (e.g. breeding, molt, migration, hibernation) allow animals to deal with seasonally predictable and unpredictable environmental variation. Therefore, appropriate timing of these transitions, so that they correspond to optimal environmental conditions, can have a major impact on lifetime reproductive success. Understanding the underlying environmental cue response mechanisms is central to understanding how animals deal with environmental variation. While the responsiveness to photoperiod cues has been widely studied, less is known about how non-photic cues influence the timing of transitions between annual cycle stages. This study examined the importance of social cues in timing of the breeding-molt transition in House Finches (*Carpodacus mexicanus*). Captive males and females were housed on naturally-declining photoperiod after the summer solstice either adjacent to a hormonally-implanted opposite sex stimulus bird, or to unimplanted same-sex birds. The birds paired with hormone-implanted stimulus companions did not delay gonadal collapse or the onset of molt as predicted. Further analysis of circulating hormone levels and behavioral data may be illuminating. Precisely when in the annual cycle the social cues are experienced may be critical to the response induced.

P3.129 BRASILI, A.*; JOHNSON, A.S.; ELLERS, O.; Bowdoin College; abrasili@bowdoin.edu
Temperature and size-dependent growth in a marine ectotherm: the green sea urchin *Strongylocentrotus droebachiensis*.

Temperature alters growth of ectotherms, but growth also depends on size. We examine the scaling of growth, size and metabolic rate of the green sea urchin, *Strongylocentrotus droebachiensis*. We are growing 468 urchins ranging in weight from 0.02 to 295 g (0.42-8.97 cm diameter) in six tanks at three different temperatures (7, 14 and 17°C). Urchins are weighed once per month and will be in their 5th month of growth by January 2009. There is a lag phase in the growth of the smallest urchins (< 2 cm diameter) and accordingly we use the gamma function (Ellers and Johnson, 2009) to describe growth rate as a function of size. After the first month of growth, analysis of residuals from the fit of the gamma function to the pooled data revealed significant differences between temperatures. These differences are size-dependent: the urchins still in the growth lag grew fastest at 14°C and most slowly at 7°C, whereas urchins larger than 4 cm diameter grew fastest at 7°C and most slowly at 17°C. All urchins will be past the growth lag by November, at which time we will fit the growth data with the von Bertalanffy equation, which includes anabolic and catabolic coefficients and a metabolic exponent. We expect that this analysis will show that the anabolic and catabolic coefficients have different Q10 values, and consequently, urchins will grow to smaller sizes at higher temperatures. The predicted maximums for each temperature will be compared to the actual sizes at which the urchins stop growing to test this theoretical model for growth.

P1.138 BRIGHT, J.A.*; GRÄ NING, F.; University of Bristol, University of York; j.bright@bristol.ac.uk
Strain accommodation in the zygomatic arch of the pig (*Sus scrofa*) in vitro and in silico.

It has been suggested that mammalian cranial sutures act to reduce the levels of strain experienced by the skull during feeding. A complete skull of a domestic pig was loaded and strains in the zygomatic arch were investigated using Digital Speckle Pattern Interferometry (DSPI), a full field strain measurement technique offering several advantages over the more traditional use of strain gauges. The zygomatic arch was chosen for the presence of a large and patent suture, and the skull was loaded incrementally on a testing rig that flexed the skull dorso-ventrally. Interference fringes were recorded after each step, from which the strain distribution was calculated. The zygomatic suture is clearly visible as a region of highly localised, increased strain in DSPI-produced contour plots. DSPI also distinguishes differences in the magnitude of deflection experienced by the two adjacent bones, supporting the theory that it may be acting to accommodate deformation and thereby minimise bone strain. Finite Element Analysis (FEA) of the same specimen is able to reproduce similar patterns of strain, but is dependant on how the suture is modelled: including soft tissues always reduces the overall strain, but while joining the suture with spring elements replicates strain patterns of an open-suture model, joining it with tetrahedra replicates patterns of a solid model, and is more similar to patterns observed using DSPI. DSPI therefore provides a means of validation for the FE models, and here highlights the importance of correctly modelling the soft tissues when including sutures in FEA.

P1.158 BROWN, Brian*; JINDRICH, Devin L; Arizona State University; brian.brown@asu.edu
Effects of increased rotational inertia on the mechanics of human cutting turns

Locomotion in the environment is seldom steady-state. Animals and humans must constantly maneuver to change direction and negotiate obstacles. Maneuvering performance can determine predation risk for animals injury risk for humans. However, the mechanics and motor control of maneuverability are poorly understood. Comparative studies have suggested that common mechanical constraints and control strategies may be used by a diversity of runners. A simple algebraic model can successfully relate the ground-reaction forces used by bipeds (ostriches and humans) and hexapods (cockroaches) during running turns to a limited set of morphological and behavioral parameters. However, the active responses of to perturbations have not been determined. We sought to assess the mechanical and behavioral consequences of perturbations to two morphological parameters: mass (M) and rotational inertia (I). We studied humans during moderate-speed running. We constructed a rigid backpack frame with rigid poles attached at the waist, extending fore and aft. The apparatus weighs 5.7 kg. The pack is tightly fitting and adjustable to each participant. By adding mass to different locations fore and aft of the center of mass (COM), M and I could be independently changed. Changes in M of 1%-4% can increase I about the vertical axis by 1-4 times. Kinematics were collected using a VICON® 3-D motion tracking system, and ground-reaction forces measured using two force platforms (Bertec) covered by rubber mats to obscure their location. Subjects ran at 3 m/s and executed sidestep cuts with their right leg. Preliminary results suggest that although increasing I may decrease braking forces somewhat, even the highest (4%) increases were not associated with acceleratory forces, suggesting active changes to other behavioral parameters in addition to ground-reaction forces.

P3.27 BRYER, PJ*; DAVIS, BL; SUTHERLAND, MA; MCGLONE, JJ; Lamar University, Beaumont TX, Texas Tech University, Lubbock TX, AgResearch, Hamilton NZ; pamela.bryer@lamar.edu

Emotional states of domestic and feral pigs

Feral pigs in Texas (USA) are descended from introduced European wild boars and escaped domestic pigs. The objective of this project was to determine differences between the emotive states of feral and domestic pigs. Domestic (D; n = 4) and trapped feral (F; n = 4) pigs at approximately 3 weeks of age were used for this comparative study. Repetitive back tests were performed 7 days apart to determine pigs' coping responsiveness by measuring the number of escape attempts. Pigs were placed in an open field arena with and without a standing person. Lastly, pigs were exposed to an unknown auditory stimulus (startle-freeze) and the delay and duration to the response was recorded. All behavioral testes were recorded continuously. Data were analyzed using the MIXED procedure of SAS. All feral and domestic pigs were low responders. Domestic pigs moved through fewer ($P < 0.05$) squares than feral pigs before the observer entered the room (D: 5.6 ± 1.91 squares; F: 12.6 ± 1.91 squares). Once an observer was present, domestic pigs moved through more ($P < 0.001$) squares than feral pigs (D: 11.0 ± 1.76 ; F: 3.5 ± 1.76). In response to the startle-freeze test, feral pigs showed a shorter ($P < 0.05$) delay in responding to the auditory stimulus over time compared to domestic pigs. Domestic pigs habituated rapidly to the repeated startle. However, the duration of freeze increased ($P < 0.001$) among feral pigs over time; feral pigs did not habituate to the startle over time. While domestic pigs habituated to humans and startle-noise, feral pigs did not. Domestication involves a genetic and a learned component. This research suggests habituation in response to novelty (humans or unknown auditory stimulus) may be a predominantly learned aspect of domestication as these traits are not maintained in wild-domestic cross pigs.

P2.158 BROWNING, J. A.*; SANTHANAKRISHNAN, A.; MILLER, L. A.; University of North Carolina-Chapel Hill; jamesb@unc.edu

The Effects of Wing Flexibility on Small Insect Flight

Previous work on insect flight has focused on larger insects ($Re > 100$) where the effects of viscosity can largely be ignored. Only a few studies have examined the smaller insects that fly at Reynolds numbers below 100. This work has shown, however, that the flight kinematics and aerodynamics of these insects can be significantly different from those that fly at higher Reynolds numbers. In our project, we focused on flexible wing rotation at Reynolds numbers below 100 using dynamically scaled physical models. The model wing was immersed in a tank and attached to a motor via a shaft mounted on the top of the tank. Low Reynolds numbers were achieved using various mixtures of glycerin and water. We measured the flow velocities around the wings using both flexible and stiff wings in root rotation with digital particle image velocimetry (DPIV). We find that at Reynolds numbers below ~40 both leading and trailing edge vortices do not separate from the wing. In addition, the circulation strengths of these vortices appear to depend on wing stiffness.

P3.46 BRZOZOWSKI, Frances J.V.*; ROSCOE, Jennifer; WEINREICH, Brian; WAGNER, Fabian; ALBERTSON, Dr. R. Craig; Syracuse University; fjbrzozo@syr.edu

Inheritance of Complex Color Patterns in Lake Malawi Cichlid Fishes

African cichlids are renowned for their propensity to speciate at extremely fast rates. Variation in color patterning is thought to contribute to these speciation events through sexual selection. We are currently working to characterize the genetic basis of color variation in two Lake Malawi cichlid species. Outbreed individuals of *Labeotropheus fuelleborni* and *Tropheops red cheek* were used to produce F_2 hybrids. Patterns of inheritance indicate that while many color traits are segregating in complex ways, others have a relatively simple genetic basis (i.e., one gene). We also observed transgressive color patterns in the F_2 that mimic variation in natural populations of cichlids, consistent with the hypothesis that the sorting of alleles between cichlid species can be an important mechanism through which phenotypic variation is generated. Future work will focus on characterizing the full spectrum of this variation using QTL analysis, which will provide a better understanding of the genetic basis of traits important to the evolutionary success of this group.

P2.159 BUCHWALD, Robert*; DUDLEY, Robert; University of California, Berkeley; rbuchwald@gmail.com

Maximum flight performance in bumblebees reared under variable hypobaria

Many bumblebee taxa are distributed across pronounced elevational gradients, but the effects of associated variation in environmental conditions on morphology and flight performance are not fully understood. Altitudinal ascent is associated with reduction in ambient temperature, air pressure, and oxygen availability, and bumblebees may be particularly sensitive to such changes given their high in-flight metabolic rates and tracheal respiration. In order to examine how bumblebees respond to the challenges of flight at high elevation, we reared bumblebee colonies (*Bombus impatiens*) at three experimentally imposed air pressures corresponding to sea level, and altitudes of 1500 m and 3000 m. Mature colonies were exposed to hypobaric conditions, and individuals then reared from eggs to adulthood were tested for maximum vertical force production in hovering flight. Measured morphological parameters included total mass, flight muscle mass, and wing length. No differences among normo- and hypobaric treatments were found in morphological parameters or in load-lifting capacity, suggesting that this bumblebee species does not respond in these measures to changes in ambient air pressure.

P2.147 BURDICK, S.L.; SWANSON, D.L.*; Univ. of South Dakota, Vermillion; david.swanson@usd.edu

Overwintering Physiology and Hibernacula Microclimates of Blanchard's Cricket Frogs at their Northwestern Range Boundary

Blanchard's cricket frogs (*Acris blanchardi*) in the central portion of their range show minimal capacities for freezing tolerance and survive overwinter by using terrestrial hibernacula where they avoid freezing. However, frogs may exhibit greater freeze-tolerance capacity at high latitude range limits, where winter climate is more severe. We studied freezing tolerance, glucose mobilization during freezing, and hibernacula microclimates of cricket frogs in southeastern South Dakota, at the northwestern limit of their range. Cricket frogs from South Dakota generally survived freezing exposure at -1.5 to -2.5°C for 6-h periods (80% survival), but uniformly died when exposed to these same temperatures for 24-h freezing bouts. Hepatic glucose levels and phosphorylase activities increased significantly during freezing, but hepatic glucose levels remained low, only reaching levels approximating those prior to freezing in freeze-tolerant species. Moreover, muscle glucose and hepatic glycogen levels did not vary with freezing, suggesting little mobilization of glucose from hepatic glycogen stores during freezing, contrasting with patterns in freeze-tolerant frogs. Temperatures in soil cracks and burrows potentially used for hibernacula were variable, with some sites remaining above the freezing point of the body fluids throughout the winter, some sites dropping below the freezing point for only short periods, and some sites dropping below the freezing point for extended periods. These data suggest that cricket frogs in South Dakota survive overwinter by locating hibernacula that prevent freezing, although their toleration of short freezing bouts may expand the range of suitable hibernacula. These data also suggest that overwinter mortality may be high at the northern range boundary and might limit cricket frogs from expanding their range northward.

P2.148 BURDETT, KA*; BUCK, CL; FLORANT, GL; Department of Biology, Colorado State University, Fort Collins, CO 80523, Institute of Arctic Biology and Department of Biology and Wildlife, University of Alaska Fairbanks, AK 99775; kburdett@rams.colostate.edu

Torpor patterns during hibernation in golden-mantled ground squirrels (*Spermophilus lateralis*) under natural conditions

Golden-mantled ground squirrels (GMGS) have been used in lab hibernation experiments for many years. They undergo hibernation, defined as multi-day torpor bouts, to survive the winter. The torpor patterns of this species have been well studied under lab conditions, but little is known about their torpor patterns in the field. We hypothesized that under natural conditions there will be significant differences between gender and age classes, as well as having a significant difference in the torpor patterns of GMGS in the field compared with lab kept GMGS. To determine this, we surgically implanted body temperature data loggers (iButtons) into the abdominal cavity of GMGS and released them prior to the hibernation season (August 2008). Recapture and iButton removal took place in spring (May 2009). Animals hibernating in the field displayed long, sustained torpor bouts of 8-14 days on average with a maximum length of 21 days, decreasing their body temperature (T_b) to $0^\circ\text{C} \pm 1^\circ$. Animals hibernating in the lab typically demonstrate torpor bouts of 5-7 days, with T_b around $6^\circ\text{C} \pm 1^\circ$ and ambient temperature at $5^\circ\text{C} \pm 1^\circ$. In the field, adult males emerged earlier, spent less time in torpor, and had fewer torpor bouts that were shorter in duration, compared with females and juveniles in the field. These preliminary results support our hypothesis that torpor patterns differ both between lab and field, as well as between gender and age classes. Further studies are underway to make distinctions between gender and age classes in the field and lab.

P3.118 BURMESTER, EM*; FIELDS, PA; Franklin and Marshall College; eburmest@gmail.com

Proteomic analysis of the heat shock response in the Atlantic Ribbed Mussel *Geukensia demissa*

As an intertidal organism inhabiting the North American east coast, the Atlantic ribbed mussel, *Geukensia demissa*, experiences a wide range of temperatures on a daily, seasonal, and geographic basis. Body temperatures from below freezing to 45C have been measured in individuals in the field. Using two-dimensional gel electrophoresis, we examined how heat shock affected the protein response in these organisms. We acclimated *G. demissa* to 15C and exposed six individuals each to 35C, 40C, or 45C for one hour with a six-degree-per-hour increase to target temperature, followed by a 24 h recovery period at 15C. Quantification of protein density from gill tissue using gel image analysis software (Delta 2D) revealed significant differences between treatment groups and control. Hierarchical cluster analysis indicates similar expression between control and 35C-exposed individuals, but significant changes after exposure to 40C and 45C. Using tandem mass spectrometry we identified a subset of proteins that showed significant changes in expression after exposure. In addition to upregulation of heat shock family proteins (particularly HSP70s, HSP90s, and glucose-regulated protein 78), changes were found in other proteins involved in protein folding, including peptidyl prolyl isomerase (downregulated) and cysteine disulfide isomerase (upregulated). These results show that *G. demissa* is capable of mounting a robust response after exposure to extreme heat stress.

P1.139 BUTCHER, M.T.*; HUDZIK, N.B.; WHITE, B.J.; WOLFF, L.M.; GOSNELL, W.C.; PARRISH, J.H.A.; BLOB, R.W.; Youngstown State University, Clemson University; mtbutcher@ysu.edu

Patterns of strain in the femur of the opossum (*Didelphis virginiana*) during terrestrial locomotion

Previous studies have found that limb bones from upright, cursorial species of eutherian mammals experience high bending loads with minimal torsion, whereas the limb bones of non-avian reptiles exhibit considerable torsion in addition to bending. To help determine the evolutionary timing of this divergence in bone loading patterns, we measured *in vivo* terrestrial locomotor strains in the femur of the Virginia opossum (*Didelphis virginiana*). This species not only uses more crouched limb posture than cursorial mammals but, as a marsupial, belongs to a clade phylogenetically between reptiles and the eutherian mammals studied previously. The presence of substantial torsion in the femur of opossums, similar to non-avian reptiles, would suggest that this loading regime likely reflects an ancestral condition for tetrapod limb bone design. Strain recordings indicate the presence of both bending and moderate torsion in the opossum femur. Shear strains appear similar in magnitude to peak compressive axial strains, with opossum femora experiencing lower bending loads but higher levels of torsion compared with most previously studied mammals. Thus, loading patterns of opossum limb bones appear intermediate in some respects between those of non-avian reptiles and mammals. Supported by NSF IOB-0517340.

P1.113 BYSTRIANSKY, J.S.*; CLARKE, C.; DEVLIN, R.H.; SCHULTE, P.M.; University of British Columbia, Pacific Biological Station, Nanaimo, B.C., Department of Fisheries and Oceans Canada; jbystria@zoology.ubc.ca

Smoltification and salinity tolerance of growth hormone transgenic coho salmon (*Oncorhynchus kisutch*)

Transgenic coho salmon containing the growth hormone gene construct OnMTGH1 and non-transgenic coho salmon from the Chehalis river, British Columbia (progenitor strain of transgenic strain) were raised under a simulated natural photoperiod in freshwater and fed to satiation. Growth hormone transgenic salmon grew significantly faster and exhibited signs of smoltification one year prior to control salmon. Over a two year period individuals from each group were directly transferred to full strength seawater for 24 hours and plasma sodium concentration was determined. Transgenic salmon were significantly better than control salmon at regulating plasma sodium levels in their first year, coinciding with higher survival rates following seawater exposure. To assess whether the improved salinity tolerance of transgenic salmon was due to higher levels of growth hormone, or simply due to a larger body size a second experiment was conducted comparing sized matched growth hormone transgenic and control salmon. Size matching was accomplished through a ration restricted diet for transgenic fish which matched the appetite of control fish. A third experimental group consisting of transgenic salmon fed to satiation which were a year class younger (and therefore of similar size) was also included to differentiate any potential impact of ration restriction. Individuals from each group were exposed to seawater for up to 30 days and changes in plasma sodium, chloride, gill Na^+K^+ -ATPase activity and isoform (mRNA) expression were monitored. In general, the three experimental groups showed a similar timeline for seawater acclimation suggesting that overall size is a larger determinant of seawater tolerance than growth hormone production.

P1.159 BYRNES, G.*; JAYNE, B.C.; University of Cincinnati; byrnesgt@ucmail.uc.edu

Decreased substrate diameter and increased surface compliance decrease climbing performance in snakes

Differences in the size, orientation and compliance of branches in arboreal habitats pose challenges for animal locomotion. For example, morphological constraints may limit the ability of an animal to conform to or grip narrow substrates. Successful vertical climbing also depends on the ability to press against the substrate and generate sufficient frictional forces, but this ability may be compromised by excessive surface compliance. Therefore, very narrow and compliant substrates would seem especially demanding for climbing animals. We varied the diameter and compliance of ropes independently to determine their effects on locomotor mode and performance during vertical climbing of juvenile boa constrictors. We measured rope deformation using a load cell and determined climbing velocity from video images. With decreased diameter and rope tension, locomotor performance of the snakes decreased significantly and the amount of rope deformation increased. The snakes used concertina locomotion on all surfaces, but the manner in which they pressed against the rope varied. On some large diameter stiff substrates, the lack of rope deformation implies that within each ventrally flexed gripping region the snake generated balanced opposing forces. By contrast, as substrate compliance increased and diameter decreased, the snakes used moment couples at successive pairs of gripping regions to deform the rope and increase its tension. This behavioral mechanism may compensate for morphological limitations on making the small radius of curvature required for gripping using only ventral flexion. Thus, these changes in behavior may allow the snakes to move on otherwise impassable narrow and compliant surfaces although locomotor performance is diminished compared to wider and stiffer surfaces.

P2.3 BYWATER, C.L.*; WILSON, R.S.; The University of Queensland; c.bywater@uq.edu.au

Competition drives the reliability of signalling in the two-toned fiddler crab (*Uca vomeris*).

Males of many species possess specialised weapons that are often displayed to resolve territorial disputes without direct physical contact. It is predicted that the evolution of increased weapon size should be associated with increased competition for resources and weapon strength should increase simultaneously with size (a reliable signal). In this study we tested this association by examining inter-population variation in the size and maximum strength of the enlarged claw of the two-toned fiddler crab (*Uca vomeris*). We also compared claw size and strength with population biomass and levels of competition. Fiddler crabs represent an ideal group for studying the evolution of weapon strength as males possess one enlarged and brightly coloured claw that is used both as a weapon during disputes with other males and to attract females during courtship. We examined 10 populations of *U. vomeris* in the creeks along the south-east coast of Queensland. We predicted that the increased competition that results from high population biomass would be associated with larger relative claw sizes and greater weapon performance. We estimated biomass and collected a sample of males from each population. We measured body size, claw size and maximum claw closing strength for each individual. We will discuss the variation observed in relative and absolute size of male weaponry among populations and the association with maximum strength and population biomass and level of competition.

P3.65 CABLE, A.E.*; DE MIRANDA, M.A.; KANATOUS, S.B.; Colorado State University, Colorado State University; amber.e.cable@gmail.com

Unmasking age class-specific differences in the Weddell seal proteome

During prolonged periods of hypoxia, Weddell seals (*Leptonychotes weddelli*) and other diving mammals are adapted to rely on internal oxygen stores to fuel aerobic energy production in their primary swimming muscles. Interestingly, nondiving Weddell seal pups are born with a higher potential for aerobic output than elite diving adults, as seen in the higher percentage of type I slow oxidative fibers in pups. Because this developmental trend is opposite that of terrestrial mammals, the process through which this adaptive change occurs is not well understood. The goal of this study is to better understand the differences in skeletal muscle physiology of this unique model system using proteomics to generate protein signatures from the two physiologically distinct age classes: pups (age 3-5 weeks; nondivers) and adults (age 7+ years; expert divers). Building on previous proteomic data confirming the reliance on cross-species analysis, this study found a suite of protein identifications for both age classes that are consistent with skeletal muscle physiology. Several spots, however, consistently yielded unsuccessful protein matches, suggesting the presence of unique seal proteins. Furthermore, myoglobin was found in multiple gel spots, alluding to the possibility of myoglobin isoforms, which were previously thought to exist only in species of fish. Knowledge of these unique adaptations in skeletal muscle are valuable due to the potential pharmacological implications for treating human disease, specifically those that involve hypoxic conditions such as cardiovascular and pulmonary diseases. This research was supported by the NSF (grant #OPP-0440713).

P2.22 CAMPBELL, B.R.*; LINDSAY, S.M.; DECHARON, A.V.; University of Maine, Orono, Darling Marine Center, Walpole ME; beth.campbell@umit.maine.edu

Regeneration in the classroom: linking infaunal injury and ocean literacy using integrated concept mapping

Injury and regeneration are fascinating topics that students are eager to learn more about. This allure makes injury a great hook to introduce students to a broader set of biological and ecological concepts. We focus on marine infauna, such as polychaetes, because they are important "ecosystem engineers" that often lose tissue to predators or other disturbances. For example, they influence sediment chemistry, nutrient cycling, and microbial communities as they burrow, feed, defecate, and irrigate their tubes. Evidence suggests that injured infauna are less active while they regenerate and these reductions can have individual, habitat, and community consequences. Concept maps are a useful educational tool to examine the costs and benefits of injury and regeneration, particularly linking the impacts from individuals and ecosystems. Such maps effectively show these linkages and encourage exploration of the processes that control and connect the immediate effects of injury on individual infauna with larger scale habitat and ecosystem changes. Our goal is to expand on the resources that are currently available to middle, high school, and post secondary educators using the COSEE-Ocean Systems (OS) Concept Linked Integrated Media Builder (CLIMB: <http://cosee.umaine.edu/tools/cmb/>) to create an interactive concept map of how injury affects marine benthic invertebrates, communities, and ecosystems. Here we present our initial concept map of how infaunal injury affects marine benthic ecosystems with examples of multimedia content, introduce the COSEE-OS concept mapping tool, suggest inquiry based activities for the classroom, and invite our colleagues to begin building their own concept maps of the integrative biology of injury and regeneration.

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The Functional Morphology and Transmitter Distribution an Olfactory Organ of *Tritonia diomedea*

The sea slug *Tritonia diomedea* has become a model for investigating the neural mechanisms that underlie orientation and navigation behavior. Previous research has shown that this epibenthic marine organism uses a combination of at least three primary sensory modalities (mechanoreception, magnetoreception, and chemoreception) to explore and navigate through its environment. Both magnetoreception and mechanoreception appear to provide the animal with direct directional information that serves to guide the animal in an appropriate direction. Olfaction, on the other hand, appears to serve as a motivational cue that initiates different types of behavior, including rheotaxis. For example, a sea pen (the primary prey of this sea slug) upstream of the slug initiates positive rheotaxis, whereas a predator (*Pycnopodia helianthoides*) elicits a swim escape response. One of the primary organs mediating chemoreception is the lateral tip of the animal's oral veil. Here we report the functional morphology of the lateral tip as it relates to chemoreception. The tip forms a densely ciliated channel on the ventral surface that drives a current of water up from the substrate to the base of the tip. These cilia are controlled by at least two different and widely distributed neurotransmitters, the neuropeptide TPep and 5HT. In addition, an opening on the tip leads to a cylinder that runs the entire length of the tip and contains large cilia-like structures, the function of which is unknown. Video recordings of the behavior of the lateral tip, coupled with previous research, imply that the organ functions much like a nose and that the cilia, controlled by centrally released neurotransmitters, can increase or decrease the amount of chemosensory information entering the CNS by changing beat frequency.

P3.4 CARRUTH, W. C.*; HUTCHISON, N. L.; HARRISON, J. S.; ROSTAL, D. C.; Georgia Southern University, University of Louisiana at Lafayette; wcarrut1@georgiasouthern.edu

Genetic diversity within and among three different populations of the gopher tortoise (*Gopherus polyphemus*)

The gopher tortoise, *Gopherus polyphemus*, is considered a keystone species in sand hill, longleaf pine, and scrub ecosystems of the southeastern United States. The current distribution of *G. polyphemus* is highly fragmented due to habitat loss and degradation resulting in isolated populations that vary significantly in size. Populations that experience a decrease in size can experience a decrease in genetic diversity. Those that remain small and isolated for long periods of time are expected to lose genetic variation through random genetic drift and increased levels of inbreeding. This loss of genetic variation can result in lower average fitness and decreased adaptive potential. This study focuses on three isolated populations of *G. polyphemus* that differ in their estimated census population size: George L. Smith State Park, Georgia (GLS) at 300-500 individuals; Fort Stewart Army Reservation, Georgia (FSAR) at 3000-5000 individuals; and Kennedy Space Center, Merritt Island, Florida (KSC) at >15,000 individuals. The main objective is to characterize the genetic variation within and among GLS, FSAR, and KSC populations of *G. polyphemus* using 8 microsatellite loci. Two primary questions are addressed: 1) What is the degree of population genetic subdivision among the three populations? and 2) Is the level of genetic variation (allelic diversity, expected heterozygosity, etc.) lower in smaller populations? Possible effects of lowered genetic diversity in tortoises will be discussed.

P2.37 CASTRO, C.*; SANCHEZ, J.A.; Univ. de los Andes, Bogotá; c.castro55@uniandes.edu.co

Zoochorous dispersal of *Symbiodinium* by the stoplight Parrotfish *Sparisoma viride*

Many terrestrial vertebrates have been identified as important zoochorous dispersers of seeds, contributing to the population dynamics and regeneration of plant populations. In the tropical oceans most of coral species reproduce through asymbiotic larvae hence depending on free-living pools of *Symbiodinium* to their post-larval survival and resilience after disturbances such as bleaching. Then, where do these new symbionts come from? It has been recently found that parrotfish feces, carry viable *Symbiodinium* cells. The aim of this study was to estimate the extent of the zoochorous dispersal of zooxanthellae (*Symbiodinium* spp.) by *Sparisoma viride* in Caribbean reefs. They feed at a rate of $6,95 \pm 0,49$ bites min^{-1} in a combined diet of scleractinian corals (12,9%), sponges (7%), macroalgae (23,6%) and filamentous algae on sediments (56,5%). Feces are dispersed in the water column and substrates at a rate of $18 \pm 1,69$ feces h. Viable symbionts were observed from most feces collected (80 samples) with densities ranging between 22 and 3481 cells ml^{-1} (2354 ± 1309 cell ml^{-1}) and cultured at the laboratory reaching densities between 8.2 and 24.6×10^3 cells ml^{-1} suggesting viability after ingestion from fishes. The preliminary results of this study suggest an ecological important role of parrotfishes as a marine zoochorous system for zooxanthellae in coral reef ecosystems, that could facilitate larvae infection and uptake by bleached corals. Although these results help us to understand free-living *Symbiodinium* populations, questions remain on the life span and survival of symbionts in the environment. Likewise, the dynamics of coral-zooxanthellae symbiosis re-establishment awaits further studies.

P3.48 CHAN, X. Y.*; LAMBERT, J. D.; University of Rochester, University of Rochester; xinyichan@gmail.com
IoTis11 is Segregated into Ventral Third Quartet Cells of the *Ilyanassa* Embryo and is Required for Their Development

During embryogenesis, all animals employ asymmetric cell division to specify cell fates, but there are relatively few cases where the functionally relevant segregated molecules have been identified, and it is not clear if a conserved mechanism underlies asymmetric cell division across animal kingdom. Spiralian embryos seem to be particularly reliant on asymmetric cell division for embryonic patterning, since most early divisions are unequal and generate cells with distinct fates. In *Ilyanassa* embryos, RNA segregation is widespread, but it is unknown whether this has functional consequences for embryonic patterning. IoTis11 is a zinc finger-encoding transcript that was recovered in a screen for segregated RNAs in early cell divisions. It is segregated into 3rd quartet micromeres and restricted to 3a and 3b cells of the 3rd quartet, suggesting that IoTis11 is important for normal development of these cells. Ablation of 3a and 3b always prevented the development of the esophagus and digestive glands, and frequently impaired development of the velum, foot and stomodeum. Lineage tracing shows that 3a and 3b directly contribute to all these organs except the digestive glands, suggesting that previously unrecognized signaling from 3a and 3b is necessary for development of these organs. Knockdown of IoTis11 by morpholino generated larvae with similar phenotypes as 3a and 3b ablation: they had no esophagus, occasionally lacked digestive glands and had abnormal velum, foot, and stomodeum. This result shows that IoTis11, a segregated RNA, is specifically required for differentiation of 3a and 3b cells, and supports the idea that widespread RNA segregation in the *Ilyanassa* embryo is important for establishing the normal pattern of cell fates.

P1.75A CEASE, Arianne*; ELSER, James; HAO, Shuguang; KANG, Le; HARRISON, Jon; Arizona State University, Chinese Academy of Sciences, Institute of Zoology, Chinese Academy of Sciences, Institute of Zoology; acease@asu.edu
Grasshopper developmental plasticity in heavily-grazed Asian Steppe pastures

Higher population density and reduced food quality promote formation of phenotypes with improved migratory capacity in many insects. We tested the effects of density and an N-fertilized plant diet on migratory polyphenism in *Oedaleus asiaticus*, a dominant pest across the Asian Steppe. This grasshopper has populations comprised of green and brown individuals. Anecdotally, it forms long-distance migrating swarms comprised primarily of brown individuals. *Oedaleus* population density and percent brown increased with grazing intensity. *Oedaleus* in heavily grazed pastures were warmer than species in ungrazed pastures. Percent brown increased with higher densities and decreased with N-fertilization. N-fertilization also decreased size and viability, suggesting that it decreased food quality. Brown hoppers had an increased metabolic rate (controlling for body size), were heavier due to increased hind leg and thorax mass, but had decreased jump performance relative to green forms. Neither form flew for long durations in a variety of flight trials, suggesting that neither form is prone to flight. Green-brown forms in *O. asiaticus* differ in many aspects of morphology and physiology and plastic changes in color respond similarly to population density and food quality as in other insects. However, color does not appear to be related to migratory capacity. This research was partially supported by a GPSA award from ASU, and ARCS award, and a Sigma Xi to AC and NSF DEB-0925017 to JE.

P1.39 CHEN, HY*; WATSON, RD; University of Alabama at Birmingham; elgasecho@hotmail.com
Effect of eyestalk ablation in the blue crab (*Callinectes sapidus*) on intracellular calcium in Y-organ cells and the hemolymphatic ecdysteroid titer
 Secretion of ecdysteroid molting hormones by crustacean Y-organs is negatively regulated (inhibited) by molt-inhibiting hormone (MIH), a neuropeptide produced by neurosecretory cells in eyestalk ganglia. The inhibitory effect of MIH is mediated by one or more cyclic nucleotide second messengers. In addition, available data indicate that ecdysteroidogenesis is positively regulated (stimulated) by intracellular calcium. However, despite the apparent critical role of calcium in regulating ecdysteroidogenesis, the level of Ca^{++} in Y-organs cells has not been previously determined. In studies reported here, eyestalks were ablated from blue crabs (*Callinectes sapidus*) to remove the endogenous source of MIH and activate Y-organs. At 0, 3, 6, and 9 days after eyestalk ablation (D0, D3, D6 and D9, respectively), the level of Ca^{++} in Y-organ cells was determined using a fluorescent calcium indicator (fluo-4), and the hemolymphatic ecdysteroid titer was determined by radioimmunoassay. Calcium fluorescence in D6 Y-organs was 2.4-fold higher than that in D0 controls; calcium fluorescence in D9 Y-organs was 3.0-fold higher than in D0 controls ($P < 0.05$). Associated with the increase in intracellular Ca^{++} was a significant increase in the hemolymphatic ecdysteroid titer: The level of ecdysteroids in hemolymph rose from 2.5 ng/ml on D0 to 76.2 ng/ml on D6 and 150.4 ng/ml on D9 ($P < 0.05$). The results are consistent with the hypothesis that ecdysteroidogenesis is stimulated by an increase in intracellular Ca^{++} . Our previous studies suggest Ca^{++} promotes ecdysteroidogenesis in Y-organs by activating a Ca^{++} /calmodulin-dependent cyclic nucleotide phosphodiesterase (PDE5). Grant sponsor: MS/AL Sea Grant (NA06OAR4170078).

P2.160 CHENEY, JA*; TON, D; RISKIN, DK; SWARTZ, SM; Brown University; jorn_cheney@brown.edu

Hindlimb movement of *Cynopterus brachyotis* during flight

Many discussions of bat flight focus primarily on the forelimb, but because the wings of bats are continuous with the entire hindlimb, the hindlimbs can also influence aerodynamics. We examined the kinematics of the hindlimbs of flying bats to determine whether leg motions are consistent with the hypothesis that hindlimbs play an active role in modulating wing shape during flapping flight. If the hindlimbs are actively shaping the wing, we expect that its movement would not passively follow the motion of the wing's trailing edge. If the hindlimb does influence wing shape, we would predict that the dorsal orientation of the ankle would primarily explain changes in angle of attack. We also asked if hindlimb motion influences wing camber, given that movement of the ankle toward the midline of the body, away from the fifth digit, will lengthen the wing's trailing edge and increase tension in the plagiopatagium. We flew five *Cynopterus brachyotis* (Pteropodidae) five times each in a wind tunnel over a range of speeds (3.2 – 7.8 m·s⁻¹). We recorded the motions of several markers on the body, hindlimb, propatagium, and plagiopatagium using three phase-locked high-speed cameras, and reconstructed their 3D motions using the direct linear transformation method. As predicted, we found that the position of the ankle marker moved toward the midline and away from digit V, at some parts of the wingbeat cycle, and that the movement of the ankle in the dorsoventral direction preceded movement of the trailing edge. This suggests that the hindlimb plays an important role in actively shaping the membrane during flight. Thus, while both insects and birds modulate angle of attack and camber at the leading edge of the wing only, bats appear to be able to modify these parameters at the trailing edge. Interestingly, aircrafts and bats appear to have converged on similar systems of control in this regard.

P2.82 CHO, I-G.*; COVI, J.A.; BADER, B.D.; CHANG, E.S.; MYKLES, D.L.; Colorado State University; ilgyuesque@gmail.com

Effects of Molt Induction on Expression of a Myostatin-Like Protein in the Green Crab, *Carcinus maenas*

Myostatin (Mstn), a member of the TGF-beta superfamily, is a negative regulator of muscle mass. In mammals, Mstn reduces mass by stimulating protein degradation and inhibiting protein synthesis. In crustaceans, a Mstn-like protein may regulate protein turnover in a reversible molt-induced muscle atrophy, which facilitates withdrawal of the claws during ecdysis. In land crab, molting causes a dramatic down-regulation of Mstn associated with increased protein synthesis. We hypothesize this increased turnover is required for remodeling of the contractile apparatus as fibers are reduced in size. We have cloned a partial cDNA (872 bp) of a Mstn-like protein from green crab, *Carcinus maenas*, that is highly conserved with Mstn in the land crab, *Gecarcinus lateralis* (78% amino acid identity), and lobster, *Homarus americanus* (74% amino acid identity). The Cm-Mstn encodes the entire 114 mature peptide amino acid sequence and part of the propeptide sequence. Real-time RT-PCR is being used to quantify the effects of molting on Cm-Mstn expression in claw and thoracic muscles. Supported by NSF (IBN-0618203).

P3.97 CHESTER, E.M.*; FRENCH, S.S.; DEMAS, G.E.; Indiana University, Bloomington, Utah State University, Logan; emcheste@indiana.edu

Effects of Timing of KLH Exposure During Pregnancy on Offspring Physiology and Behavior in the Siberian Hamster

It is increasingly evident that influences other than genetics can contribute to offspring phenotype, including behavioral phenotype. In particular, maternal influences are an important contributing factor to offspring survival, development, and likely behavior. Common environmental pathogens such as viral or bacterial microorganisms can induce maternal immune responses, which have the potential to alter the prenatal environment via multiple different pathways. Here we characterize the effects of keyhole limpet hemocyanin (KLH)-induced humoral immune activation in Siberian hamster (*Phodopus sungorus*) mothers at 4 time points on adult offspring behavior and physiology. KLH is a novel antigen that stimulates a B-cell mediated antibody response. Hamsters were injected with KLH or saline, either: 1) pre-mating, 2) early pregnancy, 3) mid-pregnancy, or 4) early post-partum. Mothers' food intake and body mass were monitored throughout pregnancy. Litters were measured weekly for growth until adulthood when stress and immune responses, as well as social behavior, were examined. Social interactions involved placing an animal into a resident's home cage and scoring behaviors (i.e., aggression, submission, grooming). Data will be presented on maternal and offspring measures. Collectively, these data will improve our understanding of the effects of maternal immune activation on the immune and endocrine systems and behavior of offspring in hamsters and likely other species.

P1.95 CHRISTOPHER, R.J. Laver*; JOHN, S. Taylor; University of Victoria; claver@uvic.ca
O, Darwin, Our Opsin Genes Are So Many, But Our Expressed Opsins Are So Few - A Gene Expression 'Tale' of the 10-Opin Gene Repertoire in Guppies (*Poecilia reticulata*)

Despite the remarkable physiological similarities among vertebrate eyes, it is increasingly clear that visual perception can vary, among and even within closely related species, with many animals evolving or 'tuning' their visual-pigments (opsins) to spectral selective pressures in the environment. Such tuning has resulted in a diversity of opsin gene repertoires that can vary greatly in sequence, copy number, and expression among species. Remarkably, the guppy (*Poecilia reticulata*) contains 10 opsin genes predicted to be most sensitive to different wavelengths of light. This observation, coupled with studies showing that guppy male reproductive fitness is positively correlated with conspicuous red, orange, and yellow colorations, suggests that increased spectral discrimination of male coloration might be a selective force driving opsin gene duplication and divergence in this species. Since guppy embryos as well as juveniles do not show these characteristic colors, and by definition are not sexually active, we hypothesize that variation in long-wavelength sensitive (LWS) opsin expression will coincide with sexual maturity. Using real-time RT-qPCR, we show that juveniles and adults predominantly express (>95% relative abundance) three or four of their nine cone opsin genes, with sex-specific upregulation of LWS A180 in males and LWS S180 in females. Although the functional significance of this expression pattern is unknown, males and females are likely to exhibit differential wavelength sensitivity and/or discrimination. Intriguingly, the only other taxa with sex-specific differences in opsin gene expression are the lycaenid butterflies, where color-based sexual selection has also been demonstrated.

P1.38 CHUGHTAI, A.*; BREWINGTON, A.K.; PREHODA-WYERS, M.M.; DEAROLF, J.L.; Hendrix College, Conway, AR; chughtaiaa@hendrix.edu
Prenatal steroids: do they affect the development of the guinea pig rectus thoracis muscle?

Glucocorticoids are used to accelerate the lung development of premature babies. The effects of glucocorticoids on breathing muscles are unknown, however. To determine the effects of these steroids on the accessory inspiratory rectus thoracis muscle, pregnant guinea pigs were injected with betamethasone, a glucocorticoid. It is known that this steroid stops the proliferation of muscle fibers, causing the differentiation of these cells to begin earlier. In the case of the guinea pig rectus thoracis, the last fibers to differentiate and, therefore be affected by steroid exposure, are the type IIA fibers. Thus, we hypothesize that betamethasone exposure will cause the IIA fibers in the rectus thoracis to be reduced in number and size. Betamethasone was injected at 65%, 75%, and 85% gestation of the pregnant guinea pigs. Samples of the fetal rectus thoracis were collected, sectioned, and antibody stained to distinguish between the different fiber types. Digital images of the stained muscles were collected, and Scion Image was used to analyze fiber number and diameter. The percentages of type IIA fibers in the muscles of treated and control fetuses were compared to determine if the treated muscles had less of these fibers. When fetuses are exposed to glucocorticoids, the inspiratory muscle fibers may be reduced in number and size. These changes could cause the inspiratory muscles of premature babies to have a reduced ability to produce the amount of force needed to survive outside the womb, in comparison to unexposed babies.

P2.75 CLARK, Paul, R.*; KRISTAN, Deborah, M.; CA State Univ. San Marcos; clark146@cougars.csusm.edu
Interactions between parasites: tapeworms alter life history of nematodes during co-infection in the laboratory mouse host

Wild animals often host multiple parasite species simultaneously. One parasite may alter the life history of another parasite, especially if they occupy the same physical space in the host. We tested if the bile duct tapeworm (*Rodentolepis microstoma*) could alter the distribution, size and reproduction of the intestinal roundworm *Heligmosomoides bakeri* using the laboratory mouse (*Mus musculus*) host. We used three co-infection experimental groups (an initial infection with *R. microstoma* followed by *H. bakeri*, an initial infection with *H. bakeri* followed by *R. microstoma*, or both parasites given to the host at the same time) and one group with *H. bakeri* infection only as a control. We found that presence of *R. microstoma* did not affect the total number of *H. bakeri* worms ($p=0.079$) or *H. bakeri* sex ratio ($p=0.283$). However, *H. bakeri* occupied more distal locations in the mouse small intestine if *R. microstoma* was given to the host first ($p=0.004$). For female *H. bakeri*, worms grew longer ($p=0.016$) and produced more eggs *in vivo* ($p<0.0001$) and *in vitro* ($p<0.0001$) when from a host where *H. bakeri* was given first or was alone in the host compared to infections where *R. microstoma* was given first. These data show that life history traits of parasites may vary due to presence of other parasite species in the host. Changes in parasite growth, reproduction, and distribution within host tissue can have important consequences to host-parasite transmission dynamics and to physiological changes experienced by the host itself.

P1.121 CLAIRARDIN, SG*; PAITZ, RT; BOWDEN, RM; Illinois St. Univ.; sgclair@ilstu.edu
Are estrogenic effects of bisphenol A due to inhibition of estrogen metabolism?

Bisphenol A (BPA) is a man made chemical that can disrupt endocrine signaling and is of particular public concern due to its wide use in the production of consumer products. Although some of the estrogenic effects of BPA have been described, little is known about the mechanism by which this chemical exerts its effects. One possible mechanism is through disruption of steroid metabolism. We hypothesized that the estrogenic effects of BPA are due to inhibition of estrogen (E2) metabolism. In the red-eared slider (*Trachemys scripta*), E2 levels in the yolk decline rapidly during the first 15 days of development. We predicted that BPA would inhibit this decline, leading to estrogenic effects such as the increased production of female hatchlings. To test this, ten clutches of eggs were divided as follows: two eggs were sampled at oviposition, two eggs were treated with vehicle only (ethanol) and the remaining eggs were treated with 0.1 µg of E2 in ethanol plus one of three doses of BPA (0, 1.0, or 10.0 µg). Eggs were then incubated at 27°C; on incubation days 2 and 12, one egg from each E2 treatment was sampled. Vehicle and any additional E2 treated eggs in the larger clutches were incubated to hatch. E2 was quantified in the yolks of eggs sampled on Day 0, 2, and 12. E2 administration did significantly elevate E2 levels in the day 2 eggs compared to the untreated day 0 eggs. By day 12, E2 had declined to similar levels in all groups. To determine the effects of BPA treatment on hatchling phenotype we will measure hatchling mass, plastron length, righting time, and sex. These parameters, along with information about steroid levels, will aid our understanding about the effects of BPA, as well as potential mechanisms through which it may exert its effects.

P1.140 CLARK, A.J.*; SUMMERS, A.P.; Clemson University, Friday Harbor Laboratories; aclark7@clemson.edu
Mechanical properties of the hagfish egg capsule

Hagfishes develop slowly within large eggs that normally function in environments of low temperatures, high salinities and pressures. To ensure embryonic survival, the egg capsule must withstand a suite of physical stresses while permitting transport of oxygen and waste. Therefore, the mechanical properties of hagfish eggs are important underpinnings to reproductive success. We performed quasi-static tensile tests to failure on the egg cases of the Pacific hagfish (*Eptatretus stoutii*) to determine strength and stiffness. Individual egg capsules were divided into four sections with each section corresponding to the mechanical property (strength or stiffness) and the direction of the applied load relative to the longitudinal axis of the egg (parallel or perpendicular). Data were collected from three batches of eggs originating from different animals. One batch included eggs contained within the ovary and the second and third batches consisted of deposited eggs (1 and 30 days old). All intact eggs were approximately 20 mm long, however the capsules of *in utero* specimens were less tan and lacked the polar anchor filaments present in deposited forms. Though mean strength (13.6 MPa), stiffness (14.3 MPa), and thickness (0.156 mm) were similar in both batches of deposited eggs, deposited eggs were significantly thicker, stiffer, and stronger than *in utero* eggs (thickness, 0.113 mm; strength, 8.5 MPa; stiffness, 3.5 MPa). Similar strength and stiffness in both directions relative to the egg's longitudinal axis suggests an orthogonal alignment of reinforcing collagen fibers in the capsule. These data show that internally developing hagfish eggs undergo a substantial increase in thickness, strength, and stiffness associated with tanning prior to deposition.

P1.107 CLAUSEN, R.C.*; FIELDS, P.A.; Franklin and Marshall College; rudy.clausen@gmail.com

Hyposalinity causes changes in gill protein expression in the ribbed salt marsh mussel *Geukensia demissa*

Geukensia demissa, the ribbed salt marsh mussel, is found along the east coast of North America from the Gulf of St. Lawrence to Northern Florida. In its intertidal habitat *G. demissa* is exposed to extreme changes in temperature, salinity, and hypoxia. Organisms exposed to environmental stresses, such as changes in salinity, may alter protein expression to maintain tissue function. To determine how protein expression changes in *G. demissa* in response to salinity, we acclimated mussels to 100% (35‰) artificial sea water (ASW), then exposed six individuals to 80%, 70%, 60%, or 40% ASW for 6 h, and allowed them to recover for 24 h in 100% ASW. Six control (100% ASW) individuals also were sacrificed after acclimation. Proteins extracted from gill tissue were detected by 2D gel electrophoresis. Thirty gels (6 replicates x 5 treatments) were analyzed using Delta2D gel image analysis software (Decodon). Using ANOVA, hierarchical clustering, and principle components analysis, we found little change in expression, compared to control, after exposure to 80%, 70% or 60% ASW. Exposure to 40% ASW, however, resulted in significant changes in protein expression (161 proteins up-regulated; 83 down-regulated out of 1178 detected protein spots). These results indicate *G. demissa* is able to withstand moderate reductions in salinity without large-scale changes in protein expression. More severe salinity change (40% ASW) leads to significant alteration in protein expression patterns. We will use tandem mass spectrometry to identify those proteins that change most significantly in expression after exposure to hyposalinity.

P3.89 CLEMONS, A*; FREESTONE, C; TONETTI, J; O'BRIEN, S; WINGFIELD, JC; Marian University, University of California, Davis; sobrien@marian.edu

Seasonal influence of kisspeptin on fine-tuning reproduction in the Puget Sound white-crowned sparrow (*Zonotrichia leucophrys pugetensis*)

All organisms must time breeding to appropriate times of the year that ensure the possibility for maximizing offspring survival. Migratory birds must time the onset of reproduction while making their way to their breeding grounds, which may or may not be conducive to breeding once they have arrived. Thus, individuals with challenges such as these must fine-tune the onset of full reproductive capability. Historically, the neuropeptide gonadotropin-releasing hormone (GnRH) was seen as the major player in beginning the orchestration of such events. However, the recently discovered neuropeptide, kisspeptin (KiSS) as been shown to be implicated in influencing GnRH-mediated release of the reproductive gonadotropin hormones, luteinizing hormone and follicle-stimulating hormone (LH and FSH respectively). Recent studies have shown peripheral and central injections of KiSS to have rapid and lasting effects on plasma LH levels in a variety of vertebrates. Here we examine whether jugular injections of KiSS in wild-caught Puget Sound white-crowned sparrows (*Zonotrichia leucophrys pugetensis*) influences plasma LH levels. We captured birds on their breeding grounds early and late in the breeding season, took a pre-injection blood sample at time 0, gave a bolus injection of KiSS, then subsequently took blood samples at 5, 10 and 15 minutes post-injection. Results show KiSS to have a rapid effect on plasma LH early in the breeding season when LH levels are highest, though KiSS fails to have an effect on plasma LH later in the breeding season as LH levels are dropping. These preliminary results may identify KiSS as a key player in the mechanisms that fine-tune early breeding events for a variety of seasonally breeding organisms.

P3.22 CLEMENT, Meredith L.*; BARTHELL, John F.; LIU, Lucy; PRESKY, Miyeon E.; REDD, JeAnna R.; WELLS, Harrington; University of Central Oklahoma, University of North Carolina, Chapel Hill, SUNY College at Oneonta, University of Tulsa; mclement@uco.edu

THE ROLES OF FLOWER COMPLEXITY AND REWARD QUALITY IN HONEY BEE FORAGING BEHAVIOR AT ARTIFICIAL FLOWERS

Honey bees (*Apis mellifera* L.) represent a model system for understanding the foraging dynamics of pollinators at flowers. In the current study we examined how honey bees made decisions when confronted with complex artificial flowers designed to simulate composite (asteraceous) flowers in nature. In order to do so, we varied cost and numbers of florets at each flower. A sucrose reward was deposited into the wells (representing florets) of the artificial flowers with the nectar volume being held constant at 2 µl per well. Each artificial flower was built with either one or four wells. Experiments were performed using 2M vs. 0.5M and 1.75M vs. 0.75M sucrose rewards in each flower type. When comparing artificial flowers with the same number of wells, the honey bees consistently chose the flowers that held the more highly concentrated (2M and 1.75M) sucrose rewards. When the reward was held constant and the number of wells was varied, the honey bees chose the simpler flower to visit. However, when both reward and well number were manipulated, the bees chose the higher sucrose concentration rewards even if the flower was more complex (4 wells). The handling and flight times of bees at flowers were also measured for both flower designs, and the complexity of the flower did not seem to limit the time that honey bees spent foraging at an artificial flower. These results have implications for understanding the foraging dynamics of honey bees in native and non-native habitats.

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Investigating the interaction between ghrelin and insulin on the endocrine control of appetite in the brain of tilapia (*Oreochromis mossambicus*)

Appetite is regulated by the coordination of many endocrine and non-endocrine factors. Further, several hormones that play a role in appetite are also known to play a regulatory role in metabolism in vertebrates. Ghrelin (GRLN) which stimulates appetite is also hypothesized to function as a metabolic signal in mammals. Conversely, insulin which exhibits hypoglycemic actions is known to amplify satiety and decrease food intake in mammals. Much is known about the individual appetite effects of GRLN and insulin in mammals. However, little is known about their regulatory roles in controlling appetite in fish. Therefore, this study was designed to investigate the effect of the appetite stimulant GRLN alone and in combination with insulin (an appetite inhibitor) in the tilapia (*Oreochromis mossambicus*). Fish were given a single intraperitoneal injection of tilapia GRLN-C8 (1 µg/kg), tilapia GRLN-C10 (1 µg/kg), insulin (1 U/kg), or a combination of either GRLN-C8 or -C10 (1 µg/kg) with insulin (1 U/kg). Tissue samples were collected 4 h post-injection. Neither form of GRLN alone or in combination with insulin exhibited any effect on brain NPY mRNA expression. Similarly, none of the treatments altered the mRNA levels of the GRLN-R (GHS-R1a). GRLN-C8 treatment significantly elevated brain mRNA levels of GRLN. The stimulatory effect of GRLN-C8 on GRLN mRNA levels in brain was significantly attenuated by the co-administration of insulin. These results provide evidence of a novel interaction between insulin and GRLN in regulating the hormonal mechanisms controlling appetite within the tilapia brain. This work was supported by the NSF (IOS-0639771) awarded to LGR.

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Prey choice in snakes may be influenced by temperature

Effectively distinguishing appropriate prey is a basic yet vital ability of all predators. For snakes, prey differentiation is primarily conducted by chemoreception when prey odors are transferred from the tongue to the vomeronasal organ. As with most ectotherms, snake physiological and behavioral functions vary with temperature and have received considerable attention; however, the effect of temperature on prey discrimination and prey preference in snakes remains relatively untested. We examined the ability of juvenile kingsnakes, *Lampropeltis getula*, to distinguish prey odors at 10, 15, 20, 25, 30, and 35°C. Snakes were tested on the following odors: rodent, reptile, fish, and distilled water. Odors were presented to individuals on sterile cotton swabs and tongue flicks, strikes, and latency to strike were scored for 60 seconds. As hypothesized, nonprey odors (i.e., fish and distilled water) resulted in few tongue flicks and low tongue flick attack scores over all temperature treatments while scores for rodent and reptile odors were significantly higher. No differences were observed between rodent and reptile odors at 25, 30, and 35°C, yet at 10, 15 and 20°C snakes preferred rodent odor over reptile odor. Feeding trials conducted at 10, 15, 17, and 25°C, confirmed a preference toward rodent prey over reptile prey at lower temperatures. Overall, the thermal performance curve on tongue flicks for preferred prey odors exhibited a similar shape to the few prior studies on prey preference in reptiles. Although dietary shifts in reptiles are common for multiple reasons (i.e., ontogeny and prey availability), this may be the first study to attribute prey choice to body temperature.

P3.7 CONDON, CH*; TRAPPETT, AG; WHITE, CR; WILSON, RS; The University of Queensland, Australia; c.condon@uq.edu.au

Costs and benefits of a sexually selected ornament in male threadfin rainbowfish, *Iriatherina werneri*.

Sexually selected traits are used as inter-specific signals of reproductive potential and mate quality. Theory predicts that females choose males that display elaborate sexually selected traits as they are considered to be reliable indicators of male quality. The exaggeration of male ornamentation is thought to be constrained by the costs of producing and maintaining these traits. Here we investigate the costs and benefits of an exaggerated sexually selected ornament in the male threadfin rainbowfish, *Iriatherina werneri*. Male *I. werneri* possess long thread-like extensions from the second dorsal and anal fins and a large fan-shaped first dorsal fin that are used in both courtship and male competition. To examine the benefit of ornamentation to males, we conducted male choice trials to determine whether males with larger ornaments were also more attractive to females. We also examined the costs of fin ornamentation by investigating both the metabolic cost of activity and maximum escape velocity for males with different size ornaments. We found that males with larger ornamentation received the most attention from females however larger fins were also costly, resulting in an increase in resting metabolic rate.

P3.37 COLEMAN, L.A.*; WILSON, P.S.; California State University, Northridge; lena.coleman.519@csun.edu

Moss floristics in Sequoia National Park

California, with its summer droughts, is considered one of the top five centers of endemism worldwide for bryophytes (mosses, liverworts, and hornworts). Yet in the Sierra Nevada the natural history of even the common species has never been cataloged. We are studying the bryophyte species and their niche characteristics along an elevation gradient in Sequoia National Park. The first stage is to produce a pictorial guide to the species with notes on their microsite characteristics and features of their mesohabitats. We wish to present this at the conference as a virtual poster shown on a computer as a slideshow with captions. The virtual poster shall conclude with a statement on how the patterns of habitat utilization seem to change from low to high elevation and possible explanations why.

P2.9 COPELAND, Donald*; SHAH, Shilp; LONDRAVILLE, Richard/L; University of Akron; londraville@uakron.edu

Response of Carp Leptin to Acute Cold Shock

The cytokine hormone, leptin, is involved in several energetically costly processes including thermogenesis, reproduction, immune function, and bone remodeling. The pleiotropic nature of this peptide hormone has also led researchers to examine its role in cold acclimation. In mammals, cold exposure has been shown to negatively affect leptin mRNA and serum protein concentrations, though the physiological significance of this response is still unknown. Recently, the mammalian homologue of leptin has been discovered in the common carp (*Cyprinus carpio*). Although little is known about leptin signaling in fishes, cold shock is an established stressor in carp and it is expected to decrease leptin production similarly to mammalian cold exposure responses. We tested the effect of cold shock on leptin-I gene expression by exposing koi (an ornamented variety of carp) to 10°C cold shock for 30 and 360 minutes. Cold shock significantly reduced hepatic leptin expression at 30 minutes and 360 minutes compared to controls. However, at 360 minutes, leptin expression increased significantly compared to the 30 minute group. These results suggest that, similar to the mammalian response, cold shock antagonizes leptin expression by curtailing leptin mRNA expression. The consequent rise in expression at 360 minutes suggests that koi acclimate to cold shock relatively quickly. It is not known whether plasma leptin concentrations reflect the changes seen in gene expression however, we are currently developing an ELISA for leptin-I using recombinant carp leptin produced in BL21 cells.

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The evolution of turtle shell kinesis: A comparative review

Recently discovered fossil evidence from the Triassic (220 MYA) suggests that the presence of the plastron preceded that of the carapace in the oldest known ancestral form of modern turtles. Beginning in the Tertiary, the shell underwent substantial diversification as turtles left the oceans to colonize terrestrial environments. Such diversifying events likely facilitated the evolution of shell kinesis as a structural adaptation enhancing predator defense, diet, and reproduction. Specifically, kinesis allows for the complete withdrawal of limbs, the opening of the anterior carapace to accommodate larger prey items, and of the posterior in species that lay large eggs. To frame shell kinesis within a systematic context, we review all currently available descriptions of turtle species and emphasize their position on a molecular phylogenetic tree. Additionally, we map the distributions of the taxa in question to draw biogeographical inferences. Our analysis suggests that palstral kinesis has evolved independently in families Kinosternidae, Emydidae, Geoemydidae, Pelomedusidae, and Testudinidae. Moreover, distinct variations of kinesis mechanisms occur among subclades of those families. Carapacial kinesis and pankinesis are less common but have arisen independently in the Testudinidae and Trionychidae, respectively. Moreover, kinesis appears independently in turtles in North and South America, Europe, Africa, and Asia. Thus, this adaptation in an iconic trait provides an excellent model of morphological convergence in a successful, globally distributed clade.

P2.114 COX, L.N.*; EMMER, S.A.; ZASLAVSKAYA, N.I.; MARKO, P.B.; Clemson University, Russian Academy of Sciences;
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Going all the way: Phylogeography and trans-Pacific divergence genetics of two rocky-shore snails

Although fluctuating climate over the last 2 million years (MY) repeatedly caused latitudinal shifts in species distributions, did the glacial-interglacial dynamics of the Pleistocene drive regional genetic differentiation and potentially speciation? For species whose distributions spanned the entire north Pacific, regional extinction of northern populations during cooler glacial periods may have resulted in isolation of eastern and western populations, potentially leading to trans-Pacific differentiation and speciation. To characterize patterns of east-west differentiation in rocky-shore species whose current (i.e. interglacial) distributions span the entire north Pacific, we have gathered genetic data from two intertidal gastropods, *Nucella lima* and *Littorina sitkana*. Although *N. lima* is present in Japan and Alaska, we failed to find it on the Kamchatka Peninsula, Sakhalin Island and the Sea of Okhotsk, suggesting a discontinuous distribution. MtDNA sequences from *N. lima* are reciprocally monophyletic with respect to eastern and western populations, suggesting an extended period of geographic isolation. In contrast, *L. sitkana* is continuously distributed across the entire North Pacific and lacks any obvious east-west mtDNA phylogeographic structure. Both species show a marked asymmetry in mtDNA diversity, with much higher sequence diversity in the west. To determine if differences in mtDNA genealogies actually reflect different population histories (rather than stochastic variation in gene tree coalescences), we have gathered data from several nuclear genes, which will presumably allow us to jointly estimate divergence times, gene flow, and effective population sizes between eastern and western populations with greater precision than mtDNA alone.

P3.21 CORNELIUS, JM*; HAHN, TP; HUNT, KE; WIKELSKI, M; Max Planck Institute, University of CA-Davis, University of Portland; cornelius@ucdavis.edu

Energetic expenditure in free-living red crossbills, *Loxia curvirostra*, using heart rate telemetry

Estimation of metabolic rate in free-living, behaving songbirds has recently been made possible with the development of heart rate telemetry. By fixing radio-transmitters that have been modified to detect heart rate to free-living songbirds we can estimate the metabolic cost of different life cycle stages. Red crossbills, (*Loxia curvirostra*), are opportunistic breeders and nomadic migrants that offer a unique opportunity to compare the metabolic costs of life cycle stages under very different environmental conditions (e.g., breeding in summer versus winter). As a first step in this long-term project, we measured heart rate in free-living red crossbills in Grand Teton National Park from July through September. This population did not breed due to a below average conifer seed crop, to which crossbills are specialized, but rather molted earlier than usual. We present heart rate data, foraging rates, habitat use and movement ecology of free-living male red crossbills from this below average food year and discuss these variables in the context of their unique opportunistic and nomadic annual schedules.

P3.28 COX, Christian L*; ANDERS, Michael B.; University of Texas, Arlington; clcox@uta.edu

Global patterns of body size in turtles

The influence of body size on species assemblage has been demonstrated for cosmopolitan groups of organisms that are both species rich and ecologically diverse. However, global patterns of body size for species-poor groups of organisms that are morphologically and/or ecologically restricted have not previously been assessed. We analyzed global body size distributions for turtles, and examined the roles of continental origin, insularity, evolutionary lineage, habitat use, and species richness in the structuring of body size distributions. We compiled body size and ecological data from the literature using multiple sources. Body size distributions were analyzed using distributional statistics, nonparametric tests and resampling statistics. We found that while the global and all continental body size distributions are structured in a similar form, fixed lineage effects lead to considerable variation in body size distributions among families. For global, continental and family body size distributions there is evidence of a strong minimum limit on body size that suggests the external shell is a biomechanical constraint at small sizes. We found that body size distributions for both insular and terrestrial species are influenced by the evolution of large body size by many insular terrestrial turtle species, primarily those of the family Testudinidae. Additionally, the negative relationship between species richness and body size suggests either higher diversification rates of turtles with small body sizes or greater extinction probabilities of large bodied turtles.

P1.160 CRANDELL, KE*; HERREL, A; AUTUMN, K; LOSOS, JB; University of Montana, CNRS/ Museum National d'Histoire Naturelle, Paris, Lewis & Clark College, Harvard University; kristen.crandell@umontana.edu

Frictional adhesion and toe pad micro-morphology of *Anolis*

Dry fibrillar adhesives that allow an organism to attach to a surface have evolved convergently at least three times within squamata. Adhesive toe pads consist of modified subdigital scales that contain microscopic hair-like structures (setae) that facilitate a strong bond with a substrate via weak molecular van der Waals forces. Little is known about how variation in toe pad microstructure contributes to adhesive performance at the organismal level, however. The adhesive system of the *Anolis* clade offers the opportunity to explore aspects of seta morphology independent of spatula density, unlike the gecko attachment system, in which each seta bears many spatulae. Physical models of seta-surface interaction suggest that micro-scale geometry will dictate the limits of toe pad performance. Because the squamate adhesive is fibrillar, it may behave as a pressure sensitive adhesive by meeting Dahlquist's criterion for tack with a Young's modulus of less than 100 kPa. Here, we present morphological data that allows us to predict the effective Young's modulus. Our data suggest anole setae have an appropriate effective modulus to allow us to model setae as cantilever beams. By taking a comparative approach and incorporating organismal-level adhesive performance data for 14 species of anole, we test predictions associated with the cantilever model. Preliminary analysis indicates a positive correlation between stress and setae length, consistent with a cantilever model of fibrillar adhesive.

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Poisson's Ratio of Crustacean Exoskeleton

The crustacean exoskeleton is constructed from a stacking plywood arrangement of the chitin fibers connected by cross-linking proteins and hardened by mineral deposits. When an animal out-grows its exoskeleton, it is shed and the new underlying exoskeleton is inflated and hardened through additional protein cross-linking and mineral deposition. This study examines how the structure of the chitin matrix of crustacean exoskeletons affects the material properties of the exoskeleton, specifically the Poisson's ratio. The Poisson's ratio describes how a material behaves along lengths perpendicular to a plane of deformation. Most materials have a positive Poisson's ratio. This means, for example, that when a material is stretched along one axis, the perpendicular axes will shorten. In contrast, some manufactured materials have negative Poisson's ratios, meaning that these materials expand in all dimensions when stretched, due to the arrangement of their microstructures. This microstructure arrangement appears to be similar to the stacking plywood/honeycomb pattern of the chitin matrix in the crustacean exoskeleton. To test the Poisson's ratio we used store bought shrimp, *Penaeus sp.* Samples of exoskeleton were taken from the pleuron and tergum of abdominal segments one, two, and three. Samples were tested under tension using an MTS Synergie, and the change in length perpendicular to the tensile forces was measured with an extensometer. In contrast to previous studies on other crustacean exoskeletons, we found that the samples demonstrated a negative Poisson's ratio. In industry, it has been shown that negative Poisson's ratio materials have high energy absorption and high resistance to fracture. Therefore, a negative Poisson's ratio in crustacean exoskeleton has some interesting ramifications for our understanding of crustacean ecology.

P3.53 CRAWFORD, S.*; SADDLER, C.; CATAPANE, E.J.; CARROLL, M.A.; Medgar Evers College, Brooklyn; catapane@mec.cuny.edu

Toxic Effects of Manganese on Mitochondrial Respiration and Mitochondrial Membrane Potential in Gill of the Bivalve *Crassostrea virginica*

Manganese (Mn) is an essential metal that at high levels in brain produces Manganism. The mechanism of action of is not completely understood but may be related to oxidative stress and damage to dopaminergic systems in people. Previously, we showed cilia of lateral cells of gill of *Crassostrea virginica* are controlled by serotonergic-dopaminergic nerves. Mn disrupts the cilio-inhibitory dopaminergic system. We studied effects of Mn on mitochondria from gill using a YSI Micro-Biological Oxygen Monitor. Mn caused dose dependent decreases in O₂ consumption that was blocked by pretreating with 1 mM of calcium disodium EDTA (EDTAcA) or p-Aminosalicylic Acid (PAS). Both drugs are being tested as therapeutic agents for Manganism. Adding EDTAcA or PAS to Mn treated mitochondria partially reversed the toxic effects of Mn. In other experiments we studied effects of Mn on mitochondrial membrane potentials using the anionic oxonol-based membrane potential-sensitive fluorescent dye, HLB021-152, which increases fluorescent intensity upon depolarization of the mitochondrial membrane. Fluorescence was measured in a Molecular Devices SpectraMax M5 Plate Reader. Mn decreased mitochondrial membrane potential. The decrease was partially blocked by co-treatment with PAS. The study shows Mn reduces oxygen consumption and causes depolarization of mitochondrial membrane potentials. The EDTAcA was an effective blocker against the effects of Mn and may be beneficial in reversing negative effects of Mn accumulations. The ability of PAS to ameliorate symptoms of Manganism is postulated to be related to its chelating actions and our results corroborated this. The work was supported by grants 2R25GM06003-05 of NIGMS, 0516041071 of NYSDOE, 0622197 of NSF and P382A080040 of the USDE.

P1.142 CRYNES, GL*; AZIZI, E; ROBERTS, TJ; Brown University; gavin_crynes@brown.edu

Variable gearing in artificial pneumatic "muscles"

In pinnate muscles, fibers are oriented at an angle to the muscle's line of action and rotate as they shorten, becoming more oblique throughout a contraction. This change in fiber orientation decouples the shortening velocity of a fiber and the output velocity of the muscle tendon unit (MTU). Fiber rotation can provide a velocity advantage by increasing the gear ratio (MTU velocity/Fiber velocity) with which a muscle operates. However, this velocity advantage comes at a cost to force since a smaller component of the fiber force is oriented along the line action. A recent study has shown that a muscle's gear ratio varies depending on the load such that a muscle operates with a high gear during rapid contractions and low gear during forceful contractions. Here, we examine whether a similar automatic gearing mechanism can be replicated in artificial pneumatic "muscles". We used McKibben actuators, which shorten in tension when filled with compressed gas. Similar to real muscle fibers, the actuators expand radially during shortening to maintain a near constant volume, a feature known to be a critical part of the variable gearing mechanism in pinnate muscles. We used an array of McKibben actuators, oriented spatially to mimic a pinnate muscle, to quantify the system's gear ratio when acting against a range of loads. Video was used to measure the gear ratio during each contraction. Similar to pinnate muscles, the gear ratio decreases significantly with increasing load. Variable gearing results from load-dependent variation in actuator rotation, as has been demonstrated for natural muscles. We show that variable gearing can be mimicked by an artificial pneumatic muscle system and suggest that actuator designs inspired by pinnate muscle architecture may provide a significant performance advantage. Supported by NIH AR054246 to EA.

P3.1 CUNNINGHAM, Christopher/B*; CARRIER, David/R;
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How is the Primate Brain influenced by Physical Competition's Intensity?

Primates have relatively large brains. Physical male-male competition may have helped drive enlargement of the primate brain because aggressive conflicts entail extensive cognitive interactions; including perception, assessment, reasoning, and neuromotor coordination. This leads to the question: Do primate species that exhibit higher levels of physical male-male competition intensity have larger relative brains sizes. To address this prediction, we examined the correlation between brain size and three reliable indicators of physical male-male competition intensity: body mass-/canine height-sexual dimorphism, and relative male maxillary canine height. Analyses were conducted with phylogenetically independent contrast values. Significant, positive correlations exist between brain size and body mass sexual dimorphism within All Primates, Strepsirrhines, Haplorhines, New World monkeys, and Old World monkeys. Significant, positive correlations were also seen between brain size and maxillary canine sexual dimorphism within All Primates, Haplorhines, and Old World monkeys. In conclusion, brain size is positively correlated with male-male competition overall; however, there can be some variability within specific phylogenetic sub-groupings. These correlations are consistent with the hypothesis that sexual selection pressures due to physical competition among males are partially responsible for the large brains of primates.

P3.18 CURTIS, N.E.*; PIERCE, S.K.; SCHWARTZ, J.A.;
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An Ultrastructural Comparison of Cells Lining the Digestive Diverticulum of 4 Sacoglossan Species of Differing Kleptoplastic Abilities

Certain species of the sea slug group Sacoglossa incorporate intact, functional chloroplasts from their algal food sources into specialized cells lining the digestive diverticulum. Most slug species are unable to maintain these plastids for more than a week. However, in *Elysia clarki*, the chloroplasts are photosynthetically functional for many months and there is evidence that at least 1 nuclear encoded, algal gene for a chloroplast protein has been horizontally transferred into the slug genome. *E. clarki* can feed on species from several ulvophytic genera, including species of the Bryopsidlean genera *Penicillus* and *Bryopsis*. Other sacoglossans (*E. patina*, *E. rufescens*, and *P. kingstoni*) share algal food sources with *E. clarki*, but are unable to maintain the chloroplasts for more than a week, with *P. kingstoni* apparently being unable to maintain chloroplasts for more than 24 hrs. We have performed extensive ultrastructural analysis on the chloroplast sequestering cells of these animals looking for morphological differences that may account for the variations in chloroplast sequestering and maintenance amongst sacoglossans. Our results indicate that *P. kingstoni* does not actively sequester chloroplasts, digesting them instead. However, the sequestering mechanisms of *E. patina* and *E. rufescens* are similar to *E. clarki*, and therefore the differences in sequestered chloroplast longevity may be explained by the presence or absence of transferred algal genes.

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Variation in critical thermal maxima of eastern narrowmouth toads, <1>*Gastrophryne carolinensis*1>;, over a latitudinal gradient

Critical thermal maxima (CTM) were determined for adult eastern narrowmouth toads, <1>*Gastrophryne carolinensis*1>, in four populations located along a latitudinal gradient from southern Kentucky to mid-Florida. At 30 C acclimation, eastern narrowmouth toads in more southerly populations usually had higher CTM's than those in more northerly populations. Among populations, toads in the mid-Florida population had a significantly higher CTM than those in southern Georgia, which in turn had a higher CTM than toads in a NW South Carolina population. However, eastern narrowmouth toads in a southern KY population had a similar CTM as those in the Florida population and a higher CTM than the other two populations. At 20 C acclimation, populations did not show a significant difference, but the KY population had the highest CTM. The high CTM of the KY population may be influenced by variables other than latitude, such as the type of microhabitat where the frogs occur. Here the puddles were more open and exposed to sunlight, and thus were likely exposed to higher developmental temperatures for eggs and tadpoles. These factors may have contributed to the higher CTM observed in these populations.

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Diverse antifreeze proteins as models for adaptive protein evolution

The threat of organismal freezing in the ice-laden Polar marine environment has driven the evolution of specific biochemical adaptations in the resident fauna. Unlike hypoosmotic teleost fishes which are known to be protected against freezing by antifreeze proteins, marine invertebrates are isoosmotic to seawater and therefore have long been considered immune to freezing due to the colligative freezing-point depression of their fluids. Although being isoosmotic may partially explain survival of invertebrates in Polar waters, the countless species that encounter ice and supercooled water require supplementary adaptations. Expression of antifreeze proteins (AFPs) may be one mechanism by which invertebrates survive the harsh polar environment. My surveys of many polar macroinvertebrates have revealed a diverse but entirely Polar distribution of AFPs. My initial characterizations of invertebrate AFPs suggest that they may have evolved from a common protein ancestor in some lineages, but other species appear to have arrived at independent solutions to the problem of freezing-avoidance. The evolution of antifreeze proteins in response to environmental cooling over geologic timescales is an exemplary example of adaptive protein evolution. AFP purification and sequencing followed by genomic analyses in a comparative and phylogenetic context is expected to result in the reconstruction of the pathways of protein evolution in these models.

P2.64 DARDA, D.M.; Central Washington University; dardad@cwu.edu

Vertebrate morphology in the biology curricula of four-year colleges and comprehensive universities: observations, data, and a suggestion

In general, as biology departments at four-year colleges and comprehensive universities have bolstered the curriculum in cell and molecular biology and emphasized the increasing importance of ecological study, the amount of curricular space for organismal level courses has decreased. In the anatomical realm, classical embryology and histology have been pushed aside to make room for other priorities. Each of the few remaining courses offers a limited view of vertebrate morphology as a whole. Given that students struggle to make room for even a single anatomical course in their undergraduate program, they are left with an incomplete perspective on animal form and function and are potentially underprepared for the rigors of medical school and other professional programs. In this poster, I summarize initial data resulting from an informal survey I conducted among the four-year institutions in Washington State and suggest how the undergraduate vertebrate morphology curriculum might be modified to meet student needs given the constraints of staffing and time.

P3.127 DAVIES, S. *; SWEAZEA, K. L.; DEVICHE, P. ; Arizona State University, Tempe; Scott.Davies@asu.edu

The influence of acute and chronic stress on plasma glucose of a desert songbird

A regularly cited adaptive value of the avian stress response is the mobilization of energy stores to enable behavior aimed at increasing chances of survival. It is commonly accepted that this mobilized energy comes mainly in the form of glucose. However, the notion of acute stress-induced hyperglycemia is largely based on studies in captive rodents, with only a handful of studies on captive European Starlings and no data available on free-ranging birds. Furthermore, based on studies in chickens, chronically elevated corticosterone, the primary stress hormone in birds, is thought to elevate plasma glucose concentration by mobilizing endogenous glycogen stores and inhibiting glucose uptake by tissues. Yet little data is available on the affect of chronic stress on plasma glucose in wild birds. We investigated acute stress-induced changes in plasma glucose of free-ranging Abert's Towhees, *Pipilo aberti*. In captivity, we then mimicked chronic stress conditions in these same birds by treating them with corticosterone-filled Silastic capsules. We predicted that acute stress would fail to elicit a hyperglycemic response but chronic corticosterone administration would increase plasma glucose. Consistent with studies of other captive birds, 60 minutes of handling and mild restraint failed to elicit a hyperglycemic response. Furthermore, corticosterone-treated towhees experienced a decrease in body weight, but plasma glucose in these birds did not differ from that of controls. These data suggest that the primary energy source mobilized to mount a stress response in birds may not be glucose.

P1.135 DAS, S.*; HOPKINS, P.M.; KHAMBADAKONE, D.; DURICA, D.S.; Univ. of Oklahoma; sunetra.das-1@ou.edu
RNAi mediated disruption of ecdysteroid signaling during limb regeneration in the fiddler crab, *Uca pugilator*.

Growth, molting, limb regeneration and reproduction in crustaceans are regulated by arthropod steroid hormones, ecdysteroids. To study the role of ecdysteroid signaling during limb regeneration in fiddler crabs, we have applied RNAi (dsRNA) mediated silencing of *UpEcR* and *UpRXR*, which encode the functional heterodimer ecdysteroid receptor. The silencing of receptors should disrupt ecdysteroid signaling. Silencing was evaluated by receptor knockdown, and disruption was evaluated by changes in growth rate and morphology of limb regenerates. In these experiments, both *EcR* and *RXR* dsRNA (200ng/200nl), were injected into the blastemal chamber on days four and seven following autotomy. RT-PCR results indicated a two-fold knockdown of both *UpEcR* ($p=0.001$) and *UpRXR* ($p=0.003$) in day nine blastemas. Previously, we have shown that injections with either dsEcR or dsRXR into the blastema led to a significant drop in circulating ecdysteroid titers. Lowered ecdysteroids were also observed in crabs injected with both dsEcR and dsRXR. Taken together with the previously reported effects of RNAi on contralateral uninjected limb buds, these results suggest that RNAi has a systemic effect. In addition, 62% of dsRNA injected limb blastemas failed to emerge and progress towards blastemal growth as compared to 5% of control blastemas. Preliminary hematoxylin and eosin staining of the arrested blastema have shown absence of cuticular ingrowths that may be due to lack of cellular proliferation and differentiation. Although some of the dsRNA injected blastema progressed towards basal and proecdysial limb growth, the crabs failed to molt and died whereas control crabs molted and regenerated limbs. The failure to molt after dsRNA injections in the crab implies a sustained systemic effect.

P1.161 DAWSON, Tricia*; JINDRICH, Devin L; Arizona State University; tadawson@asu.edu

Mechanical properties of rat hindlimbs during locomotion

Rodents, and rats in particular, are currently the preferred animal model used to study neuromotor injuries such as spinal cord injury. Despite the fact that locomotion is the most common functional assessment used, the mechanics and motor control of rodent locomotion have not been extensively studied. For example, although at high speeds rats exhibit whole-body spring-mass mechanics, it is unclear whether rats exhibit inverted-pendulum dynamics at low speeds similar to other quadrupeds. Moreover, the mechanical leg and joint mechanics during rat locomotion have not been extensively described. We measured kinematics and single-leg force production during running in laboratory rats to characterize joint- and limb-level mechanics. Rats ran along a horizontal trackway in which a small force platform (AMTI HE 6x6) was mounted. Ground-reaction forces from individual hindlimb steps were recorded. Video recording of leg and body markers using two cameras allowed for three-dimensional analysis of leg and joint mechanics. Preliminary results suggest that rat legs are compliant over a wide range of speeds. The results from these experiments will provide specific control targets for impedance-based functional electrical stimulation systems currently under development using a rodent model.

P3.109 DE LEEUW, J.R.*; PORTER, M.E.; LIVINGSTON, K.R.; LONG, J.H.; Vassar College; jodeleew@vassar.edu
Evolving Intelligence in Autonomous, Fish-like Biorobots: Does Competition for Resources Matter?

We are interested in understanding how different selection environments drive the evolution of intelligence in aquatic animals. Because many of the character changes in early vertebrates appear to have enhanced mobility, we contrasted selection environments in which resources were scarce or bountiful. If greater intelligence, relative to other individuals in the population, is required to forage in a scarce-resource environment, then the population will evolve greater foraging intelligence compared to the population in the bountiful-resource environment. To model this system, we evolved two populations, one in each resource environment. Each population consisted of ten autonomous and physically-embodied biorobots, called NERDs (NeuroEvolving Robotic Device). Individuals differed only in their genomes, which coded for the topology of a neural network. The neural network converted sensor inputs from an infrared proximity detector array and from a photocell array into motor output at the flapping tail. The fitness function was the difference between the amount of photic energy harvested and the energy used to swim. Preliminary results indicate that a variety of foraging strategies evolve. This work was supported by NSF DBI-0442269 and IOS-0922605.

P2.101 DEMAINTE, Marta J.; Univ. of Hawaii, Hilo; demainte@hawaii.edu
Systematics and evolution of Panamic Anachis and related taxa (Neogastropoda: Columbellidae)

Columbellid gastropods are a highly diverse group of marine neogastropods, comprising over 600 nominal species worldwide. In the Panamic region, about 45 species are common epibenthic members of intertidal to shallow subtidal communities. Though common, the systematic relationships of these species have never been objectively addressed. The objective of this project, which started during a workshop on the Phylogeny of Neogastropods sponsored by the Smithsonian Institution and hosted by the Smithsonian Tropical Research Institute in 2006, is to investigate the systematics and evolution of the nearshore Panamic columbellid taxa, especially from the genus *Anachis* and its nominal relatives *Costoanachis*, *Parvanachis*, and *Glyptanachis*. These are among the most diverse of the regional columbellid fauna, comprising about one third of the known Eastern Pacific and Western Atlantic species, and they are largely restricted to the region. Membership in these taxa is presently based primarily on shell sculpture. Results of systematic analysis based on anatomy and morphology suggest revision of the taxonomy of these well-known taxa, though some aspects of the traditional taxonomy are supported. This revisionary work is also being expanded to include western Atlantic taxa as well, such that a more accurate picture of the evolution of this group during closure of the Isthmus of Panama will result.

P3.17 DELAVAN, Sarah K.*; WEBSTER, Donald R.; Georgia Institute of Technology; gth900g@mail.gatech.edu
Field boundary layer characteristics as modified by clams in habitats of varying survival rates

Previous observations indicate that clam survival rates are higher in and around both oyster beds and sea grass beds than survival rates recorded for mud flats. Flow characteristics in these regions may influence predation rates by creating a refuge from predation. In this regard, clam presence and behavior has the potential to modify the boundary layer momentum distribution and alter the flow refuge from predation depending on the turbulence characteristics of the background flow. To determine the effect of the presence and pumping behavior of the bivalve clam, *Mercenaria mercenaria*, on the boundary layer momentum distribution, velocity profiles were collected for flood tides in the tidal rivers adjacent to Wassaw Sound, Georgia, USA. Velocity profiles were collected simultaneously with two adjacent Acoustic Doppler Velocimeters for boundary layer flows above sediments with and without the presence of buried clams. Treatment sites included clams buried in mud sediments, sand sediments, downstream of oyster beds, and downstream of sea grass beds. Vertical profiles of mean velocity, turbulent kinetic energy, and Reynolds shear stress are calculated from the collected time records. We hypothesized that the modification of the vertical profiles is unique to the treatment characteristics. Preliminary analysis suggests that flows downstream of sea grass and oyster beds are less affected by the presence of clams than flows over sand and mud flats. Clam presence reduced the velocity above mud substrates in all three coordinate directions compared to the adjacent measurements without clams present, particularly close to the substrate. Conversely, clams in sand sediments increase the average velocity.

P3.130 DESCAMPS, Emilie*; BUYTAERT, Jan; ADRIAENS, Dominique; DIRCKX, Joris; Ghent University, Belgium, Antwerp University, Belgium; dominique.adriaens@ugent.be
High-resolution and non-invasive 3D-visualisation of soft tissues in vertebrates - the use of OPFOS

Three-dimensional visualisation tools have been applied in biological sciences for decades, generally relying on destructive histological protocols. It is only with micro-CT-scanning becoming readily accessible that non-invasive 3D-visualisation has become popular in biology. At its best, resolution achieved in micro-CT nowadays approaches that of standard histological techniques. Apart from bone, even soft tissues can be made visible through micro-CT-scanning, however, discriminating between structures of the same tissue as well as between different tissue types remains a challenge. An alternative approach, which seems yet to be explored to its full potential, is Orthogonal-Plane Fluorescence Optical Sectioning microscopy (OPFOS). This method is for instance used for studying the suspensory tissues and bones of the middle ear, but has not yet found its way in many other fields of biology. To test the potential of this method for discrimination between different types of tissues, as well as different structures of the same tissue type, we applied this technique to stage 46 tadpoles of *Xenopus laevis*. Three-dimensional reconstructions were generated using Amira, and compared to reconstructions made using serial histological sections. In this poster, an overview is given of the pros and cons of both techniques, with a discussion on their applicability for a wider scope of biological research.

P3.58 DHILLON, R.S.*; SCHULTE, P.M.; University of British Columbia; dhillon@zoology.ubc.ca

Variation in mitochondrial properties in the muscle of two sub-species of killifish, *Fundulus heteroclitus*, during thermal acclimation.

Killifish, *Fundulus heteroclitus*, inhabit salt marshes and estuaries along the Atlantic coast of North America from New Brunswick to northern Florida. Previous studies have detected differences in metabolic rate between northern and southern sub-species of killifish. In this study, we explain these differences in metabolism by comparing factors that influence mitochondrial properties. Fish of each sub-species were acclimated to 5, 15, and 25 °C. Adenylate status (indicative of signals activating the mitochondria), cytochrome oxidase and citrate synthase enzyme activities (indicative of mitochondrial content), and lactate dehydrogenase and creatine kinase enzyme activity (indicative of cytosolic metabolic capacity) were measured. Whole-body fiber typing and capillary density was used to compare muscle ultrastructure in the two sub-species. Mitochondrial enzyme activities were greater in the northern sub-species at all but the highest acclimation temperature, suggesting higher mitochondrial content in cold adapted northern fish. The relative proportion of oxidative:glycolytic muscle fibers were larger in the northern sub-species than the southern sub-species at all acclimation temperatures. Mitochondrial volume density and cristae surface density were also analyzed using TEM. Together these data suggest that differences in metabolic rate are related to differences in mitochondrial properties.

P2.149 DOHERTY, Alison R. H.*; ROBL, Nick J.; VINYARD, Christopher J.; Northeastern Ohio Universities Colleges of Medicine; ahdoherty@gmail.com

Preliminary analyses of blood serum to assess bone maintenance in wild woodchucks (*Marmota monax*) before and after hibernation

Long periods of inactivity in most mammals result in significant bone loss that may not be completely recoverable during an individual's lifetime regardless of changes in activity. Prolonged inactivity is the norm for hibernating animals, but it is largely unknown whether they suffer from adverse bone health after hibernation that affects their ultimate survival. We examined blood serum calcium and inorganic phosphate as indicators of bone metabolism before and after hibernation in a preliminary sample (n=18) of wild-caught woodchucks (*M. monax*) to test the hypothesis that these metabolites are altered with hibernation reflecting bone maintenance. Animals were live trapped in Ohio between April and October. Blood samples were collected from the external jugular vein and serum stored at 4 °C. Metabolite concentrations were read on a spectrophotometer within 7 days using Pointe Scientific calcium Arsenazo and inorganic phosphate liquid reagent kits. There was no significant difference in calcium levels pre- and post-hibernation (i.e., April-May versus Sept.-Oct.), however there was a significant increase in calcium levels during June and July compared to pre- and post-hibernation months (p < 0.001). Inorganic phosphorous did not change significantly between seasons. Based on the preliminary data from the two metabolites, we suggest that bone is not lost during hibernation in woodchucks, but that bone metabolism is increased during the summer. Ongoing analyses, aimed at quantifying other bone-specific serum concentration levels (including osteocalcin, calcitonin, leptin, and osteoprotegerin) will provide additional insights into the details of how woodchucks maintain bone during hibernation.

P1.7 DIXON, JM*; ALLEN, JD; Randolph-Macon College, College of William and Mary; jmdixon23@gmail.com

The role of encapsulation in the marine gastropod, *Nucella lapillus*.

Organisms that live in rocky intertidal habitats experience highly variable environments and have evolved reproductive strategies to cope with these harsh conditions. For intertidal gastropods, encapsulation of embryos is one answer to the reproductive challenge of development in both air and water. Encapsulation is often thought of as protection from predation or desiccation, but may also protect against bacterial attack, temperature shock or wave forces. Few studies have examined whether encapsulation protects embryos from predation. We conducted laboratory and field studies to test the relative levels of predation on encapsulated and unencapsulated embryos of the intertidal snail, *Nucella lapillus*. The offspring of *N. lapillus* hatch directly as juveniles, bypassing a mobile larval stage. Since *N. lapillus* egg capsules remain fixed to the benthos for 2-4 months, morphological protection of the egg capsule, chemical protection through reduced palatability or adult behaviors that determine laying location may all aid in juvenile survival. We designed our experiments to distinguish between the following combinations of morphological and chemical defenses: (1) egg capsules are highly protective and embryos are tasty, (2) egg capsules are highly protective and embryos are distasteful, (3) egg capsules are not protective or weakly protective and embryos are distasteful, and (4) egg capsules are not protective or weakly protective and embryos are tasty. We found high levels of predation both in the field and in the lab on all baits regardless of encapsulation or flavoring. Future directions will explore the idea that the capsules do not provide protection from predation and that adult behaviors determining capsule location may be more important to egg capsule survival.

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A comparative method approach to estimation of heritability with inbred strains

Quantitative genetic studies, now applied to an increasing number of species, remain challenging to do with outbred populations. Thus, use of inbred lines continue to be an important resource for establishing genetic based differences of complex phenotypes. Heritability and genetic correlations from inbred lines are obtained either by controlled crosses or by one-way analysis of variance of strain means. Just like in comparative studies of species, however, this approach assumes statistical independence among the inbred strains. The actual (or estimated) phylogenies available for most inbred strains (e.g., mice, rats) resemble hierarchical species phylogenies and only in special cases do they take on a star, non-hierarchical topology. Thus, the lack of independence among strains will lead to inflated degrees of freedom and invalid estimates of standard errors. Here, I show how use of phylogenetically based methods can be used to improve heritability and genetic correlation estimates from inbred strains, with examples of mice and rat interstrain variation in aerobic capacity.

P2.38 DOUGLAS, Hector/D*; SPRINGER, Alan/M; BUDGE, Suzanne; AUCOIN, Lacey; University of Alaska Fairbanks, Kuskokwim, University of Alaska Fairbanks, IMS, Dalhousie University, Dalhousie University; hddouglas@yahoo.com
Fatty acid and stable isotope analyses explain variability in ecosystem productivity and consumption patterns of top predators

The utility of seabirds as environmental indicators depends upon the sensitivity and resolution of the scientific tools employed as well as the ecology of the animals. Planktivorous auklets occupy a trophic niche close to the base of the marine food web and may serve as sensitive indicators of climate-induced change. We discuss how the combined application of stable isotope and fatty acid (FA) analyses with this guild can help explain variability in ecosystem productivity and consumption patterns of top predators. We tested for differences in diets among crested and least auklets (*Aethia cristatella*, *A. pusilla*) in the Bering Sea at several levels (interdecadal, geographic, seasonal). Interdecadal differences in stable isotope composition (C, N) at Little Diomedea I. in the northern Bering Sea exhibited a pattern similar to the trend observed in bowhead whale baleen. Auklet FA profiles exhibited seasonal and geographic patterns that contrast dependence upon local versus advected production. As we predicted, there were interspecific differences in FA profiles that could readily be discriminated at all levels of comparison. Contrary to predictions and assumptions in the literature, adult auklet diets differed significantly from chicks. The results of this preliminary study illustrate the power of these techniques to discriminate patterns from the fine scale to the global in populations of these top predators and the marine food web. Hence, these tools have utility for studying climate induced change in the northern oceans.

P1.2 DUBIN, Matthew E*; WEISS, Stacey L; Univ. of Puget Sound; medubin@gmail.com
The effect of female ornamentation on aggressive male-male interactions in the striped plateau lizard (*Sceloporus virgatus*)

The intensity of male-male competition is hypothesized to be influenced by the quality of the contested resource. When competing for females, that quality may be signaled with sexually selected female ornamentation. In the striped plateau lizard (*Sceloporus virgatus*) females develop ornamental orange throat patches before ovulation, and previous research has shown that the more ornamented females are of higher phenotypic quality and also produce offspring with higher phenotypic quality. Therefore, we hypothesize that variation of the female ornament influences the intensity of male-male competition. Beginning approximately twenty days before ovulation, lizards were captured and held in groups of two males and one female for five days, such that all three lizards were in separate cages and the males could see the female but not each other. Males were then placed in the female's cage and videotaped for twenty-minutes (n = 51). Male aggression was quantified using an ethogram and each aggressive behavior was weighted using Principle Component Analysis. Male aggression was found to be uncorrelated with female patch area, hue, brightness or chroma (p > 0.05). These results indicate that male-male aggression during the breeding season is not influenced by the female ornament. Past research has found that the intensity of male-male aggression increases in the presence of a female. Further research is needed to determine how variation in the intensity of male-male competition is influenced by female or environmental cues.

P1.18 DREWRY, M.D.*; WILLIAMS, J.M.; HATLE, J.D.; University of North Florida; m.drewry@unf.edu
Effects of reduced dietary intake and reduced reproduction on longevity in the lubber grasshopper
 Many studies that use reduced dietary intake to produce longevity have not been able to separate the effects of reduced reproduction that correspond to the reduction in diet. A previous study on grasshoppers has shown that ovariectomized females (OVX) can live up to 30% longer than fully reproductive controls (sham). A separate study showed that grasshoppers subjected to dietary restriction (60-70% *ad libitum*; DR) live >50% longer than *ad libitum* fed controls (FD). With this study we have combined these two manipulations to test the life spans of: OVX & DR; OVX & FD; sham & DR; sham & FD. This will allow us to determine whether the treatments are additive, which would suggest that they extend lifespan in separate ways. To date, only 12.5% have died, so survivorship curves cannot be reported. However, there are strong independent effects of diet or surgery on body mass (P > 0.01), but little effect of the interaction of diet and surgery on body mass. Reproductive data from the sham groups shows a decrease in the number of eggs laid per clutch in response to DR (P < 0.0004), but no change in age at reproduction (P > 0.4999). These data suggest that our DR treatments are effective at limiting the nutrition of the grasshoppers, and that DR is reducing reproductive output but not delaying reproductive timing. In addition, there is no significant difference in the total antioxidant activity of the hemolymph among any of the groups at ~100 days (P > 0.25). Survivorship and reproductive output data will be discussed in terms of whether or not OVX and DR are additive and extending lifespan in different ways. An additional treatment of partial ovariectomy will help determine whether the level of reproduction corresponds to longevity, or if any non-zero reproduction shortens lifespan.

P3.43 DUEÑAS, L.F.*; SANCHEZ, J.A.; Universidad de los Andes, Bogotá, Colombia; lf.duenas161@uniandes.edu.co
Are modular characters labile in deep-sea bamboo corals?
 Character lability has been associated with morphological traits that appear multiple times in the tips of a given phylogeny. Labile traits could confer advantages for adaptation to specific ecological opportunities. Given that shallow-water octocorals exhibit character lability, it is reasonable to expect the same pattern in deep-sea octocorals. Bamboo corals (Octocorallia, Isididae, Keratoisidinae), long-lived deep-sea organisms, are characterized by a noticeable modularity that coined diverse branching morphologies. Ribosomal sequences (16S mtDNA and ITS2 nDNA) were obtained to depict the Keratoisidinae phylogenetic relationships and character lability for some New Zealand bamboo corals. In addition, an ancestral character state reconstruction was accomplished for twelve morphological characters. Keratoisidinae genera were polyphyletic and none of the selected morphological characters exhibited character states forming monophyletic groups in the molecular phylogenies. The lack of monophyly shown by the continuous gains and losses of the character states comprised robust evidence for trait lability in bamboo corals. However, it is possible that these deep-sea octocorals exhibit also phenotypic plasticity associated with continuous characters, given that they can respond to environmental variation. An exploration of the different mechanisms leading to modularity and character evolution, in bamboo corals, is needed. In addition, these findings have a direct impact on Isididae systematics because modular morphological characters are the basis for their taxonomy.

P3.77 DUFEAU, DL*; WITMER, LM; Ohio University; dd299405@ohio.edu

Acoustic resonance of the middle-ear in Alligator-implications for behavioral correlations.

The middle-ear space of crocodylians, and the pneumatic diverticula arising from it, are greatly expanded. This expanded sinus system invades the braincase to the extent that broad contralateral communications are created, resulting in a middle-ear volume that completely encircles the brain. This augmented middle-ear volume increases the compliance of the sound transduction mechanism, thereby optimizing the impedance matching performance to lower frequencies. Additionally, this increased paratympanic sinus volume also can act as a Helmholtz resonator, responding to particular frequencies as a function, in part, of its volume. Using CT scanning methods, we examined a growth series of American alligator ranging from perinatal to individuals approaching the growth asymptote. From these data we were able to characterize the acoustic properties of the middle ear. We gave particular attention to its resonance with the goal of discovering correlations between calculated resonant frequencies and particular performance parameters or behavioral auditory cues. A number of bony ostia were tested as candidate resonator openings—one particular bony opening, the subtympanic foramen, yielded resonant frequencies in the range of 950 to 1200 Hz between the specimens sampled. This range of frequencies represents a good fit to frequencies corresponding to both measured greatest cochlear sensitivities and greatest call intensities of hatchling alligators. It is not clear whether the morphological conformation required for this range of resonant frequencies is an adaptation in response to juvenile calling or is merely exapted such that juveniles call at frequencies that exploit this acoustic aspect of crocodylian anatomy. This correlation does, however, underscore the role of audition to parental care in crocodylians.

P3.3 EASTERLING, J.G.*; SOTO, W; NISHIGUCHI, M.K.; New Mexico State University, Las Cruces; jeasterl@nmsu.edu
Experimentally Evolved *Vibrio fischeri* Examines Responsiveness to Temperature Adaptation.

Luminous bacteria in the family Vibrionaceae (g-Proteobacteria) are found living mutualistically in the light organs of both sepiolid squids and monocentrid fishes. *Vibrio* symbionts are transmitted environmentally, and are inherently exposed to a wide spectrum of abiotic conditions during each cycle of their life history. Temperature differences between habitats fluctuates, and may prevent dispersal of these otherwise cosmopolitan bacteria. Because *Vibrio* symbionts have been observed to be transient between different host species, a temperature assay using several symbiotic strains of *Vibrio fischeri* (ES114, EM17, and ET401) was developed to map detailed growth extremes at environmental temperatures. Results indicate that all three strains have visible growth at temperature extremes between 8 and 37°C. We also examined temperatures that will be used in additional experimental evolution experiments at 20 and 31°C, that are representative of low and high temperature extremes. Comparison of these measurements with other abiotic factors will eventually help us better understand whether vibrios that have broad temperature ranges can become a more competitive symbiont than those with more narrow temperature ranges.

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EcR/RXR LBD Isoforms in Crustacea

The primary amino acid sequence encoded by the *U. pugilator* *EcR* and *RXR* genes was previously elucidated by cDNA sequencing. These studies indicated isoforms within the hinge and ligand binding domain (LBD) of *RXR* and the hinge region of *EcR*. An isoform missing the C-terminal region of *EcR* LBD was observed, but N-terminal isoforms were not detected, suggesting the LBD variants might have different physiological functions. We describe here the intron-exon organization of the *UpEcR* gene determined from overlapping genomic clones. A contig covering a total of 9320 bases was assembled identifying seven exons and six introns. An intron was observed within the A/B region of the *EcR* gene, leaving the possibility for alternative A/B splicing. Hinge region isoforms arising through alternative splicing were identified; in addition, a cryptic exon in the ligand binding domain was detected and evidence for the expression of this isoform was obtained from RT-PCR. To examine whether the LBD isoforms of *Uca* *RXR* might have different physiological properties in vitro, EMSA analyses were performed with different isoforms of the *Drosophila* receptors. The cognate crab and fly receptors differ in EMSA assays in their responses to hormone in that neither 20E nor PA increases DNA binding for the *Uca* heterodimers, while ecdysteroids stimulate binding for the *Drosophila* *EcR*/*USP* heterodimers. In mixing experiments, *UpEcR*/*DmUSP* heterodimers did not show ligand responsive differences in DNA binding; both *Uca* LBD isoforms, however, conferred ligand responsive increases in DNA binding with *DmEcRs*, with differing effectiveness relative to different *DmEcR* isoforms. These data indicate that both *UpRXR* LBD isoforms can heterodimerize with the heterologous *DmEcR* receptors and promote ligand and DNA binding, but suggest each may promote isoform-specific differences in *EcR* conformation.

P2.39 EASTLACK, D. T.*; DAVIS, J. R.; KOUBA, A. J.; VANCE, C. K.; Memphis Zoo, TN; Rhodes College, Memphis TN, Memphis Zoo, TN, Memphis Zoo, TN; Mississippi State University, MS; eadst@rhodes.edu
Is the bufonid *Anaxyrus fowleri* resistant to chytrid fungus?

Amphibian populations are declining globally due to habitat loss, climate change and the rapid spread of the pathogenic chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*). The purpose of this study was to determine if *Bd* is present in Fowler's toad (*Anaxyrus fowleri*) populations around Memphis, TN and to assess levels of infection within the species. To determine the presence of *Bd* infection in *A. fowleri*, a total of 156 adults and 36 recently metamorphosed toads were collected from 11 locations in the Memphis metropolitan area. These toads were swabbed using standard published procedures and swabs were analyzed quantitatively for *Bd* using Tagman qPCR. We confirmed the presence of *Bd* infection at 7 of the 11 study locations in at least 9 of 156 individuals; however, populations are thriving at these sites without evidence of widespread mortality or population declines. Furthermore, those animals confirmed positive showed no visual signs of reduced health. Although *Bd* was found in *A. fowleri* individuals, the level of infection was often too low to observe in a single sampling, even considering that sub-clinical levels of *Bd* spores are detectable using highly sensitive qPCR analysis. The non-lethal presence of *Bd* in this bufonid species suggests basal levels of resistance or immunity by *A. fowleri*. Research shows that resistance to chytrid infection may vary among amphibian species and is often connected to the production of large quantities of host defensive peptides or bacterial flora, which can inhibit *Bd* growth. Further research is needed determine the mode of resistance to *Bd* by *A. fowleri* and to determine if there is potential in preventing *Bd* infection in other amphibian species.

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Retrograde Labeling of Zebrafish Spinal Interneurons for Calcium Imaging Studies

Teleost fish such as zebrafish utilize a rapid escape response, or C-start, in response to aversive stimuli. This response occurs when a stimulus triggers a "C"-shaped posture through the contraction of the musculature on one side of the body and involves activation of circumferential descending interneurons (CiDs). The neuroexcitatory peptide c4a, a major component in the injected venom of the fish-hunting cone snail, *Conus catus*, elicits a qualitatively similar response. C4a induces repetitive firing of motor neurons in the snail's prey, resulting in sustained muscle contractions that effectively paralyze the fish in the C-start posture. Knowing that CiD interneurons are involved in the rapid escape response, the goal of this study is to determine whether CiD interneurons are activated in the presence of c4a and convey the signal for rapid paralysis. *Danio rerio* (zebrafish) was used as a model system for *in vivo* calcium imaging of spinal neurons. Motor neurons and CiD interneurons were retrograde labeled with the calcium sensitive dye Calcium Green Dextran in 72-hour larvae. Calcium imaging of fluorescently labeled motor neurons in the presence of c4a showed an increase in intracellular calcium coinciding with muscle contractions, indicating the firing of these neurons. We are examining whether retrograde labeled CiD interneurons, like motor neurons, are also activated in the presence of c4a.

P2.61 EDWARDS, Thea*; GUILLETTE, Louis; Tulane University, University of Florida; tedwards@ufl.edu

Mentoring the Next Generation of Scientists

In the United States, there is current emphasis on undergraduate recruitment, mentoring, and education in the sciences. This movement is promoted by major funding organizations, including Howard Hughes Medical Institute (HHMI) and the National Science Foundation (NSF). We are currently in our third year of an HHMI funded program called GATOR, or Group Advantaged Training of Research. Our program pairs undergraduate researchers with graduate student mentors in a two-pronged approach to mentoring that benefits both undergraduates who plan to go to graduate school, and graduate students who will pursue academic careers. We have evaluated our program both quantitatively and qualitatively, using the HHMI-supported national SURE survey and a comprehensive undergraduate survey developed by our second cohort of graduate mentors. Year to year, student gains are influenced by how the program is structured and which components are emphasized. Our retention in science research is good, with the majority of our undergraduates pursuing a second year of research and/or applying to graduate school. Graduate students in the GATOR program report improved confidence in mentoring and appreciation of the importance of a good match between mentor and mentee. We will present our analysis of this team-oriented approach to science research mentoring.

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The complete mtDNA sequence of the water mite *Unionicola foili* (Acari: Acariformes): another highly rearranged genome among Acariformes

There has been increasing interest in sequencing mitochondrial genomes and using these data to study animal phylogenies. Mitochondrial genomes have been especially useful in resolving relationships among high order taxa (e.g., among phyla and classes), given that genomic features, such as gene content, gene arrangement, and secondary structures of rRNAs, are usually conserved at lower taxonomic levels (e.g., within a genus, family, or order). In contrast to most animals, low-level taxa within lineages of the Acari (mites and ticks) exhibit a high degree of variation in mt gene order and secondary structure of rRNAs and these genomic characters are being used to reconstruct phylogenetic relationships within the group. As part of a much broader study that is using mt genomic data to resolve phylogenetic relationships among *Unionicola* mites, we sequenced the complete mt genome of *Unionicola foili*. Although gene content of the mt genome for *U. foili* is consistent with those that have been reported for other members of the Acari, its gene arrangement, along with those that have been reported for other members of the Acariformes ('mite-like' mites), vary substantially from both the hypothetical ancestral genome for the Acari and representative species from the Parasitiformes (ticks and mesostigmatid mites). When the mt genome for *U. foili* was compared to the eight other Acariformes species whose mt genomes have been sequenced, gene orders were unique for seven of the eight species. Results of this study add to the growing body of evidence suggesting that lower taxonomic levels within the Acariformes exhibit extraordinary degrees of mt genome variation when compared to animals in general and other members of the Acari in particular. Future studies will address possible causes for high rates mt gene rearrangement among taxa from this mite lineage.

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The Prudent Parent Meets Old Age: Senescence in Thick-billed Murres

The "rate of living" theory suggests a tradeoff between metabolism and survival. It is supported by inverse correlations between metabolic rate and survival rates, however charadriiform seabirds are exceptional in having long life spans despite high sustained metabolic rates. To investigate the tradeoff between metabolic rate and survival in a long-lived charadriiform seabird, the Thick-billed Murre, we monitored foraging behaviour, reproductive success, survival, metabolic rate, and corticosterone levels. Reproductive success increased with age between 7-11 y before leveling off, with experience being a better predictor of reproductive success than age during the first 12 y. Reproductive success was lower during the final year of life compared to previous years, suggesting that death may be related to health effects evident in the last year of life. In support, baseline corticosterone levels were elevated for birds 17+ years old. Hematocrit and metabolic rate appeared to decrease linearly with age, perhaps as a strategic adjustment to reduce blood viscosity and forestall potentially effects of high blood pressure on the vascular system in old age. When foraging conditions were experimentally worsened, time spent at the colony increased with age, with 33% of the youngest adults abandoning their chicks, and corticosterone response levels to handling were higher in younger experimental birds. Although foraging ability and dive efficiency was independent of age, older birds appear to be more willing to sacrifice future reproductive success for current offspring leading to an increase in reproductive success with age, although this may also be related to experience occupying a cliff breeding site. Meanwhile, the increase in baseline corticosterone levels, lower metabolism, lower reproductive success and lower apparent survival for birds over 20 years old suggest that murre show signs of deteriorating health when they are 20-25 years old.

P2.105 ESCOBAR, D.A.*; SANCHEZ, J.A.; Universidad de los Andes; dai-esco@uniandes.edu.co

Molecular phylogenetics inside the "Cliona viridis complex" (Porifera, Demospongiae, Hadromerida)

A species "complex" is a group of closely related species, where intraspecific variability overlaps with interspecific variation. Frequently, members of a species complex do not have complete reproductive isolation. In contrast, the complex may go through extensive gene flow and hybridization. This study examined the phylogenetics of the Caribbean members of the "Cliona viridis complex" (*C. caribbaea*, *C. tenuis*, *C. aprica*, and *C. varians*) based on nuclear sequences (ITS2). The intragenomic ITS2 variation and its secondary structure were evaluated using a mixed approach of Denaturing Gradient Gel Electrophoresis (DGGE), sequencing and structure prediction. Abundant intragenomic variation was found in all the species, which comprised apparently functional ITS2 secondary structures. Despite the evident morphological differentiation in these excavating sponges, the intragenomic copies of every individual had a polyphyletic placement in the ITS2 genealogy. Genetic distances revealed that part of the interspecific variation overlapped with both intra-specific and intragenomic variation, which suggest either incomplete lineage sorting or extensive gene flow. To corroborate the species limits in the complex, as well as to sort out the nature of the intragenomic variation, an analysis of ITS2 nucleolar dominance is needed in order to tell which of the copies are actually expressed and functional. In addition, mitochondrial sequences will be obtained to check for mito-nuclear discordance and gene flow directionality in the complex.

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Does seasonality determine the utility of landscape corridors for promoting seed dispersal by birds?

Habitat fragmentation is a leading cause of species decline and extinction. Habitat corridors are a common strategy for mitigating fragmentation and creating connectivity. Plant fitness can hinge upon birds dispersing seeds, yet we know little about the mechanisms by which fragmentation and connectivity impact bird dispersal behavior. Seasonality governs movement and population structure of seed eating birds in many habitats. This study assesses seasonal variation in patterns of seed dispersal in an experimentally fragmented forest in order to compare the utility of corridors for promoting dispersal by birds in summer and winter. This study is ongoing at the Savannah River Site in South Carolina. The site consists of eight experimental landscapes; each has five 1.3-hectare habitat patches arranged with four peripheral patches equidistant from a central patch. One peripheral patch in each landscape is connected to the central patch by a corridor. Habitat within the patches is young longleaf pine (*Pinus palustris*) savannah; the matrix separating the patches is mature loblolly pine (*Pinus taeda*) forest. I use a single species of fruiting plant, *Solanum americanum*, for this study. *S. americanum* does not occur naturally in the patches. During summer 2009 I planted 38 fruiting plants in the center patch of each landscape, and I installed 16 seed traps on perch poles in every patch. Birds dispersed seeds into 3 of 8 center patches and 5 of 24 isolated peripheral patches. No seeds were dispersed down corridors. Most birds eating *S. americanum* fruits in summer are territorial; thus their foraging and movement may be driven more by breeding requirements than by landscape features like corridors. I will repeat this study in winter 2010, when seed eating birds at SRS are not territorial.

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Disruption of hedgehog signaling during different developmental stages in zebrafish reveals discrete cranial features potentially affected by regulation of hedgehog during evolution

Hedgehog signaling has been shown to play an important role in proper craniofacial development. While the role of this signaling pathway in early embryonic development in zebrafish has been well documented, its role in later larval development has not been as well investigated. We have examined the role of Hedgehog (hh)-signaling on the development of the neurocranium and viscerocranium in the zebrafish. Cyclopamine, a pharmacological agent known to block all hh signaling, was administered to embryonic and larval zebrafish. Different treatment times (12 hours post fertilization [hpf], 24, 36, 48, 60, and 72 hpf) were used to determine the role of hh signaling during different developmental time points. When embryos were treated at the earlier time points (12, 24hpf), the treated zebrafish did not develop branchial cartilages suggesting that hh-signaling is necessary for branchial arch differentiation. Later treatment times showed reduced growth of all pharyngeal cartilages as compared with controls. Moreover, experiments with later treatment times revealed that structures that had developed normally prior to treatment with cyclopamine were not maintained once hh signaling was blocked. These findings suggest that the hh-pathway is not only important in differentiation of branchial arches, it is also important for the growth and maintenance of the pharyngeal cartilages. Surprisingly, growth of the second pharyngeal cartilage, the hyoid, did not show significantly reduced growth. These findings suggest that a different genetic pathway may control hyoid growth. The potential role of hh signaling in the regulation of cranial shape and size during the course of evolution will be discussed.

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Control of locomotion in the lobate ctenophore, Mnemiopsis leidyi

The control of locomotion in many aquatic animals depends on a complex interaction between the animal's sensory systems, processing within the central nervous system, musculoskeletal mechanics, and the hydrodynamics of the body. This complexity challenges our ability to understand the major principles that govern the performance of swimming. In the interest of exploring these principles in an experimentally tractable system, the present study developed a mathematical model of the hydrodynamics and control of swimming in the lobate ctenophore, *Mnemiopsis leidyi*. Ctenophores move with rigid body dynamics, generate thrust with a series of propulsors (comb plates), and control their locomotion largely by peripheral nervous processing. The contributions of these components were included in the model, which generated predictions of the rate and direction of swimming. We verified these predictions with recordings of the three-dimensional kinematics of swimming. The accuracy of this model suggests that ctenophores offer great promise as a system to investigate principles of locomotor control.

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A biomechanical comparison between three large theropod dinosaurs: relative roles of functional and phylogenetic constraints

Understanding differences in cranial anatomy and biomechanics can help elucidate the causes and modes by which carnivorous dinosaurs (Theropoda) evolved large size. Comparisons of basic cranial anatomy and stress strain ratios generated by Finite Element Analysis were conducted to determine what aspects of cranial anatomy of *Tyrannosaurus rex*, *Allosaurus fragilis*, and *Majungasaurus crenatissimus* (encompassing three major clades of large theropods) were influenced by the functional consequences of allometry as opposed to phylogenetic constraints of trait complexes retained from their small-bodied ancestors. The main assumption, that large-bodied theropods function more similarly to each other than to small-bodied ancestors or relatives, proved false. Large size in theropods, which evolved independently in separate groups, does not seem to come with specific prescribed adaptations. *Tyrannosaurus* showed more differences in cranial traits (relating to function) compared to *Dilong*, its basal relative, than to *Majungasaurus*, and *Allosaurus* exhibited disparities with other large theropods. Differences in feeding function influence cranial adaptation more than large size or inherited traits do, which is further supported by the observation that the cranial anatomy of *Majungasaurus* is more similar to large sister taxa than to small-bodied ancestors, yet it likely fed in a completely independent fashion. The stress distributions from this and previous studies show relatedness by exhibiting a general pattern of stress dispersal through the skull during biting that large and small theropods share, which suggests an inherited theropod condition. However, slight discrepancies in distribution support the idea that there were differences in feeding habits among the three taxa.

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Changes in protein expression in gill tissue of the ribbed marsh mussel *Geukensia demissa* in response to aerial exposure

The ribbed mussel *Geukensia demissa* inhabits salt marshes along the eastern coast of North America from Florida to the Gulf of St. Lawrence. *Geukensia* often occurs above mean tidal height in its habitat, in part to avoid predation, and so can experience periods of emersion exceeding 12 h. To examine the effects of prolonged aerial exposure on protein expression in gill tissue of *Geukensia*, we acclimated mussels to continuous immersion at 15C for three weeks. We then exposed 6 individuals to moist 15C air for 3, 12 or 18 h. After 24 h recovery, immersed, proteins were extracted from gill tissue. We analyzed changes in protein expression among treatment groups via two-dimensional gel electrophoresis, separating proteins by mass and isoelectric point. The density of 981 protein spots on the 24 gels (4 treatments x 6 replicates) was quantified (Delta2D software), and changes in protein expression profiles among treatment groups were compared using hierarchical cluster analysis (HCL) and principal components analysis (PCA). We found clear differences in protein expression depending on the duration of emersion. *Geukensia* responds robustly after 3 h emersion (221 spots upregulated relative to control, 22%). Remarkably, there is little overlap in the proteins significantly upregulated after 3 h emersion (vs. control, t-test $\alpha=0.01$) compared to 12 h (104 spots; 5 spots overlap) or 18 h (64 spots; 11 spots overlap). Furthermore, both HCL and PCA indicate that the protein expression profiles of the 18 h group cluster with the controls, and the 3 h and 12 h groups cluster together, suggesting that 18 h emersion may be stressful enough to inhibit new protein synthesis. Tandem mass spectrometry will be used to identify those proteins that are upregulated most strongly in each of the treatment groups.

P3.131 FIELD, D.J.*; GOLDBOGEN, J.A.; CAMPBELL-MALONE, R.; BEN-ZVI, M.; PINTO, S.J.; SHADWICK, R.E.; Univ. of British Columbia, Brown University; danieljaredfield@gmail.com

Quantitative Computed Tomography of Rorqual Mandibles: Mechanical Implications for Lunge-feeding

Rorqual whales lunge at high speed with mouth open to nearly 90 degrees in order to engulf large volumes of prey-laden water. This feeding process is enabled by extremely large skulls and mandibles that effectively increase mouth area, thereby enhancing the flux of water into the mouth. When these mandibles are lowered during a lunge, they are exposed to high drag and therefore may be subject to significant amounts of bending. Quantitative computed tomography (QCT) was used to investigate the morphology of a pair of sub-adult humpback whale mandibles (length = 2.10 m). QCT data indicated a significant increase in mineral density and cross-sectional area from the mandibular symphysis to the coronoid process, thereby providing high resistance to bending much like a cantilever beam. These data contrast significantly with the density distribution previously reported for right whales, which employ a different filter feeding method that does not involve high speed or extreme gape angles. This comparison suggests that adaptive bone remodeling is a significant contributing factor in establishing mandibular bone density distributions in cetaceans. We conclude that the morphological design of rorqual mandibles functions to accommodate high drag loads during lunge-feeding without experiencing high strain. To further test this hypothesis, we incorporated QCT data into a finite element model and explored the mechanical behavior of the bone when simulated drag forces were applied.

P2.154 FINKLER, M.S.*; HAYES, C.J.; Indiana Univ. Kokomo;
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Sexual dimorphisms in visceral organ mass, metabolism, and energetics in pre-breeding American Toads (*Anaxyrus americanus*)

Sexual dimorphisms in body size are common in many species of anurans, and have often been ascribed to different selective forces that influence reproductive success in males and females. However, little is known about dimorphisms in whole-organism physiology or in internal morphology in anurans. In this study, we investigated potential differences in visceral organ mass, hematology, metabolism, and stored energy content between reproductive male and female American Toads (*Anaxyrus americanus*) collected en route to breeding areas during the spring. Female toads were both longer and more massive than males, but males tend to have larger somatic masses (i.e., sans reproductive organs) at a given snout-vent length. Females had proportionately greater kidney masses than males, whereas males demonstrated larger increases in heart mass with body mass than did females. Liver mass did not differ between the sexes once somatic body mass was accounted for. None of the hematological parameters examined (RBC counts, Hct, and [Hb]) differed between the sexes, but oxygen consumption rates increased with increasing somatic body mass in males but not in females. The caloric content of the carcass (sans the heart, liver, kidneys, and reproductive organs) and the did not differ between males and females once corrected for carcass mass. The relevance of these observed differences towards increasing reproductive success in each sex will be discussed.

P2.166 FLAMMANG, B.E.*; LAUDER, G.V.; TROOLIN, D.R.; STRAND, T.; Harvard University, TSI Incorporated, TSI Incorporated; bflammang@oeb.harvard.edu
Instantaneous volumetric wake analysis of locomotion in teleost fishes

Previous studies of the wake hydrodynamics of fishes have been restricted to two-dimensional digital particle image velocimetry (DPIV) slices by available technology. By comparing multiple slices, previous researchers hypothesized the three-dimensional structure of the vortex wakes produced by swimming fishes. In teleost fishes, such as the bluegill sunfish, the homocercal tail produces a single jet with each lateral pass. Using conventional two-dimensional DPIV, vorticity shed by the homocercal tail was visualized as two counter-rotating vortices which were hypothesized to be part of a three-dimensional rotating ring through which the jet passed. Now, using a volumetric PIV system, we have confirmed that the three-dimensional structure of the vortex ring produced by the homocercal fin is indeed as predicted. In addition, multiple lateral passes of the tail produced a linked chain of vortex rings. Using this volumetric PIV system we were also able to instantaneously capture the three-dimensional wake interactions of the dorsal and anal fins with the caudal fin in both live fishes and robotic analogs.

P3.96 FORSMAN, A.M.*; ANGERT, E.R.; WINKLER, D.W.; Cornell University; amf226@cornell.edu
Experimental addition of nest-dwelling bacteria influences antibody titers in nestling tree swallows, but not as expected.

Nestling birds already possess circulating antibodies at hatch because of maternally derived antibodies (MAB's) transmitted via the egg yolk. MAB's confer passive immune protection to nestlings and gradually degrade over the nestling period. Prior to egg-laying, females increase antibody production; and previous studies have demonstrated positive correlations among antibody titers in female circulation, egg yolk, and nestling circulation. In this study we tested the hypothesis that female deposition of yolk antibodies is influenced by bacterial prevalence in the nesting environment. We predicted that female tree swallows (*Tachycineta bicolor*) utilizing nestboxes with experimentally increased bacterial loads would lay eggs and produce nestlings with higher antibody titers than females nesting in boxes with decreased bacterial loads or control boxes. We manipulated bacterial load during nest building by either adding bacteria, isolated and cultured from old tree swallow nests, or by misting nests with 70% ethanol to slow bacterial growth. Control nests received no treatment. Contrary to our prediction, nestlings from nestboxes with added bacteria tended to have lower antibody titers than nestlings from control and ethanol treated nests. Unexpectedly this effect was more pronounced in older nestlings. Possible hypotheses explaining these data are discussed in addition to data on antibody titers in female circulation and egg yolk samples.

P3.126 FOKIDIS, B*; SPARR, R; SWEAZEA, K; DEVICHE, P; Arizona St. Univ.; bfokidis@asu.edu
Species-specific habitat-associated changes in lipolytic metabolites during the avian stress response

The vertebrate stress response is associated with glucose mobilization, a result of glycogen mobilization and subsequent gluconeogenesis partly via lipolysis. This idea is largely based on research in captive rodents and few data on the subject are available for free-ranging birds. Birds differ from mammals in having higher plasma glucose levels and varying lipid storage mechanisms, and many use fatty acids to power muscles during flight. Body condition (i.e., energy stores) may also affect reliance on lipids during stress. We measured acute stress-induced changes in plasma glucose, free glycerol, triglycerides, and the ketone B-OH-butyrate in two songbirds: Curve-billed Thrashers (CBTH) and House Sparrows (HOSP), sampled in urban, farm, and desert habitats that putatively differ in resource abundance. Urban and farm birds have more robust stress responses and are in better body condition, which may increase substrates for gluconeogenesis, than desert birds. We predicted urban and farm birds to show greater reliance on lipolysis during stress, as evidenced by decreased triglycerides, free glycerol, and increased ketone production, than desert birds. This prediction was partly supported for desert CBTH, which depleted plasma triglycerides and free glycerol more than urban birds during stress. Stress was, however, associated with lower plasma ketones in desert than urban CBTH. Farm HOSP with unlimited food access also had higher plasma ketones during stress than urban birds, but urban HOSP had lower plasma triglycerides than farm birds. Stress did not affect plasma glucose but decreased triglycerides in HOSP from both habitats. The data support the hypothesis that lipolysis is a major response to acute stress and this response varies as a function of habitat and body condition.

P2.152 FOWLER, Melinda, A.*; CHAMPAGNE, Cory, D.; HOUSER, Dorian, S.; CROCKER, Daniel, E.; University of California, Santa Cruz, Sonoma State University, Sonoma State University; mfowler@biology.ucsc.edu
Adiposity, development and lactation impact responses to glucagon in northern elephant seals

Northern elephant seals, *Mirounga angustirostris*, fast while lactating, creating a metabolic conflict between the energy demands of lactogenesis and the energy-conserving physiological mechanisms associated with fasting. One important constraint on the ability to fast while lactating is the need to provide carbohydrate for glucose-dependent tissues while sparing lean body tissues, yet our previous investigations revealed high rates of glucose production throughout lactation. Subsequent studies revealed that the insulin response to a glucose challenge declined with adipose tissue reserves across lactation suggesting progressive insulin insensitivity. We challenged lactating and molting females with pharmacological doses of glucagon, a gluconeogenic hormone, to better understand hormonal regulation of glucose production. This study revealed a moderate, delayed, monophasic increase in plasma glucose levels, the magnitude of which declined with adipose tissue reserves and became negligible late in lactation. Plasma glucose directly varied with elevations in plasma urea nitrogen, suggesting that glucagon enhanced gluconeogenesis from amino acids. Glucagon stimulated ketogenesis, independent of adiposity or lactation status. When we repeated this study in fasting weaned pups, we found no gluconeogenic or ketogenic responses. Together these studies suggest that high rates of gluconeogenesis in fasting elephant seals involve significant glucose cycling and that hormonal regulation of glucose production during fasting varies significantly with development, adiposity and lactation status.

P2.161 FOX, JL; MYHRVOLD, CA*; HOWELL, D; DANIEL, TL;
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Lateral asymmetry in the kinematics of halteres during maneuvering flight of crane flies

The halteres of dipteran insects act as gyroscopic sensory organs for flight control. They are actively oscillated during flight and experience large inertial forces, including Coriolis forces that occur during body rotations. The mechanosensory cells at the haltere's base are thought to detect these Coriolis forces, rapidly sending information about the body's rotation to the central nervous system. However, little is known about the motions and forces that occur at the base of halteres during natural behavior. Previous simulations of haltere motion showed that body rotations result in elliptical or lemniscate tip trajectories. Additionally, visual input can affect haltere kinematics, with the potential for separate control of left and right halteres. To assess the consequences of natural free flight maneuvers to the kinematics of halteres, we captured high-speed video of the cranefly *Holorusia* in free flight. Using four cameras, we filmed 5 crane flies at 1000 frames per second for >300 ms, long enough to capture 3D kinematics over many wingbeats (~25 ms wingbeat period). We recorded natural body rotations (yaw, pitch, and roll) while simultaneously measuring the sweep and elevation angles of haltere during each wingbeat period. We found that the amplitude of the sweep angle was significantly different during wingbeats where yaw rate was high. Furthermore, despite previous assumptions that halteres move symmetrically, we found that the left and right halteres had different relative sweep angles. This suggests that control of the halteres could be lateralized, and in turn, the information entering the nervous system from haltere mechanoreceptors will also be lateralized.

P2.15 FREYMILLER, HJ*; HARTY, JJ; EDWARDS, TM;
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Using Nkx6.1 to detect pancreatic beta-cells in the American alligator

The antibody F55A10 detects the pancreatic transcription factor Nkx6.1, which is specific to insulin-producing beta cells, and thus provides a method of selective staining. Nkx6.1 has been used to mark beta cells in both mouse, rat, pig, zebrafish, human and chicken. Being that chicken and alligators are evolutionarily very close, we hypothesized that this antibody would prove to be a successful marker for Alligator mississippiensis beta cells. Prior to staining, peroxidase activity was blocked using hydrogen peroxide. Following this, the primary antibody, Nkx6.1 was applied overnight at 4°C. A panspecific biotinylated secondary antibody bridge, followed by a streptavidin/peroxidase complex was used to link the antibody to the 3,3'-diaminobenzene (DAB) dye, which allows for visualization. Nkx6.1 was a successful marker in 5 month old female alligator pancreas. Alligator beta cells are scattered as single cells, in small clusters, and in asymmetrical islets in the pancreas. This stain can be used to assess beta cell quantity in later studies.

P1.110 FRENCH, S.S.*; DENARDO, D.F.; GREIVES, T.J.; STRAND, C.R.; DEMAS, G.E.; Utah State University, Arizona State University, Max Planck Institute for Ornithology, Vogelwarte Radolfzell, California Polytechnic State University, Indiana University; sfrench@biology.usu.edu
Effects of Human Disturbance on Immunocompetence and Stress Responses in Galapagos Marine Iguanas (*Amblyrhynchus cristatus*)

The environment is currently undergoing intense changes at both global (e.g., climate change) and local (e.g., tourism, pollution, habitat modification) scales. Many of these changes are anthropogenic and have the capacity to affect the viability of natural populations. While some human impacts on species are examined, such studies typically assess population-level responses to major anthropogenic changes. However, individual physiological responses to mild human disturbance can be equally critical to the long-term survival of a species, yet they remain largely unexamined. The current study investigated the impact of seemingly low-level human disturbance (ecotourism) on specific fitness-related immune measures, in the marine iguana (*Amblyrhynchus cristatus*). Specifically, we assessed stress-induced changes in plasma corticosterone among populations to understand the impacts of human exposure. Environmental perturbations can cause stress-induced increases in plasma corticosterone which have a suite of effects on organismal physiology. We also measured set of immunological responses (i.e., bacterial killing ability, cutaneous wound healing, hemolytic complement activity) to assess stress-related effects on the health of individuals in different populations. By identifying health-related consequences of human disturbance, this study provides critical insight into the conservation of a unique and well-known species, and also contributes to the foundation of knowledge needed to understand the global significance of various levels of human disturbance.

P2.136 FRIESEN, Chris/R.*; MASON, Robert/T.; Oregon State University; friesenc@science.oregonstate.edu
Sperm competition and mate order effects in red-sided garter snakes

Female promiscuity creates the potential for high variance in male mating success and thus sexual selection due to postcopulatory processes. In addition, the dynamics of a mating system can be strongly affected by female promiscuity—i.e., when and if a female remates. In the mating system of the red-sided garter snakes of Manitoba, Canada, female choice seems to be extremely limited in large courtship aggregations within the den, where male mating success is random with respect to his size. Once mating occurs in the den, females may then remate in less dense aggregations away from the den to ensure that a large (fit) male will sire at least some of her offspring. This hypothesis requires that second-male precedence prevails. We tested this hypothesis using controlled matings where after a female mated with one male we mated her with a second male. We report the results of paternity analysis, and correlates of male paternity success. No other study has investigated the combined effects of mate order, copulation duration, and male size as correlates with paternity success in any species of snake. Further, one curious result is suggestive of potential female control over paternity.

P1.134 FROEHLICH, J.M.*; BIGA, P.R.; North Dakota State University; jacob.froehlich@ndsu.edu

Characterization of Novel Teleost Systems for Studying Muscle Growth

The zebrafish (*Danio rerio*) is an extensively used model organism in biomedical research. However, zebrafish exhibit a pattern of determinate muscle growth, limiting its usefulness into investigations of satellite cell activation. A closely related species, the giant danio (*D. aequipinnatus*), exhibits indeterminate muscle growth, which is similar to commercially important teleost species like the rainbow trout (*Oncorhynchus mykiss*). Here, we characterize satellite cells isolated from giant danio and rainbow trout, as well as the subsequent *in vitro* activation, differentiation, and proliferation of the resulting primary myoblasts. Cells were cultured for 15 days, with sampling occurring throughout the culture period. Quantitative PCR was utilized to analyze the gene expression of c-Met, Pax7, Foxk1, MyoD, myogenin and Myf5 to demonstrate cell proliferative or differentiation stages. Throughout the 15 days of culture, MyoD was present, while myogenin appeared only after the second day of culture, indicating the start of myoblast proliferation. Myf5 was detected at all sampling days, which is indicative of myofiber differentiation and growth. Foxk1 mRNA levels appeared to be highest on day 1 of culture, with a subsequent down-regulation as cells proliferate and differentiate. Pax7b and c-Met were detected throughout the culture. The presence of Foxk1, Pax7b and c-Met throughout the entire culture suggests that a replenishment of the satellite cell population might be occurring. This is the first report of myocyte-specific cell stage markers in teleost primary myoblast culture systems and supports the use of these systems in subsequent work evaluating satellite cell activation and muscle cell growth regulation. Funded by ND EPSCoR #0447679 and NIH NCRR #2P20RR015566.

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Diel Variation in Standard Metabolic Rate: Mediation by Photoperiod Cues and Melatonin?

The hormone melatonin (N-acetyl-5-methoxytryptamine) synchronizes environmental factors, such as temperature and photoperiod, with physiological and behavioral processes. Increased melatonin concentrations function in lowering some physiological set points in diurnal but not nocturnal snakes. Results from previous research suggest that melatonin decreases standard metabolic rate (SMR) in a diurnal snake. In this study, we seek to establish bearded dragons (*Pogona vitticeps*) as a diurnal ectothermic model for investigating the role of melatonin and melatonin receptor-mediated responses in physiological rate processes and behavioral thermoregulation. We demonstrate that the SMR of this highly diurnal lizard varies significantly during a 12 h:12 h LD photoperiod. The SMR of *Pogona vitticeps*, held at constant body temperature, was significantly higher during mid-photophase than mid-scotophase. This observed diel variation in SMR may be associated with diel cycles of endogenous melatonin synthesis. A reverse 12 h:12 h LD photoperiod was used to investigate if the lower SMR during mid-scotophase can be entrained by photoperiod cues. Future experiments manipulating melatonin concentrations will confirm the role of melatonin in regulating SMR of *Pogona vitticeps*. Such baseline data will help establish *Pogona vitticeps* as an experimental model for future studies investigating how melatonin mediates temporal adjustments in physiology and behavior.

P3.116 GALT, Nicholas*; BILLING, Samantha; BIGA, Peggy; North Dakota State University; Nicholas.Galt@ndsu.edu

Acute Stress Differentially Affects Myostatin Expression in Rainbow Trout, *Oncorhynchus mykiss*

Teleosts exhibit multiple myostatin (mstn) isoforms that are differentially regulated, suggesting that teleost mstn exhibits greater functional diversity. Mstn mRNA expression is found in a variety of tissues in rainbow trout (*Oncorhynchus mykiss*) when compared to its restricted muscular expression exhibited in mammals. We hypothesize that the gene expression of mstn1a and mstn1b will be affected when rainbow trout are handled to induce an acute stress, which is the result of a direct or indirect ability of mstn to partition energy towards physiological processes that are pertinent to the fitness of these fish. To determine the length of time needed for mstn mRNA levels to recover to pre-stress levels, we performed a time-series experiment where samples were collected out to 48hrs following a 60s handling stress. When handled, mstn1a mRNA levels significantly increased at all time periods from 0hrs to 9hrs, while mstn1b mRNA levels were significantly decreased from 0hrs to 9hrs. Interestingly, mstn1b mRNA levels are instantaneously decreased in both white (-29.75±1.62) and red (-228.94±16.25) muscle following handling stress, suggesting that mRNA stability is altered during this time. These data suggest mstn exhibits regulatory roles beyond what has previously been proposed, and evidence is supporting a critical role of mstn in energy partitioning in rainbow trout skeletal muscle. Future research will be conducted to elucidate the mechanisms by which mstn is being regulated and whether mstn is being acted on directly or indirectly by components of the stress response. Funded by ND EPSCoR # EPS0447679 and NIH NCRR # 2P20RR015566.

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Respiratory water loss and the effects of activity on the water budget in scorpions

The geographic distribution of *Buthotus judaicus* (Buthidae) and *Scorpio maurus fuscus* (Scorpionidae) in Israel is limited to the mesic Mediterranean zone. Nevertheless, the two sympatric species have been shown to vary greatly in their water relations traits. When exposed to prolonged desiccation *B. judaicus* maintains its hydration state and hemolymph osmolarity better than *S. m. fuscus*. In order to determine the relative importance of respiratory water loss (RWL) to their water budget, metabolic rates (MR, measured as CO₂ output) and water loss rates (WLR) of hydrated scorpions were measured at 30°C. No significant differences were found between resting MR of *B. judaicus* and *S. m. fuscus* ($F_{1,23}=3.57$; $p=0.07$), or their H₂O to CO₂ output ratio ($p=0.49$). The relative importance of RWL at rest (16.8 ± 1.5 and $15.1\pm 1.8\%$, respectively) did not differ significantly ($p=0.72$), indicating that variation in cuticular permeability is largely responsible for the ~40% lower resting WLR of *B. judaicus* ($F_{1,23}=25.8$; $p<0.001$). However, continuous respirometry for 24h revealed marked differences in activity patterns between the two species. Mean daily MR of *S. m. fuscus* were 2-fold higher than those measured for *B. judaicus*. Elevated RWL resulting from activity represent a 20.7% increase from mean total water losses of resting *S. m. fuscus* (7.8% in *B. judaicus*). The relatively high fraction of RWL associated with activity, and previously reported decreasing WLR of *S. m. fuscus* during prolonged desiccation, suggest that some scorpions may downregulate their activity in order to conserve body water under stressful conditions.

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The Lampropididae (Crustacea: Cumacea)

Lampropid cumaceans are characterized by having 3 or more terminal setae on the telson and 0-3 pairs of pleopods in the male. At present, about 100 lampropid species are described, but an additional 28 provisional species and 5 provisional genera are described, in addition to an overview of the systematics and biogeography of the family. Among the new genera and species described are 5 species in which the adult males bear a pair of penial lobes, heretofore only known from 3 other genera and no lampropids. Two of the new species also have a novel ventral structure in the adult male.

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Regional Patterns of Muscle Blood Flow During Steady Swimming in Trout

Sustained undulatory swimming in fishes is powered by slow myotomal muscle. Rainbow trout, *Oncorhynchus mykiss*, are sub-carangiform swimmers with undulations confined to the posterior two-thirds of the body axis. Skeletal muscle performs a number of roles during swimming in addition to mechanical power production, e.g. maintaining stability by controlling fin shape and orientation and powering respiratory movements. The relative energetic costs of these functions are not known. The rate of blood flow to muscle tissue is proportional to its aerobic energy expenditure. Therefore, regional blood flow to specific categories of muscle can be used to indicate their relative functional costs. We hypothesized that during steady swimming blood flow would be concentrated at the myotomal muscles, with less flow to the respiratory, pelvic and pectoral girdle and fin ray muscles. Fluorescent microspheres were injected into the trout systemic circulation via a dorsal aortic cannula at rest and swimming at speeds of 50%, 75% and 100% Ucrit. Following dissection, body tissues were digested to recover the microspheres and quantify their distribution. Over two-thirds of the total muscle blood flow was to the slow myotomal muscles at all swimming speeds. Furthermore, blood flow per gram of muscle mass increases three to four-fold from anterior to posterior myotomes. The fin ray, pelvic and pectoral girdle muscles receive less than one-quarter of total muscle blood flow. The respiratory muscles receive less than five percent of total blood flow, which may indicate a transition from branchial pumping to low-cost ram ventilation during swimming. Future studies will integrate muscle activation and mechanical performance data.

P1.143 GERSTNER, GE*; CARDINAL, MD; ZELDITCH, ML; University of Michigan; geger@umich.edu

Impact of chronic mandibular loading on craniomandibular size and shape in the laboratory rat

In an effort to gain insight into the relationship between chewing rate and jaw mass, we previously performed surgically-controlled implant studies that increased jaw mass in laboratory rats. Mean licking rates were quantified weekly, and results demonstrated no significant differences in licking rate between the two animal groups, despite a near-doubling of jaw mass in test animals compared with controls. We next assessed how the effects of increased jaw mass affected craniomandibular morphology in these two animal groups and found few significant differences between the groups. However, these previous morphometric studies were not designed to isolate size- versus shape-specific variation. In the present study, we use geometric morphometrics to determine whether doubling of jaw mass affects size and/or shape of crania and mandibles from adult male laboratory rats, 11 of which had 2-g gold implants affixed to the anterior inferior region of the mandibles versus 11 age- and gender-matched surgical controls that had 0.2-g acrylic implants affixed to the same position of the mandibles. After 12 weeks, the animals were sacrificed, and the crania and mandibles dissected, cleaned, photographed and digitized. Preliminary results indicate no significant differences in mandibular shape but the mandibles of the gold-implant group appeared to be ~ 6% larger in overall mandibular size compared with the acrylic group. These results suggest that compensatory neuromotor and musculoskeletal changes associated with this model of chronic loading are surprisingly integrated and/or broadly dispersed. This may explain why the previously observed effects of chronic doubling of mandibular mass were relatively subtle.

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Cardiovascular adaptations of Inuit sled dogs in response to seasonal changes in work load, temperature and feeding

Using ultrasonography and external heart rate monitors we have measured morphological and functional parameters of the heart of Inuit sled dogs living in traditional husbandry conditions in Greenland. We explored adaptive long-term and short-term responses of the cardiovascular system to changes in exercise, temperature and food supply. We compare measurements of same dogs in summer and winter when resting and fasting, resting and digesting, and working. Husbandry includes intermittent feeding during summer and adequate feeding in winter. In winter, the diameter of the aortic root was larger than in summer, whereas the dimensions of the left ventricle remained unchanged. We found substantial functional adjustments during winter: stroke volume (SV) was 28% higher, left ventricular ejection fraction (LVEF) was 11% higher, and fractional shortening (FS) was 7 % more intensive in the LO-dogs. We also explored short term responses to feeding and working in the dogs. In summer in resting dogs heart rates and cardiac output doubled when digesting. Elevated levels were maintained for 4 hours and slowly declined within 32 hours to fasting levels. When pulling a sledge in winter dogs maintained working heart rates of 200 bpm and cardiac output of 221.7 ml min⁻¹ kg⁻¹ compared to resting heart rates of 109 bpm and cardiac output of 114 ml min⁻¹ kg⁻¹. The Inuit sled dogs living in Greenlandic husbandry are an excellent model to study adaptations to seasonal changing conditions. The Inuit dogs adjust functionally rather than morphologically to the differing demands between the seasons and conditions. Besides long-term adjustments we also monitored dramatic short-term adjustments to digesting large meals and sustained work with doubled heart rate and cardiac output.

P2.41 GERVASI, S.S.*; SEARLE, C.L.; RELYEA, R.A.; HUA, J.; HAMMOND, J.I.; BLAUSTEIN, A.R.; Oregon State University, University of Pittsburgh, University of Pittsburgh; gervasis@science.oregonstate.edu

Interspecific variation in susceptibility to an emerging pathogen of amphibians, *Batrachochytrium dendrobatidis*

Emerging infectious diseases are gaining recognition as contributing to significant losses in global biodiversity. As a part of the overall biodiversity crisis, amphibian population declines represent one of the most urgent conservation issues. Global population declines have been linked to many factors, but infectious disease has received increased attention as a key factor in recent years. Specifically, the emerging and pathogenic fungus, *Batrachochytrium dendrobatidis* (Bd), has been implicated in amphibian declines on six continents. However, there have been few studies of species-specific variability in susceptibility to Bd. We employed a comparative framework to examine susceptibility to Bd in several amphibian species from North America. These baseline data may serve as an important first step toward highlighting differences in host-physiology that underlie disease susceptibility in amphibians.

P1.98 GIBBONS, K.R.*; BALTZLEY, M.J. ; St. Mary's College of Maryland; krigibbons@smcm.edu

Same wiring, different effect: how pressure mechanosensory neurons interact in the leeches *Macrobdella decora* and *Hirudo verbana*

The leech *Hirudo verbana* has four mechanosensory pressure neurons (P cells) in each midbody ganglion. Within an isolated ganglion, P cells have complex mutually inhibitory connections. When one P cell is stimulated intracellularly, the other P cells have a weak depolarization followed by a strong hyperpolarization. This complex response appears to be mediated by a combination of electrical coupling, monosynaptic excitation and polysynaptic inhibition. We examined the P cell homologues in the American medicinal leech *Macrobdella decora*. We found that intracellular stimulation of one P cell causes a slight depolarization in the other P cells. The magnitude of the depolarization is greater between ipsilateral P cells than between contralateral P cells. Experiments performed in a high Mg²⁺, 0 Ca²⁺ saline and a high Mg²⁺, high Ca²⁺ saline suggest that the P cells in *M. decora* have an electrical coupling, a monosynaptic excitation and polysynaptic inhibition, similar to the connections between P cells in *H. verbana*. Therefore, the difference in net response between these two species seems to be based on differences in the strengths of the electrical and chemical connections. We also tested the connections between P cells in both *M. decora* and *H. verbana* in normal leech saline with bicuculline, a GABA-antagonist. Our preliminary results show that the polysynaptic inhibition was eliminated in both species, suggesting that the inhibition is due to GABA-mediated Cl⁻ channels.

P2.24 GIANI, V. C.*; SEAVER, E. C.; University of Hawaii; vinny.giani@hotmail.com

Expression of *piwi* during development and regeneration in the marine polychaete *Capitella teleta*

Capitella teleta (formerly *Capitella* sp. 1) is a polychaete annelid that exhibits robust posterior regeneration. *C. teleta* undergoes sexual reproduction and following an embryonic period, forms a larva that undergoes metamorphosis into a juvenile worm. Several features of its biology make it an ideal system for regeneration studies, including the fact that the relationship between embryonic development and regeneration can be analyzed. In this study we characterize the expression of the *piwi* gene throughout the life history of *C. teleta*. *Piwi* is a conserved stem cell marker, and is often localized to germ line stem cell populations. The *C. teleta* genome contains two *piwi* orthologues and they show very similar expression patterns. *Piwi* expression is initially detected in early cleavage stage embryos, and is expressed at all stages examined with a dynamic spatial pattern. *Piwi* is expressed in a pattern consistent with being a stem cell marker in that it is expressed in the posterior growth zone in larval and adult stages. In the gonad of adults, *piwi* is expressed in immature oocytes within the ovary, but is absent from mature oocytes. We also observe *piwi* expression in the blastema of regenerating animals, which is localized to the mesoderm. The temporal dynamics of *piwi* expression over the course of regeneration is currently being characterized. Our description of *piwi* and another gene *eve* represent an initial molecular characterization of the regeneration process in polychaete annelids.

P2.85 GILLEN, C.M.*; WHITE, A.J.; CARPENTER, R.O.; ROHRBACK, S.E.; GAO, Y.; WHEATLY, M.G.; Kenyon College, Wright State University; gillenc@kenyon.edu

Analysis of sarcoplasmic calcium binding protein in *Procambarus clarkii* muscle

SCP1 is an invertebrate EF-hand calcium binding protein that is hypothesized to serve a function similar to vertebrate parvalbumin, which is expressed most highly in fast-twitch muscle fibers. We have identified three variants of the *Procambarus clarkii* sarcoplasmic calcium binding protein (pcSCP1a, pcSCP1b, pcSCP1c). In this study, we used relative quantification real-time PCR to evaluate the expression of pcSCP1, using variant-specific primers and 18s ribosomal RNA as an internal calibrator. All three variants are highly expressed in axial abdominal muscle and are also detectable in cardiac muscle. Expression of the three variants was 10-100 fold higher in deep flexor (fast, phasic) compared to superficial flexor (slow, tonic) muscles. To probe the function of pcSCP1, we injected double-stranded RNA to reduce pcSCP1 expression, resulting in an average 2-fold reduction of pcSCP1 expression compared to controls, with up to 10-fold reduction in individual crayfish. Crayfish with reduced pcSCP1 expression showed muscular weakness compared to controls, based on visual inspection. These findings are consistent with pcSCP1 playing a similar role to vertebrate parvalbumin. (Funded by NSF-IBN 0445202 and Kenyon College)

P3.133 GINTER, C.C.*; BÄTTGER, S.A.; FISH, F.E.; Texas A&M University, West Chester University; cgginter@tamu.edu
Morphology and Microanatomy of Harbor Porpoise (*Phocoena phocoena*) Dorsal Fin Tubercles

The unique pattern of small tubercles on the leading edge of the dorsal fins of harbor porpoises (*Phocoena phocoena*) has been widely noted in the literature. The external morphology and microanatomy of the tubercles were analyzed. Measurements were taken of height and peak-to-peak distance of the tubercles using videomicroscopy (N = 12-19/fin). Mean height ranged from 0.38 ± 0.17 mm to 0.64 ± 0.25 mm and was significantly different among individual porpoises ($p < 0.001$). Mean peak-to-peak distance ranged from 4.16 ± 1.97 mm to 5.64 ± 2.0 mm and did not significantly differ among porpoises. Samples of the dorsal fin leading edge, trailing edge and tubercles were taken for microanatomical comparison. The microstructure analysis revealed an epidermal thickness of 0.67-2.68 mm with the thickest epidermis at the site of the tubercles. The epidermis contained three distinct strata (=layers) including stratum corneum, spinosum and basale. The stratum corneum was significantly thickened in tubercles ($p < 0.001$), over four times thicker than in the leading or trailing edge of the fin. The stratum spinosum contained unusual enclosures that appear to be lipid-filled. The stratum spinosum was significantly thinner ($p < 0.001$) in the trailing edge than in the other two sites. There was no significant difference in the stratum basale (the germinal layer of the epidermis) among the three sites. A dermis with distinct dermal papillae and regular arrangements of adipose tissue and collagen fibers was also noted. Though the function of the tubercles is unknown, their position suggests that they may have hydrodynamic importance.

P3.42 GOMEZ DAGLIO, Liza E.*; DAWSON, Michael N; University of California, Merced; lgomezdaglio@ucmerced.edu
Phylogeny of shallow water jellyfish (Scyphozoa: Discomedusae) from the Gulf of California, Mexico.

Scyphozoans are important pelagic predators throughout the world's oceans, but their diversity, distribution, ecology, and systematics are poorly known. The Gulf of California (the Gulf) presents a microcosm of this problem; the area is renowned for high endemic diversity in other taxa, but only three scyphomedusae have been documented previously. Here, we propose to address the biodiversity of shallow water scyphomedusae and establish their phylogenetic relationships with and times of separation from congeneric scyphozoans, especially sister taxa in other regions. We recorded 10 species in the Gulf, including 5 new species. One species, new to science, belongs in Family Lobonematidae previously known only from the Western Pacific. Resultant phylogenies of the genera *Aurelia*, *Stomolophus* and *Chrysaora* obtained by Maximum likelihood analyses (COI) indicate the Gulf's scyphomedusae are sister taxa of the Atlantic clade. These data suggest a tropical origin for the Gulf scyphofauna. The major vicariant event that promoted the speciation of these jellyfish was likely the closure of the Panamanian Isthmus. However, the analyses of *Cassiopea* showed that is an introduced species in the Gulf. The phylogenies of the remaining taxa collected – *Pelagia*, Lobonematidae, *Phacellophora*, and *Phyllorhiza* – affirm the importance of studying Gulf of California and Central America medusae for understanding global patterns of diversity in Scyphozoa.

P3.134 GOLDBOGEN, J. A.*; POTVIN, J.; SHADWICK, R. E.; Univ. of British Columbia, Saint Louis University; jgoldbogen@gmail.com
Skull and buccal cavity allometry increase mass-specific engulfment capacity in fin whales

Rorqual whales (Balaenopteridae) represent not only some of the largest animals of all time, but they also exhibit a wide range in intraspecific and interspecific body size. Balaenopterids are characterized by their extreme lunge feeding behavior, a dynamic process that involves the engulfment of a large volume of prey-laden water at a high energetic cost. To investigate the consequences of scale and morphology on lunge feeding performance, we determined allometric equations for fin whale body dimensions and engulfment capacity. Our analysis demonstrates that larger fin whales have larger skulls and larger buccal cavities relative to body size. Together, these data suggest that engulfment volume is also allometric, increasing with body length as $L_{\text{body}}^{3.5}$. The positive allometry of the skull is accompanied by negative allometry in the tail region. In contrast, the body dimensions associated with propulsion and control surfaces were largely isometric, which should decrease maneuverability in larger rorquals. The relative shortening of the tail may represent the cost of investing all growth related resources in the anterior region of the body, thereby increasing engulfment capacity. Although enhanced engulfment volume will increase foraging efficiency, the work (energy) required to accelerate the engulfed water mass during engulfment will be relatively higher in larger rorquals. If the mass-specific energetic cost of a lunge increases with body size, then it could have major implications for rorqual ecology and evolution.

P3.135 GOO, B.Y.*; DEAN, M.N.; HUBER, D.R.; SUMMERS, A.P.; University of California, Irvine, University of Tampa, Friday Harbor Labs; bgoo@uci.edu
Jaw morphology and structure in lamniform sharks.

The Lamniformes (Chondrichthyes) are a diverse lineage of highly predatory sharks. Though taxonomically few, they vary widely with regard to trophic morphology and ecology. However, the functional morphology of their feeding apparatus is difficult to study in vivo due to the large size, rarity, and pelagic nature of many of the species. To determine whether and how skeletal performance varies with phylogeny and ecology, we calculated an indirect, shape-based measurement of jaw stiffness (second moment of area (I_{na})) from digital cross-sections of CT scans (1mm slice thickness) of adult animals. We examined 6 closely-related lamniform sharks (shortfin mako, sandtiger, salmon, goblin, crocodile, and bigeye thresher) and 2 outgroup species (Orectolobiformes: nurse shark; Carcharhiniformes: blue shark) all of which feed on nektonic prey. By calculating second moment of area along the length of the jaws, we examine the contribution of shape to skeletal flexural stiffness, locating areas of reinforcement and defining their magnitude, and describing the suggested orientation of loading among species. Our results suggest that although these sharks have similar diets, there may be large and mechanically-important differences in the morphologies of their jaws. For instance, we found dramatic increases in I_{na} toward the rostral tip of the lower jaw in the goblin shark, but toward the caudal end in the shortfin mako. Also, the maximum moment of area reported for goblin shark jaws was 9x greater than that of the mako, indicating a much larger shape-contribution to stiffness in the former species. We discuss results in the contexts of shark phylogeny and the potential mechanical demands of predation.

P3.78 GOODFRIEND, Amy C.*; STAYTON, C. Tristan; Bucknell University; acq010@bucknell.edu

A Mechanical Comparison of Shell Morphology in Two Subspecies of *Chrysemys picta*

The construction of a turtle's shell has been hypothesized to affect its performance under various loading conditions. The arrangement of bony plates in the carapace of the turtle shell can vary from species to species. The well-known painted turtle (*Chrysemys picta*), is divided into four subspecies; the two of interest in this study are the eastern painted turtle (*C. p. picta*) that has aligned scutes on its carapace, and the midland painted turtle (*C. p. marginata*) that has alternating scutes. Hybrid individuals have shell constructions intermediate to the two subspecies. Turtle shells were photographed in dorsal, lateral, and ventral views and landmark coordinates were placed on the carapace and plastron. Finite element models were constructed using those data, with sutures and bone assigned different material properties. Eighteen load cases were analyzed – the resulting data were used to compare individuals of the different subspecies. *C. p. marginata* shells were on average stronger than those of *C. p. picta* and the hybrid individuals fell in between the two. It has been hypothesized that the different shell constructions are a result of different environmental conditions during the incubation period. *C. p. picta* may not have been subjected to as severe selective pressures for shell strength as *C. p. marginata* due to the smaller size of predators found within its native range.

P3.90 GRAHAM, AW*; KOUBA, AJ; WILLIS, EL; Memphis Zoo, TN; Rhodes College, Memphis, TN, Memphis Zoo, TN; graaw@rhodes.edu

Development of non-invasive reproductive monitoring techniques for endangered snow leopards and Amur leopards

Snow (*Panthera uncia*) and Amur leopards (*Panthera pardus orientalis*) are two of the most endangered large cats on Earth. Little is known about the reproductive physiology of these cats and a basic understanding of reproductive biology will aid in conservation efforts. Therefore, the objectives of this study were to optimize fecal steroid hormone extraction procedures and determine appropriate antibodies for enzyme immunoassays. For our first objective, we compared combinations of different fecal steroid hormone extraction procedures including, ethanol vs. methanol extraction and vortexing vs. rocking samples to determine which method extracted the greatest amount of steroid hormones. Results indicated that rocking fecal samples for 24 hr extracted less steroid hormone than vortexing. For fecal androgens, a 6.8-fold increase in hormone concentration was found when samples were extracted with methanol and vortexed for 20 minutes (M/V 20 min), compared to extraction with ethanol and vortexed for 20 minutes. Although results were not significant, the M/V 20 min extraction also yielded a greater amount of estrogens, compared to other extraction methods. For our second objective, we examined whether antibodies found to be appropriate for measuring fecal steroids in other felids were also suitable for snow and Amur leopards. As was found in other large cats, our preliminary results indicated that a broad scale testosterone antibody and an estrogen metabolite (E1G) antibody can be used to measure fecal androgens and estrogens in snow leopards, and may also be applicable to Amur leopards. Results from these studies will improve procedures to characterize the seasonal reproductive profiles of pubertal and adult female and male leopards.

P1.164 GOSNELL, W. C.*; BUTCHER, M. T.; MAIE, T.; BLOB, R. W.; Clemson Univ., Youngstown State Univ.; wgosnel@clemson.edu

Ground reaction forces on the hindlimb of the opossum (*Didelphis virginiana*) during terrestrial locomotion: implications for femoral loading

Studies of limb bone loading in terrestrial mammals have typically found bending to be the primary loading regime, with torsion less significant. However, previous studies have focused on large and/or cursorial eutherian species in which the limbs are held essentially upright. Recent *in vivo* strain data from the Virginia opossum *Didelphis virginiana*, a marsupial that uses crouched rather than upright limb posture, have indicated that its femur experiences moderate torsion during locomotion. Though not as great as the torsion measured from the femora of non-avian reptiles, femoral torsion in opossums is greater than that seen in cursorial mammalian species. The elevated femoral torsion observed in opossums (compared to other mammals) might result from medial inclination of the ground reaction force (GRF), crouched limb posture, or a combination of these factors. To evaluate the mechanism underlying torsional loading in opossum femora, we filmed opossums running over a force platform, allowing us to measure the magnitude of the GRF and its three-dimensional orientation relative to the limb. Results indicate that at peak magnitude the GRF is oriented nearly vertically, with mediolateral inclination typically less than 5 degrees. These results are similar to those observed in other mammals, indicating that elevated torsional loads in opossum femora are likely correlated with their crouched limb posture, rather than differences in GRF orientation compared to other taxa. NSF IOB-0517340.

P3.39 GRAJALES, Alejandro*; RODRIGUEZ, Estefania; Richard Gilder Graduate School at the American Museum of Natural History, American Museum of Natural History; agrajales@amnh.org

Phylogenetic relationships of the subclass Hexacorallia (Cnidaria; Anthozoa): an update.

The subclass Hexacorallia comprises six orders: Actiniaria, Ceriantharia, Antipatharia, Corallimorpharia, Scleractinia and Zoanthidea. Members of this subclass are relevant components and ubiquitous to all marine habitats. Among many others, they play an important role in the maintenance of biodiversity in marine environments, since they act as habitat-providers for other species. Previous phylogenetic studies on the group supported the monophyly of the extant orders, but the relationships among them are still problematic. Over the last years, separate efforts in understanding the phylogenetic relationships among different groups of Hexacorallia produced an increase on the molecular data available; particularly significant improvement has been made in the orders Actiniaria, Antipatharia and Zoanthidea. We review and update the phylogenetic relationships within Hexacorallia using published nuclear and mitochondrial gene sequences and different approaches for construction of phylogenetic hypothesis. Results would be discussed.

P1.78 GRASSA, CHRISTOPHER*; HSIEH, TONIA; KULATHINAL, ROB; UNIVERSITY OF FLORIDA, UNIVERSITY OF FLORIDA, TEMPLE UNIVERSITY; ROBKULATHINAL@UFL.EDU

Using comparative and functional genomics to infer past lineage-specific processes among vertebrates

The extensive diversity found among vertebrate reproduction is the product of species-specific selective processes. Exploring the evolutionary landscape across different functional gene classes, particularly those involved in reproduction, will inform us about a species' unique selective history. In this study, we employ a functional and comparative genomics approach on egg-laying and live-bearing vertebrate taxa in order to understand which genes and genetic systems have evolved in a non-neutral, lineage-specific manner. Using recently sequenced genomes, we compare the evolution of orthologs from such taxa as *Danio rerio* (zebrafish), *Anolis carolinensis* (lizard), *Gallus gallus* (chicken), *Xenopus tropicalis* (frog), and *Mus musculus* (mouse). We aligned a set of ~5000 orthologous genes and annotated them according to function via gene ontologies and by associating ESTs (expressed sequence tags) from a variety of tissues including reproductive and non-reproductive tissue. Phylogenetic tests of selection across lineages and sites were applied to orthologs in an effort to understand each lineage's selective history. This functional and comparative genomics approach provides information about an organism's biology by identifying targets of directional and purifying selection. In addition, the relative strength of selection can be quantified among sexual and non-sexual loci in taxonomic groups with different reproductive strategies such as mating, fertilization, and parental care.

P2.28 GRIVAS, J.A.*; GOLDEN, B.L.; FROUNTFELTER, T.; LESCH, M.A.; COBB, A.; LAFONTANT, P.J.; DePauw University; pascallafontant@depauw.edu

Inflammation and Repair in a Goldfish (*Carassius auratus*) Model of Heart Injury.

Among teleosts, the zebrafish is able to regenerate its heart following resection. We studied the wound healing and repair response in the heart of goldfish following cauterization injury to the ventricular myocardium. Electron microscopy and immunohistochemistry studies revealed a robust inflammatory response in the first week consisting primarily of infiltrating macrophages, heterophils, and mast cells. These inflammatory cells were identified in the lumen of spongy heart, within the site of the wound, and attached to endothelial cells adjacent to the site of injury. Inflammatory cells were also present in the compact layer of myocardium both adjacent and remote to the site of injury. PCNA-positive cells were observed in the injured area during the first three weeks. Collagen fibers accumulated at the beginning of the second week in a transition zone between healthy and injured myocardium and in adjacent subepicardial regions. By 6 weeks the injury appeared to be completely resolved. Our data suggest that effective repair mechanisms suggestive of regeneration operate in the injured goldfish heart.

P3.88 GREIVES, TJ; LONG, KL; BERGEON BURNS, CM; DEMAS, GE*; Max Planck Institute for Ornithology, Department of Migration and Immuno-ecology, Radolfzell, Germany, 78315, Indiana University, Department of Biology, Center for Integrative Study of Animal Behavior, Bloomington, IN, 47401; gdemas@indiana.edu

Sex differences in response to differing doses of the neuropeptide kisspeptin

Many animals experience marked changes in reproductive status across seasons. These changes in reproductive function are regulated by the hypothalamo-pituitary-gonadal (HPG) axis. In temperate breeding rodents, activation of the HPG axis is triggered by long days. The neuropeptide kisspeptin has recently been shown to serve as a positive regulator of the HPG axis by eliciting GnRH secretion and may serve as a mechanism for gonadal activation by summer-like long days. The precise actions of kisspeptin on the HPG axis in animals of differing photoperiod-induced reproductive states, however, remains unresolved. Additionally, the cost of activating or maintaining reproductive physiology under varying environmental (i.e. photoperiodic) conditions may differ between the sexes. The current study investigated whether sensitivities to kisspeptin differ in male and female Siberian hamsters (*Phodopus sungorus*) held on reproductively inhibitory short-day or stimulatory long-day photoperiods. We found that both males and females displayed elevated LH in response to the highest dose of kisspeptin; this result differs from a previous finding where multiple injections of kisspeptin lead to decreased LH in non-reproductive females. Additionally, the sexes differed in LH response at an intermediate dose of kisspeptin, depending on their photoperiod-induced reproductive state. These findings provide further insight into the basic actions of kisspeptin in the regulation of reproduction, and indicate that this peptide may serve as a potential mechanism regulating differential reproductive responses between the sexes.

P1.124 GUNDERSON, J.L.*; MACLEA, K.S.; COVI, J.A.; CHANG, S.A.; CHANG, E.S.; MYKLES, D.L.; Colorado State Univ, UC Davis Bodega Marine Lab; jgundy@ymail.com
Cloning and Characterization of Guanylyl Cyclases from the European Green Crab

The pleiotropic neuropeptide crustacean hyperglycemic hormone (CHH) regulates glucose utilization, molting, osmoregulation, and metabolism in decapod crustaceans. Here we focus on the role of CHH and molt-inhibiting hormone (MIH) in inhibiting ecdysteroidogenesis in the molting gland or Y-organ (YO). CHH signaling is mediated by a membrane receptor guanylyl cyclase (GC-II), while MIH signaling may involve a soluble NO-sensitive guanylyl cyclase (GC-I). RT-PCR and RACE are being used to clone cDNAs encoding GC-I catalytic subunit and GC-II in the green crab (*Carcinus maenas*). An EST containing a partial GC-II (251 bp; GenBank Accession number DW249653) has been sequenced. Degenerate primers directed against conserved sequences in the GC catalytic domain were used for nested and semi-nested PCR. 3' and 5' RACE will be used to obtain the remainder of the sequences. Real-time RT-PCR will be used to quantify the effects of eyestalk ablation (ESA) on GC expression in the YO. ESA removes the primary source of CHH and MIH and activates the YO in most decapods. However, adult *C. maenas* occur in two color morphs that differ in response to ESA. Red morphs molt infrequently and are resistant to ESA; green morphs molt more frequently and respond to ESA. We hypothesize that GC-I and GC-II are differentially expressed in YOs, which may contribute to the differences between the two morphs in the regulation of molting by eyestalk neuropeptides. Supported by NSF (IOS-0725238).

P3.112 HADJISOLOMOU, Stavros P*; GRASSO, Frank W; BioMimetic and Cognitive Robotics Lab., Brooklyn College, CUNY, Brooklyn NY, Program in Ecology, Evolution and Biology, The Graduate Center, CUNY, New York NY; stavros.hadjisolomou@gmail.com

Evidence for inter-sucker coordination in the Giant Pacific Octopus *Enteroctopus dofleini*.

In contrast to the fixed-link appendages of arthropods and vertebrates those of cephalopods are soft, continuous biomechanical systems capable of generating movements with a virtually infinite number of degrees of freedom. In octopuses, that are capable of manipulating relatively small objects, fine movements of objects are accomplished through the coordinated action of the arms and the suckers. We hypothesized that motions of adjacent suckers would show a greater degree of coordination during goal-directed arm movements than during non goal-directed movements. We filmed two Giant Pacific Octopuses (*Enteroctopus dofleini*) using their arms and suckers on a glass tank wall so that suckers on each of the eight arms were visible. We used (10 Hz) digital image analysis to track the motion of suckers while the octopuses used their arms for different tasks. We deduced arm movements from sucker movements and calculated the arm-independent movements of individual suckers. We computed the cross-correlations between the movements of each pair of 20-30 in each video sequence. We found significant correlations and anti-correlations ($p < 0.01$) that demonstrating neighborhoods of coordinated activity at intervals along the arm. These patterns of correlated sucker activity differed with the task. These results are consistent with earlier results in *O. bimaculoides*: sucker motions are coordinated with arm movements and vary with behavioral context. We suggest that these results provide functional evidence for neural connectivity and information sharing between suckers within an arm and coordinated, independent use of them is recruited in the service of specific goal-directed arm movements.

P1.87 HALL, David J.*; DAY, Ryan ; SECOR, Stephen M.; University of Alabama, University of Queensland; djhall1@crimson.ua.edu

Effects of fasting and food habits on the intestinal performance of fishes

We examined the impact of fasting on the intestinal performance of the omnivorous channel catfish (*Ictalurus punctatus*) and the carnivorous largemouth bass (*Micropterus salmoides*). We quantified for fasted and fed fish, intestinal uptake of L-leucine, L-proline, and D-glucose using the everted-sleeve technique, and activities of intestinal aminopeptidase-N (APN) and maltase using colorimetric assays. Neither species experienced a change in intestinal mass with fasting. Fasting catfish had significantly downregulated small and large intestinal uptake of the three nutrients, with uptake capacity declining by 58% after 1 week of fasting. Catfish also experienced with fasting a decline in intestinal APN activity (by 48%), but no change in maltase activity. In contrast, fasting largemouth bass did not experience a decrease in nutrient uptake for their intestinal ceca or small intestine, nor the downregulation of intestinal APN (with the exception of the ceca) or maltase activity. To explore potential relationships between feeding habits and intestinal function, we compared intestinal nutrient uptake and hydrolase activities of fasted catfish, bass, and the herbivorous grass carp (*Ctenopharyngodon idella*). Intestinal uptakes of L-leucine and D-glucose varied significantly among species, as both were transported at higher rates in grass carp intestines compared to either catfish or bass intestine. Similarly, activities of intestinal ANP and maltase varied among species with the activities of both hydrolases significantly greater for the grass carp compared to either the catfish or bass. Fish species vary in their capacity to regulate intestinal performance with feeding and fasting. For these three fish, intestinal breakdown and absorption of glucose increases with the amount of plant material in their diet.

P3.20 HAGERTY, B.E.*; TRACY, C.R.; SANDMEIER, F.; University of Nevada, Reno; bh@biodiversity.unr.edu

There's no place like home: dispersal and homing behavior of the chuckwalla in southern Nevada

Animal movement has both short-term (feeding, maintenance, predation avoidance) and long-term (inbreeding avoidance, reproduction, and survival) implications for individuals and populations. We are using inferences from genetic markers as well as homing experiments to investigate dispersal patterns and homing ability of chuckwallas (*Sauromalus ater*) in southern Nevada. Chuckwallas are large, saxicolous lizards that are confined to rocky outcrops. Heterogeneous habitat has likely contributed to isolation of chuckwalla populations. Evidence from mitochondrial DNA sequences suggests that chuckwallas expanded into Nevada at the end of the last pluvial period (ca. 10,000 ya), and subsequently little-to-no gene flow has occurred among patches of suitable habitat. Although unique haplotypes occur in populations on most mountain ranges in Nevada, providing evidence that dispersal and gene flow is restricted, this pattern may only be relevant for females as inferences have so far been made from maternally inherited markers. We hypothesize that females may have very limited dispersal, and that males may have a higher propensity to disperse due to their territorial behavior that includes defense of multiple females. We predicted that males would exhibit better navigational abilities during homing than would females. To test this prediction, we displaced female and male chuckwallas, which were outfitted with radio transmitters, at incrementally longer distances from their home sites. Preliminary movement data provide some support for our prediction, although individual variation in responses to displacement is high. Additionally, both sexes exhibit different strategies in response to displacement ranging from extreme searching movements to minimal movement and settlement in new suitable habitat.

P2.97 HALL, IC*; SELL, GL; HURLEY, LM; Indiana University Bloomington; ichall@indiana.edu

Social interactions influence serotonin in the auditory system.

One mechanism by which serotonin may influence social behavior is through the modulation of sensory processing. To investigate this possibility, we used voltammetry to measure levels of serotonin in the auditory midbrain (inferior colliculus, IC) of male mice during a resident-intruder interaction. A significant increase in serotonin was observed in the IC of resident mice during the social interaction. The serotonergic response was not correlated with the age or mass of the intruders relative to those of the residents but was correlated with the duration of anogenital investigation during the interaction. These data suggest that the behaviors demonstrated during a social interaction can influence levels of IC serotonin. To investigate how repeated exposures to a social stimulus influence the behavioral and serotonergic response, the same resident mice were tested again with different intruders. During a second interaction, in addition to the behavioral correlation, the magnitude of the residents' serotonergic response was correlated with the magnitude of the serotonergic responses observed during the first interaction. These data indicate that the change in IC serotonin is not solely influenced by the interaction between mice but that the magnitude of the serotonergic response also varies with the individual, suggesting that each mouse has a unique neurochemical response profile that contributes to its behavioral phenotype.

P1.70 HAMILTON, M. A. *; WARD, A. B.; Adelphi University; MichelleHamilton@mail.adelphi.edu
Determining the relationship between environmental conditions and somite development in zebrafish (*Danio rerio*)

Somites, the precursors of vertebrae, are integral to the formation and function of the vertebral column in *Danio rerio*. Found in early development stages, somites ultimately determine how many vertebrae the fish will have. Previous research has shown that fish raised in lower temperature environments have more vertebrae; fish raised in higher temperatures have fewer. If vertebrae are affected by temperature, it can be logically assumed that their precursors would also be affected. This experiment sought to find a relationship between temperature and somite development in early stage zebrafish. It was hypothesized that both the number and length of somites would vary based on the different temperatures. To test the hypothesis, zebrafish eggs were collected and treated at various stages of development including early cleavage, early gastrulation, mid-gastrulation, and early somitogenesis at four different temperatures. At 5 and 15 days old, the fish were either antibody stained or cleared and stained in order to visualize possible changes occurring in somite or vertebral formation. Results showed a variation in both number and length of somites based on the stage and temperature treatment. These results will help to provide a basic understanding of the relationship between number and length of somites, stage of development and environmental factors. It could also give support to an understanding of how changing somite number and length cause axial elongation.

P1.165 HANCOCK, Jennifer A.*; BIKNEVICIUS, Audrone R.; Marietta College, Marietta, OH, Ohio University, Athens, OH; jah006@marietta.edu

Head-bobbing and terrestrial locomotion in charadriiform birds

Head-bobbing is the fore-aft movement of the head relative to the body during terrestrial locomotion in birds. It is predominately considered to be an optomotor response, in which the hold phase functions to stabilize an image on the retina and thrust phase is thought to use motion parallax to generate depth perception. However, previous studies have suggested that head-bobbing may be linked mechanically to aspects of locomotor biodynamics: (1) head movements are synchronized with limb movements in some species of birds and (2) locomotor mechanics differ in gulls walking with and without head-bobbing. The first goal of this study was to assess whether head-bobbing was synchronized with limb movements in free-ranging charadriiform birds while foraging. The second goal was to compare the kinematics of locomotion in head-bobbing and non-head-bobbing charadriiforms. Sixteen species (10 head-bobbers; 6 non-head-bobbers) were filmed in lateral view at 60 Hz, and the resulting videos were assessed for the timing of head and limb movements. The results found an imperfect synchronization of head and limb movements among head-bobbing charadriiforms; whereas the hold phase was predictably initiated near the onset of single limb support, the initiation of thrust phase was more variable. Furthermore, few significant differences were found between head-bobbing and non-head-bobbing species: stride duration and stance duration are similar although a speed-dependent difference in stride frequency is suggested.

P2.18 HAMMOCK, J.; LEMAITRE, R.*; HARASEWYCH, M.G.; Smithsonian Institution; hammockj@si.edu
Antarctic Invertebrates at the Smithsonian: one-stop shopping

The Antarctic Invertebrates website, <http://invertebrates.si.edu/AntIZ.htm>, is the online portal to detailed specimen information, maps, DNA sequences and multimedia for Southern Ocean invertebrates collected by the United States Antarctic Program (USAP) and other programs and housed at the National Museum of Natural History (NMNH). Modern web development and informatics tools have allowed us to provide worldwide access to the complete dataset for this collection. Present tools include taxonomic, bibliographic and station data searches, mapping of combined species and/or station data, searches of co-occurring species, and historical information about Antarctic research. The bibliography and catalog are cross-referenced and inter-navigable. Nearly half the species have photographs or micrographs and full text original descriptions, and a growing subset have DNA barcodes. Specimens are linked to their high-res images in the NMNH online catalog and to their barcodes in the Barcode of Life Database. The website presently serves data only for the NMNH collection. In the next round of web-development in 2010, we will begin serving data for other institutions who wish to share their collections online. The present map function will be replaced by an ArcGIS platform which will permit the pooling of new map data-including bottom type, bathymetry and SST- with specimen data. USAP map data will be served through the website and incorporated into the searches. (eg.: search for sponges on sandy bottoms below 1000m). Users with GIS software will be able to download map and specimen data and combine it with their own datasets for desktop analysis. We believe this combined dataset will greatly facilitate research into questions of systematics, ecology and biogeography in the Southern Ocean.

P2.53 HANSON, A.M.*; SHERIDAN, M.A.; North Dakota State Univ., Fargo; andrea.m.hanson@ndsu.edu
Effects of Environmental Estrogens on the Growth Hormone-Insulin-Like-Growth Factor System and Seawater Adaptation of Rainbow Trout

Previous studies show that successful adaptation of euryhaline teleost fish to seawater (SW) involves the GH-IGF system. Fish in aquatic habitats are exposed to increasing concentrations of environmental contaminants, including environmental estrogens (EE). In this study, we used rainbow trout (*Oncorhynchus mykiss*) to assess the effects of EE on the GH-IGF system and seawater adaptation. Juvenile trout (ca. 30g) were exposed to either low (10 µg/l) or high (100 µg/l) concentrations of β-sitosterol (BS), 4-n-nonylphenol (NP), or 17β-estradiol (E2) for 28 days in fresh water (FW) (14 C; 12L:12D), then half of the fish were exposed to 20‰ SW while the other half remained in FW. A slight elevation in plasma chloride levels accompanied by a slight depression in gill Na⁺,K⁺-ATPase activity was observed in all EE-treated fish compared to control fish 6-12 h after SW exposure. SW increased hepatic mRNA levels of GH receptor 1 (GHR1), GHR2, IGF-1, and IGF-2 in control fish 6-12 h after exposure. In gill, levels of GHR1, GHR2, IGF-1, IGF-2, IGF receptor 1A (IGFR1A) and IGFR1B mRNAs also increased in control fish 6-12 h after SW exposure. Exposure to BS, NP, and E2 abolished or attenuated normal SW-induced changes in the expression of GHR, IGF, and IGFR1 mRNAs in liver and gill. These results indicate that EE reduces SW adaptability by inhibiting the GH-IGF system. (Supported by NSF IOS 0920116)

P1.114 HARDEN, L.A.*; SOUTHWOOD, A.L.; BLANVILLAIN, G.; UNC Wilmington, Grice Marine Lab, College of Charleston; lah4492@uncw.edu

Seasonal Variation in Blood Biochemistry of Diamondback Terrapins *Malaclemys terrapin* in Southeastern North Carolina

Diamondback terrapins *Malaclemys terrapin* are one of the few reptilian species endemic to estuarine environments, making them unique in many aspects of their biology. In order to cope with the fluctuating salinity, tides, temperature, and oxygen availability of their environment, terrapins not only undergo shifts in activity and habitat use, but also in physiological mechanisms such as osmotic and metabolic adjustments. Few studies have focused on the seasonal changes in ion concentrations and metabolic capacity as relating to overwintering behavior, allowing terrapins to survive the cold, anoxic conditions of the winter. It is well documented that overwintering freshwater emydid turtles are able to survive for long periods of time in anoxic conditions by relying on an anaerobic metabolism or extrapulmonary respiration, but little is known about the degree to which terrapins rely on aerobic and anaerobic metabolic pathways during dormancy. We investigated seasonal shifts in physiological and metabolic status by examining blood biochemistry parameters of two radio-tagged terrapin populations in southeastern North Carolina. Blood samples were taken from terrapins in the spring, summer and winter 2009 to assess changes in plasma concentrations of lactate, ions (Na⁺, K⁺, Cl⁻, Ca²⁺, Mg), corticosterone, glucose, and enzymes. Analysis of co-variation was used to test for significant differences in biochemical parameters of terrapins using time of year, body size and population site will be tested as co-variates. This physiological data will provide insight as to the mechanisms by which terrapins adapt to and endure the variable conditions associated with overwintering in estuarine ecosystems.

P2.14 HARTY, J.H.*; FREYMLER, H.J.; EDWARDS, T.M.; GUILLETTE, L.J.; Univ. of Florida, Gainesville, Tulane University, New Orleans; jharty@ufl.edu

Effects of nitrate exposure on pancreatic beta-cells in American alligator

During the past fifty years, humans have produced and released a surfeit of reactive nitrogen into the environment. Now, few parts of the Earth are unimpacted by nitrogen pollution. Nitrate infiltrates surface and groundwater, potentially contaminating drinking water sources. It is suspected that over 20% of groundwater sources exceed the US and World Health Organization limits of 10 mg/L nitrate-nitrogen (NO₃-N). Thus, it is now important to understand the health consequences of excess nitrate exposure. Recent evidence suggests that type 1 diabetes (T1D) may be caused by dietary nitrates, nitrites, and N-nitroso compounds. Type 1 diabetes is an autoimmune disease in which lymphocytes attack beta cells. This reduces beta cell number and area and leads to low insulin production. We tested the effect of environmentally relevant nitrate exposure on the area and number of insulin-producing beta cells in the pancreas of *Alligator mississippiensis*. Alligator eggs were collected from Lake Woodruff, Florida, in June 2008. After hatch, the animals were exposed for five months to environmentally relevant concentrations of nitrate (10 or 100 mg/L NO₃-N) in their tank water or a tap water control (n = 15 animals per treatment). If there is a connection between nitrate exposure and diabetes, we would expect a decreased number and/or area of beta cells in the pancreas of the alligators exposed to nitrate. Our discussion will focus on the impact of nitrate as an environmental contaminant and its effect on beta cells in the pancreas of the American alligator.

P2.162 HARPER, C.J.*; AZIZI, E.; NOWROOZI, B.N.; SULLIVAN, A.C.; SWARTZ, S.M.; Brown University; caroline.harper@brown.edu

Hovering and hovering: tongue and wing movements in nectar-feeding bats *Glossophaga soricina*

During feeding, nectar-feeding bats hover in front of a flower and use their long tongues to gather nectar. The muscles used to power the upstroke and the downstroke of the wing act on specific regions of the thorax. The tongue retractor muscle, the sternoglossus muscle, also originates on the thorax. Specifically, the sternoglossus muscle arises from the xiphoid process of the sternum and inserts into the free portion of the tongue. During hovering, the actions of the flight muscles likely change the shape of the thorax, which may constrain tongue retraction. If the actions of the flight muscles constrain tongue retraction, we would expect to see a distinct temporal relationship between the movements of the wing and the movements of the tongue. Nectar-feeding bats, *Glossophaga soricina*, were trained to feed from a small feeder and high-speed videography was used to capture tongue protrusion and retraction across multiple wingbeat cycles. The kinematic data showed that tongue elongation and retraction occurred during various phases of the wingbeat cycle with no distinct pattern. Therefore, despite their anatomical connection to the thorax, the movement of the tongue appears to not be constrained by the actions of the flight muscles. This finding suggests that movements associated with feeding and flight are not tightly coupled in nectar-feeding bats.

P2.84 HAUZE, A E*; DING, Z; ROOT, R G; Lafayette College; hauzea@lafayette.edu

Modeling muscle force biochemically accurately and computationally efficiently

Mathematical models of muscle force generation typically trade off accurate representation of the conversion of chemical to mechanical energy with computational efficiency or analytical tractability. This model attains a compromise between the two, incorporating the primary biochemical features while offering computational ease adequate for inclusion in larger scale models of vertebrate physiology. The model incorporates five states of the actin-myosin binding cycle transitions amongst them based on experimentally determined kinetics. Despite this relative sophistication, the model is implemented computationally so that it can evolve the state of several sarcomeres in real time on a single processor. We demonstrate that the model replicates basic features of muscle behavior, including adherence to Hill's Law and realistic transition from relaxation to tetanus.

P1.144 HAYASHI, M*; WANG, J; GERRY, S.P.; ELLERBY, D.J.; Wellesley College; mhayashi@wellesley.edu
Explosive Seed Dispersal Mechanism in Sand Bittercress (*Cardamine parviflora*)

Some plants disperse their seeds ballistically using elastic energy stored in pod tissues. Species may rely solely on this mechanism or recruit an additional secondary dispersal method e.g. wind or water. Ballistic performance was quantified in Sand Bittercress (*Cardamine parviflora*), an herbaceous annual that uses only this seed dispersal mechanism. We hypothesized that the launch mechanism of this specialized ballistic disperser would be more effective than in a species that also used a secondary mechanism. The launch trajectories and seed dispersal pattern were quantified using a high-speed camera and a computer ballistics model. The mechanical energy storage capacity of the valves was also determined by re-extending the coiled valve tissue with an ergometer. The mean and maximum launch velocities were 6.3 ± 0.3 (mean \pm SEM, $n=83$) and 12.0 ms^{-1} respectively. The mean launch angle (55.9 ± 1.4 above the horizontal, mean \pm SEM, $n=83$), was steeper than that predicted by the ballistics computer model to maximize dispersal distance. It also differed significantly from the horizontal (0°), the expected mean launch angle for a random angle distribution. Mean and maximum dispersal distances were 0.94 ± 0.05 (mean \pm SEM, $n=83$) and 1.85 m respectively. The mass specific energy storage capacity of the pod valves was $72.4 \pm 12.4 \text{ J kg}^{-1}$ (mean \pm SEM, $n=15$). The efficiency of transferring this stored energy into seed kinetic energy was 6.7%. This energy transfer efficiency was higher than that in *Impatiens capensis* (0.5%), a species that relies on secondary dispersal via water flow to achieve long distance dispersal. With the mean launch distance also greater in *C. parviflora* than *I. capensis* (0.94 vs. 0.44 m), these outcomes suggest a more effective seed launching mechanism in the ballistic specialist *C. parviflora*.

P3.87 HAYES, T. N.*; KALB, H. J.; Georgia Southern University, Statesboro GA; hjkalb@gmail.com
Visual phases of egg development in Malayan box turtle (*Cuora amboinensis*) as observed with ultrasound technology

Little information is currently known about reproduction in Malayan box turtles in their native environment. In this presentation we will describe three visual phases that can be observed with ultrasound technology of oviducal eggs from ovulation to oviposition. The development of ovarian follicles and oviducal eggs were monitored using an Aloka ultrasound. Information was collected on the number and appearance of oviducal eggs. Newly ovulated eggs (phase 1) have bright white (echoic) yolks with a crisp white shell and more than 50% of the albumin layer appears a solid black (anechoic). During phase 2, less than 50% of the albumin is clear but the yolk is still observable. In phase 3, it is no longer possible to visualize the yolk. Since ultrasound exams were conducted on an irregular schedule, we don't have good data as to exactly how long each phase lasts. On ten occasions during this study period we were able to calculate an approximate gestation length (the nesting date minus the date an oviducal egg was first observed in phase 1). Based on that information, then phase 1 was observed to last $5.7 \pm 3.5\%$ (2.3-11.8%), phase 2 was $3.6 \pm 8.2\%$ (0-26%), and phase 3 was $64.9 \pm 16.5\%$ (32.6-91.3%) of the observed gestation periods. Neither phase 1 or 2 were observed for more than 6 days, while phase 3 was observed lasting from 6 to 103 days. It appears that changes in the duration of phase 3 are responsible for changes in the total gestation length. Information was collected from 13 females who produced 36 eggs, but similar trends have been observed during prior research. There was only 1 instance in which an egg appeared to regress to an earlier phase. These visual phases should be useful to researchers in both captive and wild populations who are trying to predict when females will nest or to track individual clutches.

P3.86 HEAD, Jennifer M.*; REIBER, Carl L.; Univ. of Nevada, Las Vegas; jennifer.head@unlv.edu
Characterization of the Genome of *Triops longicaudatus*

Triops longicaudatus is a branchiopod crustacean that has remained virtually unchanged in the fossil record for approximately 250 million years. *Triops* generally inhabits shallow, ephemeral bodies of fresh water, tolerates extreme conditions, and forms cysts during periods of desiccation. Despite many studies, reproduction in branchiopods is poorly understood. Many populations of *Triops* are female-biased and are thought to employ parthenogenic, hermaphroditic, and sexual modes of reproduction. In an attempt to elucidate the reproductive strategy and complex genome of *T. longicaudatus*, we analyzed the nuclear content of hemocytes in both male and female individuals to obtain an estimate of both the total genome size and ploidy using flow cytometry. Eukaryotic genomes range in size from 20Mb in the nematode *Pratylenchus coffeae* to 670 Gb in *Amoeba dubia*. Using Chicken Erythrocyte Nuclei as a control, we estimate the total haploid content of *Triops* hemocytes to be $131.0 \pm 0.6 \text{ pg}$ in males and $130.0 \pm 0.8 \text{ pg}$ in females, translating into a genome size of approximately 1.27 Gb. A more in depth analysis and comparison of the male and female hemocytes resulted in very different DNA profiles for male and female cell populations. While the female individuals consistently had histograms resembling those of diploid organisms, the males have what appears to be an additional haploid population of cells. The difference in ploidy between males and females could be a result of different modes of reproduction in each gender or due to a cytoplasmic endosymbiont-based reproductive strategy. Ongoing karyotyping studies will help to further clarify the reproductive biology of *Triops* as well as the size and structure of the *Triops* genome.

P3.80 HEERS, A.M.*; TOBALSKE, B.W.; DIAL, K.P.; University of Montana; amheers@mac.com

The Ontogeny of Lift and Drag Production in Birds

Flight performance in developing birds may be limited by a number of factors, including muscular output, neuromuscular control, physiological processes, and/or wing morphology. In order to assess how external wing morphology – namely surface area, camber, and feather structure – influences lift and drag production during avian development, we prepared dried, spread wings of chukar (*Alectoris chukar*) in different age classes (day 6 through adult) and revolved the wings as a propeller. The propeller was mounted on a force plate, which allowed lift and drag to be measured. At natural angular velocities (recorded in vivo during 65° wing-assisted incline running, WAIR) and under identical flow conditions (same Re), coefficients of lift and drag and lift to drag ratios increased with age, revealing that external wing morphology limits aerodynamic performance in immature birds. While lift thus appears to play an increasingly important role in older birds, drag may be directed relatively vertically during WAIR and thereby contribute to weight support and propulsion, especially in younger birds. Given certain similarities between the wings of immature chukars and those of various fossilized theropods, these findings have profound implications for understanding the evolution of avian forelimb function and for extrapolating locomotor performance to extinct fossil forms. NSF Grants IOS 0923606 and IOS 0919799.

P3.69 HERNANDEZ, LP*; MARTIN, CH; WAINWRIGHT, PC; ADRIAENS, D; MASSCHAELE, B; DIERICK, M; George Washington University, University of California- Davis, Ghent University; phernand@gwu.edu

Scum sucking, scale snipping or snail scooping: Divergence in size and structure of cranial features within incipient species of Bahamian pupfish with different diets

Sympatric speciation has often resulted in significant morphological differentiation of trophic features. A young radiation of Cyprinodon species, characterized by distinct head and body shape, resides within hypersaline lakes in San Salvador, Bahamas. Not only are these incipient species morphologically distinct, our gut content analyses show they have distinct diets. These trophic morphs include a detritivore, a specialized scale feeder and a hard prey specialist. Moreover, another prospective morph shows a tendency towards a more piscivorous diet. Previous work describing cranial differences within these morphs examined only basic changes in head shape. To more carefully assess the specific morphological differences that characterize this Bahamian radiation we have dissected, cleared and stained, and micro-CT scanned individuals. The most significant differences were seen between the scale feeder and all other morphs. While some meristic characters (tooth number) underwent changes, much of the trophic divergence within this radiation was due to changes in continuous variables. While all morphs contained the same basic divisions of the adductor mandibulae (AM) complex, the relative size and connectivity among divisions varied substantially. Total mass of the AM in scale feeders was 4 times that of either detritivores or hard prey specialists. Overall, scale specialists showed the most divergent morphology, suggesting that divergent selection for scale-biting might be stronger or act on a greater number of traits than selection for either piscivory or durophagy.

P3.108 HEROLD, Paul B*; SPRAYBERRY, Jordanna DH; Muhlenberg College; ph235004@muhlenberg.edu
Development of a complex motion stimulus to investigate neural substrates of flower tracking in the hawk moth *Manduca sexta*

A persistent question in neurobiological research regards how sensory information encoded by the brain produces behavior. The hawk moth *Manduca sexta* is an excellent model organism for investigating this problem. Hawk moths are rapidly flying nectar feeders that hover in front of flowers. They actively track moving blossoms during feeding bouts, a behavior that is primarily driven by visual cues. Object-sensitive descending neurons (OSDNs) in the cervical connectives of the moth represent highly integrated cells near the sensory-behavioral interface. Recording from OSDNs during stimulation with flower-like motions may elucidate how visual information is processed and encoded as it travels from photoreceptors to thoracic motor centers via the cervical connectives. Flower motions are complex and, as a function of the constraints of the stems, oscillatory in nature. Stimulating OSDNs with equally complex, naturalistic motions allows for the investigation of complex motion encoding that could not be accounted for with a simplistic, unidimensional stimulus. Through the manipulation of random-noise position vectors, I have developed naturalistic flower-like stimuli whose power spectra are consistent with those of hawk moth pollinated flowers. The multiplication of bounding functions with vectors of the power spectra allowed me to filter out the irrelevant frequencies of the noise signals, producing new position vectors that encompass motion dynamics seen in flowers visited by hawk moths. The resulting stimuli, in conjunction with further recordings from OSDNs, will provide new insights into the neural substrates of flower tracking in *M. sexta*.

P3.35 HERNANDEZ-GARCIA, P.J.; UNIVERSITY OF PUERTO RICO, RIO PIEDRAS CAMPUS; pabloj82@yahoo.com

Elevation gradient affect aquatic macroinvertebrate assemblages in tropical island streams

The "River Continuum Concept" presents how the macroinvertebrate functional groups changes from headwaters to the estuary, depending in channel width, forest cover and organic material inputs. Studies in spatial variation are focus in these changes, but few of them had observed if the elevation has any effect to the biota. In this study, we evaluate how elevation affects aquatic macroinvertebrate assemblages in a tropical island. Eighteen streams were selected in an elevation gradient from watersheds draining "El Yunque National Forest" in Puerto Rico. These streams were selected based in channel width (from 1 to 3.5m) in the less human impacted areas, to be similar to headwater streams. In each stream, samples were collected from the two main microhabitat (five from pools and five from riffles) using D-shape net in a standard area of 90cm². Samples were taken to the laboratory, where macroinvertebrates were extracted and classify under the microscope. Insects were classified to family level. In addition, Crabs and shrimps were classified to specie. Along the elevation gradient, we found similar aquatic macroinvertebrate assemblages, from which the most abundant were insects of family Leptophlebiidae. This result support the assumption of the "River Continuum Concept" that present that streams with similar channel width, forest cover and organic material inputs will have similar macroinvertebrate assemblages.

P1.153 HERRING, S.W.*; DUTRA, E.; CARIA, P.H.F.; RAFFERTY, K.L.; Univ. of Washington, UNICAMP, Brazil; herring@u.washington.edu

The Cheek during Mastication: Activity of the Buccinator Muscle

The buccinator muscle forms the lateral wall of the mammalian oral cavity. It is presumed to aid mastication by maintaining bolus position. Such a function would involve thickening the cheek, possibly compressing the alveolar bone. Our objective was to evaluate buccinator activity during feeding, its dimensional changes, and the pressure exerted on its alveolar attachment in miniature pigs, *Sus scrofa* (n=6). EMG of the buccinator and other oral muscles was recorded along with sonomicrometry of anteroposterior length and mediolateral thickness. Pressure transducers were placed beneath the mandibular origin of the buccinator. During mastication, buccinator EMG showed regular peaks that preceded those of the jaw closers. The buccinator shortened and thickened when it contracted. Positive pressures were observed at the mandibular attachment of the buccinator, increasing when the muscle was active. Pressure and dimensional changes were usually larger for apple and apricot than for nuts. Working and balancing sides could be distinguished with EMG but not with dimensional or pressure measures. Histological evaluation showed a complex interweaving of fibers closely associated with salivary glands. In conclusion, during mastication the buccinator thickens the cheek just before the closing stroke begins. Despite the fact that the muscle pulls on its attachment, the local mechanical environment at the alveolar bone is one of positive pressure. In addition to controlling the bolus, there may be an effect on salivation. Supported by NIH DE8513.

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Male *Taricha granulosa* have submandibular courtship glands.

The literature reports that the salamandrid species *Taricha granulosa* has submandibular skin glands used during courtship to deliver pheromones. There is no histological data, however, confirming this hypothesis. We examined the histology of submandibular skin glands from male and female *T. granulosa* using hematoxylin and eosin and the Quad stain of Floyd. Males, but not females, have PAS-positive granular glands in this region. These glands are morphologically distinct from glands in females and occur with high frequency. Thus, there is sexual dimorphism in submandibular skin glands in this salamandrid. The presence of this collection of glands in males sheds light on the origin and evolution of mental glands in plethodontids.

P2.168 HIROKAWA, J*; ROBERTS, S; FRIAS, C; KRENITSKY, N; DE LEEUW, J; LONG, J; PORTER, M; Vassar College; johirokawa@vassar.edu

A Self-Propelled Robotic Swimmer as a Biomechanical Testbed: Swimming Performance and Axial Length of the Intervertebral Joints

To directly measure how skeletal morphology impacts swimming performance, we designed and built the Mobile Autonomous Robot for Mechanical Testing (MARMT). MARMT is a self-propelled surface swimmer with programmable locomotor behaviors and swappable biomimetic skeletal elements. We programmed MARMT to vary tailbeat frequency and swimming mode (steady undulation and transient escape). As the propulsive element, we built and installed constant-length biomimetic vertebral columns that varied number of vertebrae to alter the axial length of the intervertebral joints. The biomimetic vertebral column consisted of a notochord, made from gelatin cross-linked with glutaraldehyde, encircled by a series of rigid plastic ring centra. We varied the number of intervertebral joints from zero to twelve. Three replicates of each vertebral column were tested during straight swimming and escape responses; five different tail-beat frequencies were used while tail-beat amplitude was held constant. Response variables were MARMT's velocity, acceleration, yaw rotation, tail curvature, and lateral amplitude of the tail. Preliminary analysis supports the hypothesis that increased frequency and shorter intervertebral joints lead to higher maximum and mean accelerations. Extrapolating our results to biological systems, shorter intervertebral joints may provide an adaptive advantage for bursts of speed. This may allow for quicker escapes from predators or faster attacks on prey. This work was supported by NSF DBI-0442269 and IOS-0922605.

P2.119 HO, J.M.*; DEMAS, G.E.; Indiana University, Bloomington; jmho@indiana.edu

Endocannabinoid levels in Siberian hamsters across sex and season

Regulation of energy balance is critical to survival and optimal functioning in all organisms. Siberian hamsters (*Phodopus sungorus*) adapt to harsh winter conditions with decreases in food intake and adiposity, thereby lowering energy requirements. The neuroendocrine mechanisms responsible for these changes are not well understood, and classic hypothalamic peptides involved in homeostatic regulation of energy balance provide little explanation. The endocannabinoid system is known to influence appetite and energy expenditure and may contribute to seasonal modulation of energy balance. To determine whether the endocannabinoid system is involved in mediating seasonal changes in energy balance in Siberian hamsters, we tested whether endocannabinoid signaling changes across seasons. Specifically, we examined endocannabinoid levels in the brain, liver, and adipose tissue of hamsters acclimated to short, winter-like or long, summer-like days following 0, 3, or 9 weeks of exposure. We further assessed brain levels of the endocannabinoid receptor, CB₁, and data from males and females will be presented. Together, these findings will give insight to endocannabinoid involvement in the regulation of energy balance in Siberian hamsters and provide an important model for studying dynamic regulation of energy balance in response to changes in environment.

P1.57 HOADLEY, Kenneth D*; SZMANT, Alina M; PYOTT, Sonja J; University of North Carolina Wilmington; kdh7192@uncw.edu

The Role of Cryptochrome Photoreceptors in Regulation of *Favia fragum* Diel and Lunar Reproductive Cycle

Animals use environmental cues to coordinate cyclic patterns of behavior throughout their life cycles. In stony corals, including *Favia fragum*, the diel and also lunar cycle provide well-described environmental cues that synchronize biologically important events, including diel tentacle extension and retraction and monthly reproductive cycles timed to specific lunar phases. Recent evidence showed that *cryptochromes*, a group of blue light-sensing photoreceptors known to play a role in regulation of diel rhythms, were up regulated during a seasonal broadcast spawning event in the coral *Acropora millepora*. This finding suggests that these photoreceptors may play a role in synchronizing coral spawning events with the lunar cycle. We are using QRT-PCR and histological methods to investigate the correlation between *cryptochrome* transcript abundance and key reproductive events, including gametogenesis and planulation, in the lunar reproductive cycle of the stony coral *Favia fragum* collected near La Parguera, Puerto Rico. We will also look at how these genes fluctuate throughout the 24 hour diel cycle. We have confirmed that these corals express two *cryptochrome* genes (*cry1* and *cry2*) along with other genes known to regulate the circadian cycle (*Clock*). Understanding how expression of these genes correlates with monthly and also daily biological events in *F. fragum* promises to increase our knowledge of the molecular mechanisms that entrain stony corals and other invertebrates to environmental cues.

P1.23 HOCHBERG, Adele*; HOCHBERG, Rick; University of Massachusetts Lowell; *adele_hochberg@student.uml.edu*
New insights on larval metamorphosis in sessile rotifers: Species of *Stephanoceros*
 Species of *Stephanoceros* are sessile rotifers that reside in a gelatinous tube, have a vase-shaped body and an unusual, basket-like corona. Dispersal of sessile rotifers is effected by the production of free-swimming larvae – a derived condition in the Rotifera. The larval bodyplan is generally distinct from the adult, and to date, there are limited details on how the larva metamorphoses into the adult bodyplan. Here, we provide new details on the structure of both the larva and the adult using light microscopy and confocal laser scanning microscopy, and capture larval metamorphosis with digital video. Our observations confirm that the adult corona is produced “inside” the larval body, and that the new corona gradually extends through an opening on the larval head. The muscles that supply the coronal arms of the adult undergo a gradual metamorphic transition, whereby individual muscle blocks progressively split and form an intricate meshwork of muscle fibers within individual coronal arms. Additional details on larval development are presented.

P3.85 HODGE, Melissa G.*; BENOWITZ-FREDERICKS, Morgan; Bucknell University; *mgh010@bucknell.edu*
Age- and sex-specific uptake and distribution of yolk androstenedione in chicken (*Gallus gallus*) embryos
 Steroid hormones transferred from avian females to the egg yolk of their offspring affect multiple aspects of hatchling phenotype. However the location and timing of the effects in embryos are essentially unknown. Androstenedione is found in large quantities in egg yolk and is often manipulated in experimental studies of avian maternal effects. Androstenedione is often assumed to be converted into the sex steroids testosterone and estrogen, however almost nothing is known about its uptake and use by embryos. We explored the tissue-specific distribution of tritiated androstenedione that was injected into fresh eggs in male and female chicken (*Gallus gallus*) embryos. Tritium was quantified in head, body, and yolk of day 7 embryos and in blood, brain, liver, heart, muscle, and yolk of day 16 embryos. Tritiated hormone was found in all tissues analyzed, but at both days 7 and 16 the majority of tritiated hormone was extra-embryonic. There were no significant differences between day 7 embryonic tissues. On day 16, the concentration of tritiated hormone was higher in female brains, but there was no difference in other tissues. Liver tissue from day 16 embryos contained significantly higher concentrations of tritiated hormone than all other tissues. While sex and tissue specific metabolism of androstenedione into active sex steroid derivatives remains to be investigated our study shows that yolk-derived androstenedione is present in all tissues of developing embryos. Thus, maternal androstenedione is likely an important component of avian endocrine maternal effects.

P3.68 HOCHBERG, Rick*; MALISKA, Max; LEASI, Francesca; Univ. of Massachusetts Lowell, Univ. of Washington, Univ. of Milan, Italy; *rick_hochberg@uml.edu*
Organization of the musculature in species of *Seison* (Rotifera), ectosymbionts of the marine crustacean *Nebalia pugettensis*
 Species of *Seison* are sexually dimorphic, ectosymbiotic rotifers on marine leptostracans of the genus *Nebalia*. Many studies of rotifer evolution hypothesize an ancestral position for *Seison* within Rotifera, but several details on the anatomy of the inclusive species remain unknown, hindering an understanding of rotifer evolution. In this study, we examine the muscular system of two unidentified species of *Seison* to determine if muscle patterns show a plesiomorphic organization relative to species in more derived clades. Both male and female rotifers of *Seison* sp. were collected from *Nebalia pugettensis* on the coast of San Juan Island, Washington, stained with phalloidin, and examined with CLSM. Results reveal that the musculature of *Seison* is segmentally arranged, with separate sets of longitudinal muscles restricted to the head, neck, trunk and foot. Complete somatic circular muscles are absent from both species and both sexes; however, somatic, semicircular muscles (incomplete circular muscles) are present in the head of one species and the head and trunk of a second species. Splanchnic circular muscles are complete and line the entire digestive tract. Males and females of both species possess similar somatic muscle patterns, with minor differences generally present in the number and organization of muscles that supply the reproductive systems. A comparison of seisonoids with rotifers from the other major clades is presented.

P3.34 HODGE, Anne-Marie C.*; ARBOGAST, Brian S.; VANDERHOFF, E. Natasha; BURGER, Joseph R.; KNOWLES, Travis T.; University of North Carolina-Wilmington, Jacksonville University, University of New Mexico, Francis Marion University; *ach7229@uncw.edu*
Inventory of a mid-elevation assemblage of mammals in Ecuador's eastern Tropical Andes hotspot
 Wildsumaco Wildlife Sanctuary is a new preserve (ca. 500 ha; ~1400 m – 1500m elevation) located adjacent to Sumaco National Park, in the eastern Andean foothills of Ecuador. Habitat includes primary and secondary premontane rainforest, with some disturbed areas. A mammal survey was initiated in mid-December 2008, using 12 camera traps along the established trail system. As of September 2009 we have documented 14 mammal species, with the most common image captures being black agouti, nine-banded armadillo, margay, paca, and Amazon red squirrel. A particularly rich assemblage of carnivores have been recorded, including puma, spectacled bear, margay, tayra, greater grisson, South American coati, kinkajou and long-tailed weasel. Possible images of jaguarundi await confirmation. Mammal species richness from camera trapping and visual surveys is currently 23. Presence of spectacled bear and margay are noteworthy, considering the low elevation occurrence of the bear and the high abundance of margays, a near threatened and declining species. Presence of pumas and absence of evidence of jaguars suggest that the puma represents the apex predator in this community. Future research will shift from species inventory to density estimates using noninvasive camera surveys. We will investigate human-wildlife interactions and will employ local citizens to assist with data collection. Studies will be conducted to elucidate intraguild interactions and trophic hierarchy within the local carnivore assemblage. The Wildsumaco preserve offers great potential for scientific study and conservation of mammals in a biologically rich and highly threatened corner of the Tropical Andes biodiversity hotspot.

P1.17 HOEKSTRA, L.A.*; MONTOOTH, K.L.; Indiana University, Bloomington; lhoekstr@indiana.edu

The significance of energetic constraints on the evolution of inducible physiologies

One solution to unpredictable thermal stress is the evolution of an inducible stress response; often involving the massive upregulation of molecular chaperones when temperature exceeds a sublethal threshold. Fueling this massive expression of stress response genes and the translation of stress response proteins should increase short term energetic costs, but the evolution of inducibility is thought to be favored in environments where the benefits of constitutive expression are unpredictable. We will present data that addresses the following questions: Are there evident energetic costs to inducible physiological responses? Can we quantify the significance of energetic constraints in terms of metabolic rate and fitness? To quantify energetic costs we used lines of *Drosophila melanogaster* that differ in Hsp70 gene copy number and differ by as much as ten fold in the inducibility of Hsp70 mRNA expression (Bettencourt et al., 2008, BMC Biology, 6:5). Using flow-through respirometry, we measured the metabolic performance of larvae with different Hsp70 copy numbers before, during, and after induction of the heat shock response. We show that whole organism energy expenditure during induction of the heat shock response varies with Hsp70 copy number and that larvae with more copies of Hsp70 take longer to return to their resting metabolic state. Next, we examined the significance of energetic constraints in terms of fitness using lines of *Drosophila melanogaster* deficient in components of the oxidative phosphorylation pathway. If energy is limiting during the physiologically demanding heat shock response, then metabolically compromised larvae should differ either in heat shock survival or metabolic rate. Together these results provide valuable information about the metabolic cost of gene expression and the evolution of threshold traits.

P3.73 HOLLINGSWORTH, P.R.*; HULSEY, C.D.; University of Tennessee; phollin1@utk.edu

Do constructional constraints influence cyprinid craniofacial diversification?

Constraints on form should determine how organisms diversify. Due to competition for the limited space within the body, investment in adjacent structures may frequently represent an evolutionary compromise. For example, evolutionary tradeoffs between eye size and jaw muscle volume in North American cyprinid fishes could have influenced craniofacial diversification in this group. To test the evolutionary independence of these structures in North American cyprinid fishes, we measured the mass of the three major adductor mandibulae (AM) muscles and determined the eye volume in 40 species. This data was then combined with a well-resolved molecular phylogeny in order to test for constructional trade-offs using phylogenetic independent contrasts.

P1.133 HOLLAR, A. R.*; BUCHHOLZ, D. R.; University of Cincinnati; hollar.amy@gmail.com

The role of thyroid hormone receptors in the evolution of accelerated metamorphosis in desert frogs

Thyroid hormone (TH) has profound yet varied developmental effects in all vertebrates. How such an important developmental hormone can underlie such diverse yet fundamental aspects of development across species is not well understood. Frogs are an excellent organism for the study of TH signaling as metamorphosis is dependent on TH. Because thyroid hormone receptors (TRs) act as mediators of the TH signal, TR expression levels may be a significant target of evolution underlying metamorphic diversity. Spadefoot toads are a closely related group of anurans with known phylogenetic relationships and differing larval period durations whose underlying differences in TH physiology are well established. To test whether TR expression levels correlate with larval period duration, we analyzed TR α and TR β mRNA expression via quantitative PCR in the tails of three species of spadefoot toad tadpoles with short, intermediate, and long larval period durations. We found that species with shorter larval periods had a greater increase in TR β expression over the course of metamorphosis. We also induced metamorphosis in two of the species by subjecting them to 8 and 50 nM T₃ concentration at Gosner stage 31 (premetamorphosis) and examined the expression of TR α and TR β mRNA at 12, 24, 48, and 72 hours post-TH induction via qPCR. Our results showed that the species with the shorter larval period had a greater increase in both TRs during TH-induced metamorphosis. Additionally, expression of TR β reached peak levels quicker in the species with the shorter larval period. Our results provide substantial evidence that larval period duration correlates with increased TR expression in spadefoot toads. We conclude that evolution of shorter larval periods in spadefoot toads may at least partially be due to increased TR expression during metamorphosis.

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Evolutionary Analysis of Single Nucleotide Insertions in the Mitochondrial Genomes of Glass Sponges

Occasionally, mitochondrial (mt) coding sequences can contain extra nucleotides. In general, the presence of extra nucleotides in coding sequences may be indicative of nuclear transfer of mitochondrial genes (numts) or RNA editing. Recently, a growing number of these cases appear to be due to translational frameshifting. The phenomenon known as +1 translational frameshifting is a mechanism by which an extra nucleotide in a protein coding sequence is left untranslated through a process of ribosomal bypass. Often this mechanism entails the use of a rare codon in the original reading frame which acts as a frameshifting signal. Single base insertions have been reported in the mtDNA of the eastern oyster, as well as for several species of ants, birds, and turtles. We had previously noted incidences of single nucleotide insertions in the mitochondrial protein coding genes of two glass sponges (Phylum Porifera, Class Hexactinellida). More recently, we expanded the breadth of our taxon sampling to include members of two orders and six families of the Hexactinellida. Base insertions in hexactinellid mt protein coding genes appear to conform to the +1 frameshifting pattern due to a high degree of sequence conservation and a distinct pattern of codon usage. Here we describe putative translational frameshifting in the *nad2*, *cox3*, and *cox1* protein coding genes of *Hertwigia falcifera*, *Sympagella nux*, *Iphiteon panicea*, *Euretidae sp.*, and two species of *Aphrocallistidae*, and we place these results in an evolutionary context.

P2.50 HOSKINS, T.D.*; O'BRIEN, S.; HESS, C.M.; Butler University, Marian University; thoskins@butler.edu

Does atrazine exposure induce hermaphroditism in American toads (*Bufo americanus*)?

Atrazine is the most commonly used herbicide in the United States and is largely used worldwide. Previous research has shown atrazine to act as an endocrine disruptor, influencing abnormal gonadal development, hermaphroditism, and oocyte formation in male amphibians. These studies have focused primarily on aquatic frogs (such as those of the genera *Rana* and *Xenopus*); however, more terrestrial species, such as toads, have not been examined. We exposed wild-caught American toads (*Bufo americanus*) to ecologically relevant doses of 0, 0.1, 1, and 25 ppb atrazine throughout the larval period. Preliminary findings indicate that atrazine exposure may significantly affect mass at metamorphosis, a characteristic that has not been previously correlated to atrazine exposure. Upcoming histological examinations of preserved gonads and brain tissues will indicate more thoroughly the morphological effects of atrazine as an endocrine disruptor in the primarily terrestrial amphibian, *B. americanus*.

P2.42 HOWEY, CAF*; ROOSENBERG, W; Ohio University; chris.howey@gmail.com

The Effects of Prescribed Burning on Reptile Movement Rates and Energy Expenditures

After decades of fire prevention and suppression, ecologists are making strides in understanding fire's role in forest ecosystems. Fire is a natural disturbance that changes available habitat within the environment. Collectively, little is known about the effects of prescribed fire on many reptile populations. Whereas abundances for some species have increased following a prescribed fire, others have shown a marked decrease. Reptiles that are dependent on either leaf litter or prey that are found within the leaf litter are faced with a reduction of preferred habitat following a prescribed burn. Under these conditions of patchy preferred habitat, individuals may have to increase movement rates in order to maximize their use of preferred habitat. However, the optimum foraging theory states that animals will only increase their daily energy expenditures (DEE) if the costs of foraging and obtaining prey are returned with an equal or higher gain in energy from the consumed prey. Therefore, it is the objective of this project to determine if movement rates and DEE of reptiles are altered by prescribed burning. Our focal species is the Northern Copperhead (*Agkistrodon contortrix*); an animal that utilizes leaf litter for shelter, camouflage, and obtaining prey. We plan to investigate movement rates and factors that may influence movement rates (habitat use, habitat availability, operative environmental temperature, and predation rates). We will measure DEE in the field using doubly-labeled water and we will assess prey abundances and foraging success rates within sites of differing burn frequency. Preliminary data collected thus far on movement rates and available habitat will be presented as will predictions discussing how these factors may affect DEE.

P1.108 HRANITZ, J.M.*; ABRAMSON, C.I.; CARTER IV, R.P.; Bloomsburg Univ. PA, Oklahoma State Univ., Stillwater; jhranitz@bloomu.edu

An Ethanol-Induced Hormetic Stress Response in Honey Bee (*Apis mellifera*) Brain Tissue

Previous research on the honey bee ethanol model established how acute ethanol exposure altered function at different levels of organization. Our goal was to evaluate whether or not ethanol doses that alter honey bee behavior also induce a significant stress response, measured by heat shock protein 70 (HSP70) concentrations, in the honey bee brain. Experiment 1 evaluated how pretreatment procedures affected brain HSP70 concentrations in three pretreatment groups of bees. HSP70 concentrations were similar among pretreatment groups. Experiment 2 investigated the relationship between ethanol dose and brain HSP70 concentrations. Bees were placed in seven experimental groups, the three pretreatment groups and four ethanol-fed groups. Bees in ethanol treatments were fed 1.5 M sucrose (control) and 1.5 M sucrose-ethanol solutions containing 2.5%, 5%, and 10% ethanol, allowed to sit for four hours, and dissected brains were assayed for HSP70. We observed ethanol-induced increases in honey bee brain HSP70 concentrations from the control group through the 5% ethanol group. Only bees in the 5% ethanol group had HSP70 concentrations significantly higher than the control group. The inverted U-shaped ethanol dose - HSP70 concentration response curve indicated that ingestion of 2.5% ethanol and 5% ethanol stimulated the stress response whereas ingestion of 10% ethanol inhibited the stress response. Doses that show maximum HSP70 concentration (5% ethanol) or HSP70 inhibition (10% ethanol) correspond to those ($\geq 5\%$ ethanol) that also impaired honey bees in previous studies. We conclude that acute ethanol intoxication by solutions containing $\geq 5\%$ ethanol causes significant ethanol-induced stress in brain tissue that impairs honey bee behavior and associative learning.

P2.56 HUMPHRIES, A.T.*; LA PEYRE, M.K.; Louisiana State University; ahumph3@tigers.lsu.edu

Linking structural complexity in created oyster reefs to provision of refuge and predation success

A central tenant in ecology is that habitat complexity positively affects species abundance, diversity, and ultimately, community structure. As such, management and restoration of fishery habitat is often focused on increasing habitat complexity. In coastal and estuarine environments, reefs created by oysters provide significant habitat structure that grows and becomes increasingly complex through time. Using created oyster reefs and combined field and laboratory experiments, this study (1) examined cryptic nekton use at four levels of habitat complexity, and (2) examined predation success at four levels of habitat complexity. In the field, four experimental oyster reefs were constructed (no structure, cage structure only, low, and high complexity) and cryptic nekton use was compared. In the lab, four experimental oyster reefs were constructed (no structure, low, medium, and high complexity) and predation success of wild red drum (*Sciaenops ocellatus*) on grass shrimp (*Palaemonetes pugio*) was compared over 8 hour periods. Predation success was significantly reduced as reef complexity increased from no structure to low ($p < 0.0001$), and from low to medium complexity ($p = 0.0107$); however, no significant differences were found in predation success rates between medium and high complexity ($p = 0.2829$). Differences in predation success may indicate an increased refuge role of oyster reefs as oyster density or habitat complexity increases, but that there is a threshold above which increased complexity no longer increases the refuge value of the reef.

P2.135 HURLEY, LL*; DEVICHE, P; Arizona State Univ.; llhurley@asu.edu

Population differences in reproductive biology of free-living Cassin's Sparrows, *Aimophila cassinii*.

Seasonally breeding birds use various proximate cues to regulate their reproductive cycle. In relatively stable seasonal environments, the primary cue used often is day length. In less predictable environments such as Southwest USA deserts, supplementary factors associated with weather (e.g., monsoon precipitation) may also play an important role. Little is known regarding the specific role and mechanisms by which effects of these factors are integrated to regulate the activity of the reproductive system. To begin addressing this question, we compared seasonal changes in reproductive morphology (testis size and cloacal protuberance: CP) and molt in Cassin's Sparrows, *Aimophila cassinii*, belonging to two geographically separate populations (Arizona and Colorado) that employ temporally different breeding strategies: Colorado birds breed in spring whereas Arizona birds initiate breeding in response to summer monsoon-associated environmental changes. These populations were found to exhibit quantitatively similar time courses of seasonal changes in testis and CP sizes as well as prebasic (post-breeding) molt, but exhibited a temporal shift in breeding activity so dramatic that Colorado birds were in the first stages of prebasic molt when Arizona birds were just becoming reproductively active. We are currently conducting additional experiments aimed at determining the neuroendocrine basis of these intraspecific population shifts in seasonal reproductive timing.

P3.136 IDE, C*; BADIOLA AZPEITIA, T; PALSTRA, A; VAN DEN THILLART, G; ADRIAENS, D; Ghent University, Ghent, Departament de Fisiologia, Universitat de Barcelona, Leiden University, Leiden; celine.ide@ugent.be

Bone mineralization in European eel (*Anguilla anguilla*) during maturation from the yellow eel stage to the silver eel stage

The lifecycle of European eel (*Anguilla anguilla*) has long been a mystery, until Schmidt came along. He suggested that the Sargasso Sea was the spawning location for *Anguilla* species (Van Ginneken et al, 2005). With his research the central mystery of the life cycle was elucidated, but there still remains a lack of knowledge on many aspects of the life cycle of the European eel, *Anguilla anguilla*. One of those aspects is a good knowledge on the phenotypic transformations that are linked to this shift from the yellow eel stage to the migrating silver eel stage. Drastic changes are known to occur, but a quantitative and qualitative characterization is still lacking. Additionally, it has already been shown that broad- and narrow headed phenotypes exist during the yellow eel stage. The different head shapes have been related to different diets, where broad-headed eels would feed on bigger and harder preys (Proman & Reynolds, 2000). Although some research has been focusing on this dimorphism, still very little is known about this dimorphism. For example, does this dimorphism still persist during the silvering phase, when extensive cranial transformations are known to occur (demineralization of bone, loss of teeth, increase of eye size, etc)? To test the hypothesis of differential remodeling of bone tissue during this maturation in broad- and narrow-headed eels, we calculated a "collagen stretching index" based on histological sections that were stained with Masson's trichrome. This index was evaluated as a potential indicator of bone mineralization to test both for changes during maturation as for differences between phenotypes.

P3.8 HUSAK, J.F.*; WORTHINGTON, A.M.; SWALLOW, J.G.; Univ. of South Dakota; jerry.husak@usd.edu

Do the exaggerated eye stalks of stalk-eyed flies have a predation cost?

When opponents compete for access to an indivisible resource, signals can reduce costs associated with competition for that resource. Theory predicts that for signals to remain reliable in such situations there should be costs associated with the signal. These costs may be imposed when the signal is being developed, while it is being displayed to a receiver, or simply by bearing it when not using it. Stalk-eyed flies (*Teleopsis dalmanni*) have their eyes on the ends of large peduncles, with males having significantly greater eyespans than females. Males use the span of their eye stalks to reliably assess body size and fighting ability during agonistic interactions. To test whether there is a predation cost to the exaggerated eye stalks of stalk-eyed flies we conducted predation trials with flies and a generalist predator, a jumping spider (*Phidippus audax*). We determined whether male stalk-eyed flies suffered higher predation than females. We also examined, within each sex, whether individuals with greater eyespans suffered higher predation than those with smaller eyespans. We conducted experiments in a small enclosure with a single fly facing a predator, as well as in larger mesocosms that contained 20 flies and a predator. We found no support for the hypothesis that there is a predation cost to exaggerated eye stalks. Males did not have lower survival than females, and individuals with larger eyespans did not have lower survival in either sex. No other morphological variable differed between survivors and non-survivors within a sex. In the single-fly trials, anti-predator behavior was the best predictor of survival. Thus, we found no evidence for selection against greater eyespans in stalk-eyed flies. Our results suggest that the exaggerated eye stalks of stalk-eyed flies are a condition-dependent signal of individual quality or that other costs maintain reliability of the signal.

P2.57 ITAGAKI, H.; Kenyon College; itagaki@kenyon.edu
The Use of Mock NSF-type Grant Proposals as the Capstone Assignment in Upper-Level Biology Courses.

For over a decade, I have been using mock NSF-type grant proposals as the capstone assignment in my 300-level cell biology and neurobiology courses. For the students, the process is broken down into discrete steps of: finding a topic of interest; doing the background reading; and writing a short review of the literature read. This is followed by asking and writing about the appropriate next questions based on their understanding of the reading, followed by the design of appropriate experiments to test those questions. These mock grant proposals are then peer-reviewed, and the comments are then incorporated into a final draft which is then graded. The advantages of this type of assignment in enhancing scientific skills include: the need by the students to gather new information from the primary and secondary literature and to distill it; the need for synthetic thought by the students in figuring out the next interesting questions; and the need by the students to understand the appropriate scientific techniques needed in order to test those questions. The outcomes have been good, with most students being challenged to extend their skills; the students also report a great sense of accomplishment in the process. In addition, the students who have gone on the graduate school also report that they have an easier time in the process due to this type of assignment.

P2.52 JENSEN, BH; ARCHAMBEAULT, J*; KROUSE, S; The College of Saint Rose, Albany, NY; jensenb@strose.edu
A Suite of Tests to Evaluate the Effects of the Common Insecticide, Sevin®, on Development in Zebrafish.

Sevin® is a commonly used insecticide which is known to contaminate runoff and can leach into groundwater. Its application in the spring and fall corresponds with the mating periods for many teleost fish in the northeastern United States. Sevin® is therefore of concern because the timing of its application and because its effectiveness stems from the fact that it contains the broadly acting cholinesterase inhibitor, carbaryl. Carbaryl has been shown to effectively block cholinesterase in many animals, including vertebrates. Cholinesterase is necessary to clear acetylcholine from synapses with cholinergic neurons and at the neuromuscular junction. Its importance in this role has made it a target for animal venoms, chemical weapons, and insecticides. In the zebrafish (*Danio rerio*), previous studies have demonstrated that exposure to Sevin® reduces size at hatching and alters heart rate in developing embryos. To date there have not been studies that examine the effects of Sevin® on a suite of variables within a single experimental design. Our lab has begun to examine the effects this insecticide has on *Danio rerio* development by applying dilutions of decreasing concentration to fish embryos immediately following fertilization and measuring the egg, yolk and embryo volume, heart rate, hatching time, percentage pigmentation, eye diameter, and skeletal development at the termination of the experiment. These parameters were chosen to cover a range of potential target tissues. We will present data from our first round of experiments. Currently, our results are preliminary, but we expect results caused by a systemic increase in acetylcholine levels; decreases in heart rate, eye diameter, skeletal system development, embryo and yolk volumes; and increased pigmentation and time to hatching.

P1.104 JOHNSON, J/I*; BUCHANAN, K/J; MORRIS, J/A; FOBBS JR., A/J ; Michigan State Univ., East Lansing, Allen Institute for Brain Science, Seattle WA, National Museum of Health and Medicine, AFIP, Washington DC; johnij@aol.com
Consistencies and Variations in Sulcal and Gyral Patterns in Human Insular Cortex.

To elucidate the degree of cortical folding in different regions of the insula, we measured the amount of cortical folding in a stratified sample of stained horizontal sections through each of 10 adult human insulas. The most folded region is about midway between the superior and inferior limits, and the flattest, least folded, region is in the inferiormost third of the insula. This sequence was consistent in all of the insulas sampled. A basic pattern, 6 early-formed insular sulci outlining 5 insular gyri, was reported by Afif et al., 2007; they did not detect structural variations in sulcation in any of their fetal specimens. To record the inter-specimen variation in patterns of gyral folding in adult human insulas, we photographed the exposed surfaces of 33 insulas. Only 10 of these 33 insulas showed the complete basic pattern. The remaining 23 had a wide variety of alternative folds. We were unable to identify any individual intra-insular sulcus in the horizontal sections we measured; there was no consistent difference in the depths or positions of individual sulci. The divergence of the adult patterns from the initial basic pattern may be evidence of individual plasticity in the growth and development of insular cortex. Regional consistency of the overall degree of folding, regardless of very different patterns of folds, may indicate limits on the range of possible differential growth of insular regions.

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Developmental plasticity and robustness of pigmentation in the milkweed bug, *Oncopeltus fasciatus*

Complex traits often exhibit phenotypic plasticity, the ability of an organism to alter its developmental trajectory in different genetic or environmental contexts. Yet why some traits are more phenotypically plastic than others is not well understood. Pigmentation of organisms provides an excellent system for understanding processes underlying developmental plasticity. Here the developmental regulation underlying the melanin production in the milkweed bug, *Oncopeltus fasciatus*, was analyzed. Although Hox genes were found to regulate both wing and abdominal melanic patterns, the two melanic pigmentation patterns exhibited different degrees of phenotypic plasticity when the *O. fasciatus* were reared at different temperatures. Surgical manipulations suggest that the robust patterning of the wing pigmentation may be due to developmental coupling of the wing pigmentation and wing veins. Thus, spatial arrangements of the veins may limit the amount of variability in pigmentation and underlie the robustness of wing pigmentation.

P1.131 JOHNSON, K.M.*; LEMA, S.C.; Univ. of North Carolina, Wilmington; kmj5818@uncw.edu
Identifying Pathways of Thyroid Hormone Production in the Parrotfish Thyroid Gland

The physiological and behavioral functions of thyroid hormones have been studied extensively at the organismal level in teleost fish. However, considerably less is known about the mechanisms of thyroid hormone production at the level of the thyroid tissue. Teleost fish typically possess thyroid follicles scattered throughout the branchial region, rather than the single compact thyroid gland characteristic of most vertebrates. This anatomical arrangement of thyroid follicles has restricted study of how thyroid hormones are synthesized and released in teleost fish. A few taxonomic groups of teleosts do, however, possess a discrete thyroid glandular tissue. We have recently begun examining mechanisms of thyroid regulation in the thyroid gland tissue of one of these groups of fishes, the sex-changing parrotfish (family Scaridae). The goals of this research are: 1) to identify mRNAs encoding proteins in key steps of thyroid hormone synthesis in the follicles, and 2) to examine regulation of these gene transcripts - as well as mRNAs encoding thyroid hormone receptors and deiodinase enzymes - by thyroid hormones. We recently identified two sections of coding region for a thyroglobulin cDNA from the thyroid gland of princess parrotfish (*Scarus taeniopterus*). These cDNAs consist of a 296 bp nucleotide sequence that encodes 98 amino acids that shares 46.9% homology, and a 377 bp sequence encoding 125 amino acids with 55.3% homology, to human thyroglobulin. This is one of the first descriptions of a thyroglobulin cDNA from a teleost, and the identification of thyroglobulin and cDNAs for other proteins involved in thyroid hormone synthesis will permit new investigations into how thyroid hormone production in teleosts is regulated at the level of the thyroid tissue.

P3.19 JOHNSON, JC*; TRUBL, P; MILES, L; Arizona State University at the West Campus; jchadwick@asu.edu

The urban behavioral ecology of the Western black widow *Latrodectus hesperus*

The Western black widow spider *Latrodectus hesperus* is a pest species of medical importance. Black widow populations from urban habitats of Phoenix, AZ experience a drastically different environment than their counterparts from surrounding, undisturbed Sonoran desert habitats. Specifically, urban populations tend to be densely populated (e.g. infestations) and are characterized by high prey abundance, low prey diversity, and low enemy risk. In contrast, desert populations tend to be sparsely populated and are characterized by low prey abundance, high prey diversity and high enemy risk. Here we quantify a number of life history and behavioral variables across these populations to assess whether or not they are locally adapted to these ecological differences. In particular, we quantify the cannibalistic tendencies of these populations to test the two-tailed prediction that cannibalism may be heightened in urban populations due to high population densities and low prey diversity, or cannibalism may be reduced in urban populations due to relative food abundance and selection for increased social tolerance in dense congregations. Throughout we argue that an understanding of the impact urbanization has on local fauna is required if we wish to both reduce the impact we have on other organisms and reduce the risk that dangerous urban pests have on human populations.

P3.94 JONES, Ashley/L*; THOMSON, Amy/M; KOZAKOWSKI, Michelle; KYPRIANOU, Rachel; VATNICK, Itzick; BRODKIN, Marc; Widener University; ivatnick@widener.edu
Escherichia coli* ATCC # 25922 induces an inflammatory response in adult *Rana pipiens

The inflammatory response is an early and essential component of both the innate and adaptive immune responses. We have examined the effect of environmental pollutants on the amphibian innate immune response by stimulating frogs with the experimental inflammatory mediator thioglycollate. Although this has worked well as an experimental protocol we present here a method to assess a bacterial-induced inflammatory response using *Escherichia coli*. However, not all strains of *Escherichia coli* induce a response as measured by the number of white blood cells (WBCs) in peritoneal exudates. We present data using *Escherichia coli* ATCC # 25922, a strain that induced a response. Our results demonstrate a dose response using dilutions from 10^4 to 10^6 bacteria per ml. In frogs injected with bacteria we observed both an increase in the number of peritoneal WBCs and their phagocytic activity as compared to frogs injected with Ringer solution. We are in the process of examining the genetic mechanisms controlling this response using DNA microarray chips. Although DNA microarrays have been used to study the development of amphibians, to our knowledge we are the first to use DNA microarrays to probe the genetic basis of the inflammatory response in amphibians.

P1.166 JONES, Z.M.*; JAYNE, B.C.; University of Cincinnati, Ohio; joneszm@mail.uc.edu

Perch diameter and secondary branching have interactive effects on the locomotion of anole lizards

Several aspects of arboreal habitat structure such as the diameter, incline and the density of branches create challenges for the locomotion of animals, and arboreal lizards in the genus *Anolis* have been a model system for studying correlations between locomotor performance, habitat structure, morphology, and behavior. In natural vegetation decreased branch diameter is correlated with an increased density of branches. However, unlike the well-documented detrimental effects of decreased perch diameter on sprinting speeds of long-limbed anoles, the effects of this aspect of habitat structure are unknown for anoles and nearly all other arboreal animals. Thus, we tested the locomotor performance of *Anolis carolinensis* and *A. sagrei* running on cylinders with diameters ranging from 1 to 10 cm, and we placed pegs at 10-cm intervals along the top center of these perches to simulate and determine how secondary branches may interfere with locomotion. The lizards preferred to run along the top of the cylinders without pegs. However, on smaller diameters, pegs interfered with this, and the time to travel a fixed distance nearly doubled with the addition of pegs because the lizards paused more and were slower while they were running. The magnitudes of some of these detrimental effects of pegs on speed exceeded some of those for decreased diameter. However, pegs on the 10-cm diameter perch barely affected speed, and the speeds on the 10-cm perch with pegs commonly exceeded those of the smaller diameter perches lacking pegs. Our results suggest that in addition to selecting large perch diameters in natural vegetation for their direct benefits on locomotor performance, an added benefit may be to facilitate detouring around secondary branches with little adverse effect on maximum speed.

P1.42 JOPLIN, Karl H*; SEIER, Edith; KARKI, Puja; BRAY, Alicia; ETSU; joplin@etsu.edu

Differential Gene Expression during Diapause in the Flesh Fly, *Sarcophaga crassipalpis* by Subtractive Hybridization Library Screening

Diapause is a strategy that many insects use to survive seasonally recurring unfavorable environmental conditions. Facultative diapause has been shown to be more than simple quiescence but is instead a genetically programmed developmental state that is initiated in response to environmental cues that predicts future environmental extremes. Thus, facultative diapause is an optional, inducible developmental state with dynamic processes that are responses of the organism to its environment. The Flesh Fly, *Sarcophaga crassipalpis*, in response to the environmental cue of short days (actually long, uninterrupted nights), in a circadian gated process, are induced to express the diapause alternative developmental state which enables them to survive cold winter months in a temperate environment. The developmentally distinct state of diapause is characterized by a syndrome of unique physiological functions not seen in the non-diapausing pupal stage. As such, this model organism represents a remarkable system to investigate physiological responses to environmental cues, developmental control pathways, and molecular aspects of physiological states. We have explored the differential gene expression of diapause by screening suppressive subtractive cDNA libraries of both diapause and non-diapause pupal stages. The results show that the heat shock and ribosomal protein subunits are highly up-regulated during diapause and that transcription factors are up-regulated during non-diapause pupal stages.

P3.84 JORDAN, D. C. *; WESSELS, F. J.; HAHN, D. A.;
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Capitalizing on Income: Using Stable Isotopes to Understand Reproductive Allocation in the Flesh Fly, *Sarcophaga crassipalpis*

Resources used for reproduction can come from a variety of sources, however, these sources are often categorized into two general resource pools, capital and income. Capital resources are acquired and stored prior to the reproductive period, while income resources are resources that are acquired and immediately funneled into reproduction. These terms have led to the classification of organisms as capital or income "breeders", although these categories overlook organisms that use a combination of capital and income during reproductive allocation. Most likely, the majority of organisms fall along a continuum between capital and income breeding. However, a fundamental problem with identifying where organisms fall along the continuum is separating resource acquisition from resource allocation. We used stable isotopes to separate capital and income resource pools in the flesh fly, *S. crassipalpis*, by switching isotopically distinct diets at the onset of the reproductive period (immediately following adult metamorphosis). We track the allocation of capital and income to somatic and reproductive tissue across two subsequent clutches of eggs. In addition, we characterized the turnover of polar and neutral lipids in somatic and reproductive tissue over two clutches. Our results show that *S. crassipalpis* uses primarily income resources to provision eggs, however, a small amount of capital resources are used to provision the first clutch (~18% capital) but the second clutch is provisioned almost entirely with income resources (~4% capital). These findings may reflect the life-history of flesh flies, which are highly mobile and feed on a spatially and temporally patch resource.

P1.13 KANO, S*; XIAO, J; OSORIO, J; HADZHIEV, Y; EKKER, M; RETAUX, S; CNRS, Gif-sur-Yvette, France, University of Birmingham, UK, University of Ottawa, Canada; kano@inaf.cnrs-gif.fr

Conserved Regulatory Elements found in the Lamprey Hedgehog Loci

The lamprey is the key animal to study the evolution of morphological traits, especially at the emergence of craniates. Among genes associated with craniate morphogenesis, *sonic hedgehog* (*shh*) is essential, being expressed at the forebrain and other midline tissues such as notochord and floor plate. Previous studies reported that lamprey hedgehog is expressed similarly to gnathostome *Shh*, which suggests that the regulatory logic for gene expression is evolutionarily conserved between lampreys and other vertebrates. To clarify this hypothesis, genomic sequences of lamprey hedgehog loci were determined in two lamprey species, the river lamprey *Lampetra fluviatilis* (*Lf*) and the sea lamprey *Petromyzon marinus*. We concluded that the lamprey genomes fundamentally contain only 2 hedgehog genes, named *Hha* and *Hhb*. Phylogenetic analyses indicated that they are lamprey lineage specific paralogs, which belong to the *Shh/Ihh* clade. In *L. fluviatilis* embryos, both genes are expressed almost identically to each other and similar to *Shh*, while expression at the *zona limitans intrathalamica* (ZLI) is absent in *LfHha*. Phylogenetic footprinting with other telost *Shh* loci was feasible to reveal putative lamprey conserved regulatory elements (CREs) presenting similarity with the ar-C motif previously reported in zebrafish. The putative CREs were quite dispersed, spreading over 180-800bp against approx. 140-180bp in other vertebrates. We have validated that the lamprey putative CREs function in zebrafish embryos, and some candidates are still under functional test. These findings suggest an evolutionary scenario associated with the *Shh*-type *hedgehog* and its regulatory logic.

P3.57 KAMMER, A.R.*; O'BRIEN, K.M.; University of Alaska Fairbanks; arkammer@alaska.edu

Oxidative stress in response to cold acclimation in threespine sticklebacks (*Gasterosteus aculeatus*)

We sought to quantify levels of oxidative stress during cold acclimation and to determine if increases in reactive oxygen species (ROS) might be responsible for stimulating cold-induced mitochondrial biogenesis in threespine sticklebacks. Fishes were held at 20°C for 12 wk and then acclimated to 8°C for 9 wk or held at 20°C for an additional 9 wk. Animals were harvested on the first four days of cold acclimation and at wk 1, 4 and 9. Levels of protein carbonyls were quantified by HPLC as an indirect measure of ROS production. The activity of superoxide dismutase (SOD) was measured at 14°C and at the acclimation temperature of 20°C or 8°C. All measurements were made in liver, glycolytic skeletal muscle, and oxidative pectoral adductor muscle. Protein carbonylation levels significantly increased in liver tissue after animals were maintained for 1 wk at 8°C but did not change in either oxidative or glycolytic muscles. When measured at a common temperature, SOD activity significantly increased in all tissues by day 2 of cold acclimation. When measured at the acclimation temperature, SOD activity in oxidative muscle was significantly greater in animals held at 8°C for 9 wk compared to those held at 20°C for 9 wk but remained unchanged in liver and glycolytic muscle. High levels of SOD in oxidative muscle may protect cells against cold-induced oxidative damage, thereby preventing an increase in protein carbonylation. The increase in protein carbonylation in liver tissue corresponds with an increase in the expression of some transcription factors (PGC-1 α and TFAM) that may play a role in cold acclimation. However, the lack of increase in ROS in oxidative and glycolytic muscles suggests that they do not play a role in inducing mitochondrial biogenesis in these tissues.

P1.97 KATO, DF*; HUYNH, M; MINTER, JL; SINGH, G; MURRAY, JA; California State University, East Bay; darcy.kato@gmail.com

The activity of a magnetically responsive ciliary motor neuron during crawling in normal and reversed magnetic fields in the nudibranch *Tritonia diomedea*

The nudibranch mollusk *Tritonia diomedea* has an easily accessible nervous system with large neurons that can be identified across individuals. The largest pair of identified neurons are the Pedal 5 (Pd5) neurons located on the dorsal surface of the pedal ganglia. The cells are ciliary motor neurons that respond to changes in magnetic field orientation. It has previously been shown that activity in Pd5 increases both in response to magnetic field rotations and that the increase is correlated with an increase in the crawling rate of the animal. This study was designed to understand the role of the Pd5 cells in a freely crawling animal. Simultaneous extracellular recordings from the Pd5 cells during a semi-intact preparation were compared with crawling behavior in the slug in both an ambient magnetic field and a rotated magnetic field of similar strength. Turning and crawling behavior during recording were compared with behavior of the intact animal crawling in both an ambient and rotated magnetic field. In a normal magnetic field, change in angular velocity preceded an increase in activity of the right Pd5 cell with a cross correlation coefficient of 0.1 which peaked at 66 seconds. The cross correlation coefficient for the left Pd5 cell peaked at .04, with turning preceding cellular activity by 87 seconds. In a rotated magnetic field similar results were seen, and no preference for a certain magnetic heading was found. We conclude that Pd5 may not be involved in turning behavior as previously thought. These cells may be responsible for an increase in crawling speed in response to changes in the magnetic field and therefore may still be important in orientation and navigation.

P1.106 KAUFER, M.J.*; MARKOWSKI, D.E.; LOVETT, D.L.; The College of New Jersey, Ewing; lovett@tcnj.edu
A Time-Course Study of Gene Expression in Gills of the Blue Crab *Callinectes sapidus* Transferred from Dilute to High-Salinity Seawater.

Change in gene expression in the gills of crustaceans following transfer from high-salinity to dilute seawater has been examined extensively, whereas the response to transfer from dilute to high-salinity seawater has not. In the blue crab *Callinectes sapidus*, exposure to dilute seawater initiates a substantial increase in both Na⁺,K⁺-ATPase (ATPase) activity and the relative amount of ATPase α -subunit mRNA. The activity of ATPase remains elevated as long as the crab is in dilute seawater, but the amount of mRNA eventually decreases to near basal levels by the time the crab has acclimated to the dilute seawater. In contrast, when crabs are transferred from dilute to high-salinity seawater, there is a decrease in ATPase activity within 48 h. During this time the amount of α -subunit mRNA drops to near zero, but then begins to increase near the end of the acclimation period. An increase in ATPase activity is not correlated with this increase in mRNA level. These results suggest that chronic exposure to high-salinity seawater may inhibit synthesis of α -subunit mRNA or may activate its degradation. Constitutive degradation of ATPase enzyme may eventually require synthesis of new mRNA in order to maintain basal levels of ATPase enzyme. Supported in part by TCNJ Mentored Undergraduate Summer Experience.

P3.54 KELLY, K.*; BROWN, K.; SAINT-DIC, R.; CATAPANE, E.J.; CARROLL, M.A.; Medgar Evers College, Brooklyn; catapane@mec.cuny.edu
Toxic Effects of Manganese on Mitochondrial Catalase and Cytochrome C Oxidase in Gills of the Bivalve *Crassostrea virginica*

Manganese (Mn) is an essential trace nutrient but overexposure causes Manganism in people. The mechanism of Mn toxicity remains unknown. Mn accumulates in mitochondria and toxicity may be associated with organelle dysfunction disrupting energy homeostasis and raising levels of reactive oxygen species. Previously we showed Mn accumulates in gill of *Crassostrea virginica*, disrupts the dopaminergic innervation of lateral cilia in gill, and impairs gill mitochondrial respiration. We examined effects of Mn on 2 mitochondrial enzymes, cytochrome c oxidase (COX) and catalase (CAT). COX is the principle terminal oxidase of high affinity oxygen in aerobic respiration. We prepared mitochondria from gill treated with Mn. COX activity was determined spectrophotometrically by observing the decreased absorbance at 550 nm as Fe²⁺cytochrome c is oxidized to Fe³⁺cytochrome c. We found exposure to Mn (5-40 mM) caused up to a 40% loss in cytochrome c oxidase activity. CAT protects against oxidative stress by degrading H₂O₂. Present primarily in cytosol or peroxisomes of aerobic cells, little has been reported on mitochondrial CAT, especially in bivalves. We removed right shells of oysters and placed them in containers of ASW with or without Mn for 3 days. Gill mitochondria were prepared and CAT activity determined. We found CAT in gill mitochondria and 3 day treatments with 1 mM Mn caused a 50% loss in CAT. The results corroborate our previous findings Mn disrupts mitochondrial function in oyster gill and demonstrate a mechanism by which Mn increases oxidative stress by impairing complex IV of the respiratory chain and inhibiting the activity of mitochondrial CAT. The work was supported by grants 0622197 of NSF, 2R25GM06003-05 of NIGMS, 0516041071 of NYSDOE, and P382A080040 of the USDE.

P3.45 KAYAL, E*; LAVROV, DV; Iowa State University; ehsan.kayal@gmail.com
Cnidarian tree of life based on mitochondrial genomic data

Mitochondrial DNA (mtDNA) is one of the most informative and popular molecular markers in animal phylogenetics. In addition to the large amount of sequence data, it contains other phylogenetically-informative characters including genome architecture, gene order, and genetic code. The overall structure of mtDNA (circular vs. linear) was one of the original molecular characters used to subdivide the phylum Cnidaria into two large subgroups: Anthozoa and Medusozoa. Anthozoan have single and circular mtDNA molecules. In Medusozoa, the mitochondrial genome can consist of one, two or more stable linear molecules. While sequencing circular mtDNA became a routine procedure in the last decade, sequencing linear mtDNA presents a challenge as illustrated by only three published linear mitochondrial genomes for Medusozoa in comparison to 34 circular genomes for Anthozoa. We amplified and sequenced nearly complete linear mtDNA genomes from several species representing three Medusozoa classes: Hydrozoa, Scyphozoa and Stauromedusa. Here we present a quick comparative analysis of these genomes with respect to the number of molecules, gene order and gene content. Furthermore, by investigating the sequences we found conserved class-specific features at the ends of the linear chromosome(s) of all Medusozoan mtDNAs. Our data support previously published phylogenetic relationships within a monophyletic Medusozoa group. Moreover, we provide additional support for the paraphyly of Anthozoa with Octocorallia as the sister group to Medusozoa. Finally, we suggest that additional linear mitochondrial genomes from Medusozoa, and particularly Cubozoa will help resolving the phylogeny of Cnidaria. This will also provide insights for understanding the linearization of mtDNA in this group.

P1.145 KELSEY, TJ*; ASHLEY-ROSS, MA; Wake Forest University; rossma@wfu.edu

3-dimensional kinematics of prey capture in tarantulas
 Tarantulas (family Theraphosidae) are the largest extant spiders (up to 10 inches legspan) and the most speciose family (~800 species) of the suborder Mygalomorphae, which includes the most primitive members of the arachnids. None of the mygalomorphs spin prey-catching webs; tarantulas are sit-and-wait predators that use their appendages and chelicerae-injected venom to capture and subdue their prey. Little is known about the mechanics of prey capture in these extraordinarily fast animals. We studied the kinematics of attacks using two high speed video cameras (500 frames/s) to track the movements of spiders during their attacks on crickets. We recorded a minimum of five strikes from at least three individuals of Mexican Red-Knee (*Brachypelma smithi*), Chilean Rose-Hair (*Grammostola rosea*), Guyana Pinktoe (*Avicularia avicularia*), Flagstaff Orange (*Aphonopelma sp.*), and Curly Hair (*Brachypelma albopilosum*) tarantulas. Small white dots were painted on the bottom of the spider legs, two per leg segment, for use as tracking points. A digitizing routine in MatLab was then used to track each point in order to make three-dimensional digital trajectories of each leg. Average time from initial movement of the legs to positioning the prey against the mouth was 250-300 ms. Smaller individuals tended to have much quicker attack sequences (<100 ms). Absolute strike distance varied with spider size; in general, the tarantulas tend to attack straight forward to minimize strike distance and decrease overall attack time. However, side-directed attacks are also common. Smaller individuals seem to have a much broader attacking range, even having the ability to make a complete 180 degree turn before apprehending the prey. Tarantulas are thus capable of extensive modulation of individual leg segment movements and timing.

P1.20 KHODABANDEH, S.*; OULAD, S.; ABEDIAN KENARI, A. M.; Univ. of Tarbiat Modares, Tehran, Univ. of Tarbiat Modares; surp78@gmail.com

Effects of food containing nucleotide additive on the pyloric caeca Na⁺,K⁺-ATPase- 1 \pm 1 α and NKCC1 mRNA expression in young Caspian salmon, *Salmo trutta caspius*

Na⁺,K⁺-ATPase (NKA) and Na⁺,K⁺,2Cl-cotransporter (NKCC) are generally recognized as playing a central role in cell volume homeostasis, maintenance of the electrolyte content and trans-epithelial ion and water movement in polarized cells. The influence of food additive nucleotide on pyloric caeca NKA- α 1 α and NKCC1 mRNA expression was studied in Caspian Sea salmon juveniles (W=12 g). This trial was achieved in two levels of dietary nucleotide (0.25 % and 0.5% of additive nucleotide in meal-based diet) and a control group (0% additive nucleotide). Following 8 weeks rearing, the juveniles fish (W= 26 g) were transferred into saline water (18 ppt). Following 72 hours acclimation, the pyloric caeca of 5 captured fish (from each group) were dissected. Investigation of NKA- α 1 α mRNA expression in pyloric caeca indicate that food containing nucleotide additive possesses a significantly (P<0.05) effect on expression of this gene. Result showed that 0.5% of supplemented nucleotide presence a maximum of NKA- α 1 α mRNA expression. Survey of NKCC1 mRNA expression also showed maximum volume in 0.5% received group in compare to two other groups. Results suggested that supplementation of nucleotide, significantly (P<0.05) influence on NKA- α 1 α and NKCC1 mRNA expression in pyloric caeca of young Caspian salmon and can be effective on their osmoregulatory capacities.

P1.162 KILBOURNE, Brandon M; University of Chicago; bmkilbou@uchicago.edu

The Scaling of Limb Rotational Inertia in Quadrupedal Mammals

Recent biomechanical studies have revealed that the metabolic cost of swinging the limbs is a significant portion of the total metabolic cost of locomotion. Such studies suggest that the rotational inertia of limbs is relevant to understanding the mechanics and energetics of terrestrial locomotion. However, scant data on limb inertial properties currently exist. Data on limb inertial properties – limb mass, moment of inertia, center of mass position, and natural frequency – were collected from the fore- and hindlimbs of 17 species of quadrupedal mammals (representing nine families) in order to understand how limb rotational inertia varies with body size. Muscles were left *in situ* on limb bones in order to measure limb inertial properties for the entire appendicular musculoskeletal system. To standardize comparisons, inertial properties were measured for limbs only in the extended position. As a function of body mass, limb mass scales according to geometric similarity, with limb mass being a constant fraction of body mass across mammals. Fore- and hindlimb center of mass position both scale isometrically with body mass. As a percentage of limb length, fore- and hindlimb center of mass position are independent of body size. Fore- and hindlimb moment of inertia also both scale isometrically with body mass. In both the fore- and hindlimbs, the scaling of limb natural frequency is also not significantly different from the predictions of geometric similarity. The correlation between limb natural frequency and body mass is negative, paralleling the scaling of stride frequency between small and large mammals. The regularity of changes in limb inertial properties with body mass should allow for inferences of limb inertial properties of extinct mammals, given that reasonable estimates of body mass can be made.

P1.167 KIM, HT*; SAITO, C; MEKDARA, NT; CHOUDHURY, S; GOODARZI, A; MAZLOOMI, F; SAKHA, T; SOLTANI, M; UBHI, S; CAO, Y; GOTO, JJ; MULLER, UK; California State University Fresno; umuller@csufresno.edu

The effects of the glutamate agonist BMAA on the walking behavior of adult fruit flies

BMAA (beta-methylamino alanine) is an environmental neurotoxin that is suspected to be a glutamate agonist in insects. Previous studies have shown that glutamate is an excitatory neurotransmitter in the neuromuscular junctions of insects and a neuromodulator in the central complex that affects the central pattern generator for motor output. To explore the possible glutamate-agonist action of BMAA, we fed BMAA to adult fruit flies and quantified their locomotor behavior. We fed BMAA at three different concentrations for four consecutive days and recorded the flies' behavior for 10 minutes each day. We observed that flies treated with the two lowest concentrations of BMAA walk faster and spend more time walking. The treated flies do not walk more often (which would correspond to shorter bouts of inactivity), but their walking bouts last longer than those of the control flies. These observations are consistent with BMAA acting as a glutamate agonist in the central complex that excites the central pattern generator. Previous studies on the temporal structure of walking behavior in fruit flies suggest that the central pattern generator regulates the inactive phase rather than the walking phase of activity periods. Such a control system should respond to BMAA with a shortening of the inactive period and leave the walking period unaffected. This prediction is not consistent with our observations of flies treated with the two low BMAA concentrations. At the highest concentration of BMAA, the flies show severe symptoms: they walk much less than the control group, exhibit tremors and experience difficulty standing and righting themselves after falling.

P1.56 KIMOKEO, Bethany K.*; FORSMAN, Zac H.; HUNTER, Cynthia L.; TOONEN, Robert J.; University of Hawaii, Manoa, Hawaii Institute of Marine Biology; bkimokeo@hawaii.edu

Coral Farming: Species Specific Effects of Light, Water Motion and Artificial Foods

Improved coral husbandry is the key to a more sustainable aquarium industry, and may have implications for restoration research or other studies that use coral as an experimental organism. In this study, we examine species specific responses in growth and survival to light, water motion, and artificial (i.e. non-living) food supplements. Three species representing distinct, diverse, and abundant coral genera were chosen (*Montipora capitata* (Mc), *Porites compressa* (Pc), *Pocillopora damicornis* (Pd)) for three experiments to examine; 1) the interaction of light and water motion on growth and survival of Mc and Pc, 2) effects of artificial foods on Mc, Pc, and Pd in closed systems, 3) the effects of increasing dosage of artificial foods in an open system on Mc and Pc. The results of experiment one indicate that Pc thrived at the highest light levels (450-1250 $\mu\text{mol s}^{-1} \text{m}^{-2}$), while Mc exhibited bleaching and reduced growth. High constant linear flow (11.10 \pm 0.69 cm s^{-1}) resulted in less growth than low flow (3.93 \pm 0.37 cm s^{-1}), with the exception of Mc in high light conditions. Experiment two indicated that some artificial foods result in significant growth in Mc and Pd, but not in Pc. Experiment three indicated that increased doses of artificial foods can result in decreased growth, even in an open system. All three experiments had significant species and colony level effects indicating that each species has unique requirements, and that colony health or genotype prior to fragmentation influence subsequent growth and survivorship.

P1.86 KITTILSON, J.D.; REINDL, K.M.; SHERIDAN, M.A.*; North Dakota State Univ., Fargo; mark.sheridan@ndsu.edu

Rainbow Trout Possess Two Hormone Sensitive Lipase-Encoding mRNAs that are Differentially Expressed and Differentially Regulated by Fasting

Teleost fish store lipids among several tissues primarily as triacylglycerol (TG). Upon metabolic demand, stored TGs are hydrolyzed by hormone-sensitive lipase (HSL). In this study, two distinct cDNAs encoding HSL were isolated, cloned and sequenced from adipose tissue of rainbow trout. The two partial cDNAs, designated LIPE 1 and LIPE 2, were 715 bp and 818 bp in length, respectively, and share 85% nucleotide identity. Quantitative real-time PCR revealed that the LIPE 1 and LIPE 2 were differentially expressed, both in terms of distribution among tissues as well as in terms of abundance within selected tissues of juvenile trout. LIPE 1 and LIPE 2 mRNAs were detected in brain, spleen, pancreas, kidney, gill, intestine, heart, white muscle, but were most abundant in red muscle, liver, and adipose tissue. LIPE 1 was more abundant than LIPE 2 in adipose tissue, whereas LIPE 2 was more abundant than LIPE 1 in liver. Short term fasting (2 week) increased LIPE 1 and LIPE 2 expression in adipose tissue, whereas prolonged fasting (4-6 weeks) increased LIPE 1 and LIPE 2 mRNAs in red muscle and LIPE 2 expression in liver. Refeeding reduced LIPE expression to levels seen in continuously fed fish. These findings indicate that the pattern of LIPE expression is consistent with the diverse lipid storage pattern of fish and suggest that distinct mechanisms serve to regulate differential expression of the two LIPEs in tissues and during a progressive fast. (Supported by NSF IOS 0920116)

P2.94 KLATT, J.D.*; KABELIK, D.; GOODSON, J.L.; Indiana University, Bloomington; jklatt@indiana.edu

Avian Partner Preference is Differentially Affected by Dopamine Receptor Subtypes and is Sex-Specific

Neural systems controlling affiliative behavior in non-mammals have only recently begun to be investigated. The catecholamine dopamine has been shown to be intimately linked with pair-bonding, a well-described form of affiliation almost exclusively studied in rodents. We show for the first time, a role for dopamine in partner preference in a non-mammalian species, the zebra finch (*Taeniopygia guttata*), a highly social passerine that pair-bonds for life. Using nesting males and females, subject's preferences for partner or a novel pair-bonded conspecific were tested following administration of a dopamine D1 agonist (SKF-38393), dopamine D2 agonist (quinpirole), or saline. The D1 agonist significantly decreased partner preference while the D2 agonist significantly increased partner preference in males, similar to findings in mammals. However, no effects for either D1 or D2 agonists were found in females. Dopamine D2 findings were also replicated using naturally paired males and females living in a colony environment. Thus, dopamine receptor subtypes are important regulators of partner preference in male, but perhaps not female, zebra finches.

P2.132 KLAASSEN VAN OORSCHOT, B*; CRINO, O; BREUNER, C; University of Montana;

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The Effect of Nest Microhabitat on Reproductive Success of the Mountain White-crowned Sparrow

Local environmental factors may influence nest success in many bird species. We compared nest site characteristics to fledging success and chick size in the Mountain White-crowned Sparrow (*Zonotrichia leucophrys oriantha*) at Tioga Pass, California. In this population, sparrows nest on the ground as well as in branches of small pines and willows. These site-specific environmental factors may present selective pressures on nestlings, but the consequences of nest habitat on nestling growth and fledging success are largely unknown. The Mountain White-crowned Sparrow provides an ideal opportunity to look at the affect of nest site characteristics on nest success because of the large variation in nest location in this species. We quantified nest microhabitat by measuring relative vegetation counts and density, above-ground water, and nest aspect. We found that environmental factors around the nest affected nestling size, but did not affect fledging success.

P1.123 KLEIN, T. A.*; ROSTAL, D. C. ; WILLIAMS, K. L.; FRICK, M. G.; Georgia Southern University, Caretta Research Project, Caretta Research Project; taklein85@yahoo.com

Seasonal Variation in Maternal Investment of the Loggerhead Sea Turtle (*Caretta caretta*)

With respect to reptiles, turtles have the least developed post-ovulatory parental care. Sea turtles have high seasonal fecundity and display little variation in egg size, and instead maximize clutch size. Therefore, understanding maternal contributions and strategies in reproduction can reflect how resources are allocated in response to environmental conditions that affect embryonic development, hatchling and juvenile survival, and population dynamics. This study was conducted on Blackbeard and Wassaw Island National Wildlife Refuges during the 2008 and 2009 Loggerhead sea turtle nesting season. An incubation study was performed in 2009 to determine if there are any differences in *in-situ* versus constant temperature incubation. Blood samples were taken in order to assess the adult female's physiological condition. Female physiological condition was compared with nesting event, clutch size, egg size and components. It is known that while egg size decreases over the course of the season, clutch size remains the same. Albumen, the source of the embryos' ability to absorb the yolk and therefore develop, decreases as the season progresses, while egg yolk and residual yolk mass within the hatchling remains the same. Hatchling size also decreases over the course of the season in *in-situ* nests however under constant temperature incubation this pattern is not observed. Is the allocation of different egg components across the season a sign that variation in maternal investment is being made in response to abiotic factors?

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Cold-induced mortality in *Drosophila*: Starvation, desiccation, or neither?

Organisms experience extremes and fluctuations in temperature during diurnal temperature cycles, across seasons, over geographical ranges, and as a consequence of climate change. In order to better understand how organisms acclimate and adapt to low temperatures, we are attempting to understand the physiological mechanisms of cold injury. Specifically, we are working on identifying the mechanisms of cold injury for mild exposures sufficient to induce chill coma in *Drosophila melanogaster*. Mild, chronic cold exposures are hypothesized to be analogous to starvation stress because individuals are unable to feed during chill coma. We are also considering a competing hypothesis that mortality may be due to desiccation. Alternatively, cold-induced mortality may be due to other mechanisms, such as cellular damage, that are independent of starvation or desiccation. To test these hypotheses, we are comparing the energy stores and water content of flies from five genetic lines of *D. melanogaster* that have died from starvation or desiccation with flies exposed to a range of potentially lethal low temperature exposures. These comparative data shed light on the causes cold-induced mortality.

P2.20 KOPLOVITZ, G*; MCCLINTOCK, J.B.; AMSLER, C.D.;
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Potential resistance of Antarctic ascidians to sympatric bacterial epibiosis

Both biotic and abiotic surfaces in benthic marine environments are subject to fouling by bacteria, protists and macroinvertebrate larvae. Although in certain circumstances epibiosis may be beneficial to the basibiont (the organism being fouled), for example, through the provision of vitamins and nitrogenous compounds, by in large, fouling is more harmful than beneficial. A large variety of fouling organisms are commonly found on the surfaces (tunic) of ascidians. These include bacteria, algae (such as diatoms), bryozoans and hydroids, as well as other macroinvertebrates. The focus of this study was to assess the incidence of antimicrobial activity in both lipophilic and hydrophilic crude organic extracts of a suite of solitary and colonial ascidians from the western Antarctic Peninsula. The bacterial strains tested were isolated from both the water-column and from the surfaces of sympatric benthic marine invertebrates. Antimicrobial activity of extracts from 13 species of Antarctic ascidians was evaluated using 20 strains of sympatric marine bacteria. Bacterial strains were tested using standard microbial growth inhibition techniques. Paper antimicrobial assay disks treated with ascidian solubilized extract were placed onto inoculated marine agar plates. Each plate was incubated at 4°C for several days until bacterial growth was visible and zones of inhibition could be measured. Zones of growth inhibition were compared to solvent control disks in order to evaluate antimicrobial activity of ascidian extracts. The results of this analysis will be interpreted in light of the prospective impacts of fouling in ascidians. This research was supported by NSF grants # OPP-0442769 and OPP-0442857.

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Introduced vector-borne disease in native and introduced Hawaiian forest birds on Oahu

Avian diseases, such as malaria and avian pox, are recognized as the most important factor preventing recovery of Hawaiian forest bird populations in low elevation habitats. This study investigated malaria and pox at 6 sites on Oahu in over 15 species, including two native species, the apapane and Oahu amakihi. Several species were identified as reservoirs of malaria, including house finches (68% infected individuals), chestnut mannikins (34%) and apapane (33%). Prevalence of pox was lower than malaria, with the highest incidence of pox-like lesions found in house finches (26%), northern cardinals (12%) and apapane (11%). Logistic regression indicated that the probability of an individual bird testing positive for malaria varied among species and sites in both native and introduced birds. Malaria was associated with pox-like lesions in native species, but not in introduced species. This suggests dual transmission of both diseases by the mosquito vector, but greater resistance or tolerance to pox virus in introduced species. Introduced species may be exposed to both diseases at the same rate as native species, but their longer evolutionary histories with blood parasites and viruses likely cause differential immune responses. Native Hawaiian species were not exposed to vector-borne disease until both pathogens and the mosquito vector were introduced beginning in the late 1800s. Some species of introduced birds are likely acting as reservoirs of pox and malaria, and their high abundance will maintain the disease reservoir at high levels. However, the continued presence of Oahu amakihi and apapane in some forests of Oahu may indicate these species are evolving resistance or tolerance to these diseases.

P3.14 KROCHMAL, Aaron R*; LADUC, Travis J.; PLACE, Aaron J.; Washington College, The University of Texas at Austin, Northwestern Oklahoma University; akrochmal2@washcoll.edu
Ultimate explanations for differences in learning patterns and decision-making abilities of pitvipers (Viperidae: Crotalinae)

Little effort has been devoted to investigating decision making and learning in snakes. Those studies that have been conducted generally lack biological relevance and a phylogenetic framework, curtailing the scope of these investigations and the results thereof. Recently, we described an experiment in which we investigated the ability of 13 species of pitviper - 7 rattlesnake and 6 non-rattlesnake pitvipers - to escape from a thermally stressful environment. Though all species were able to escape from the stressful environment equally well, rattlesnakes in the study learned to escape in one-trial (i.e., escape in 11 subsequent trials was faster than trial 1), whereas non-rattlesnake pitvipers never decreased their escape time over the 12 trials. We propose two ultimate-level hypotheses explaining the origins of the learning and decision-making ability of rattlesnakes. First, these behavioral abilities could have arisen to aid in navigating a thermal environment that was complex, extreme and variable, an idea supported by behavioral studies and the paleo-climate and habitat structure of the region in which rattlesnakes are thought to have arisen. Alternatively, these abilities might have risen concurrently with the rattle to aid in its appropriate use, and subsequently exapted to assist in thermoregulatory decisions; this hypothesis is supported by some behavioral studies, though recent studies of learning and rattle use do not. By evaluating both hypothesis critically, we aim to determine the most plausible hypothesis explaining the initial adaptive value that drove the evolution of the learning and decision-making abilities of pitvipers.

P3.15 KROCHMAL, Aaron R; LADUC, Travis J.; PLACE, Aaron J.*; Washington College, The University of Texas at Austin, Northwestern Oklahoma University; ajplace@nwosu.edu
Proximate explanations for differences in learning patterns and decision-making abilities of pitvipers (Viperidae: Crotalinae)

Decision making is at the center of all animal behaviors. However, the paucity of investigations into the mechanism of decision making, particularly among non-primates, combined with the lack of biological relevance of the majority of investigation into these mechanisms has left us with a poor understanding as to how decisions are made mechanistically. Recently, we described an experiment in which we investigated the ability of 13 species of pitviper – 7 rattlesnake and 6 non-rattlesnake pitvipers - to escape from a thermally stressful environment. Though all snakes were able to escape from the stressful environment equally well, rattlesnakes in the study learned to escape in one-trial (i.e., escape in subsequent trials was faster than trial 1), whereas non-rattlesnake pitvipers never decreased their escape time in 12 trials. Here we present a Bayesian statistical approach known as signal detection theory (SDT) to explain the behavior of pitvipers in thermally stressful situations. The main parameters of the model are a prior probability distribution (the probability a hypothesis is true before any evidence is obtained), evidence (neuronal firing rate in the somatosensory cortex), value (living or dying), a decision variable (derived from a likelihood ratio), and a decision rule (a constant based on the likelihood ratio). We present numerical estimates for these parameters that await experimental verification. The SDT model suggests profound differences in the neural processing abilities within the brains of rattlesnake and non-rattlesnake pitvipers. We suggest these changes in neural processing occurred at the divergence of rattlesnakes from the other pitvipers.

P3.50 KUO, D.-H.*; WEISBLAT, D.A.; Univ. of California, Berkeley; dhkuo@berkeley.edu

Dorsoventral patterning by BMP-gremlin interactions in segmental ectoderm of the leech *Helobdella*

BMPs are evolutionarily conserved players in dorsoventral (DV) patterning of bilaterian embryos. They are best known acting as a morphogen in DV patterning of *Drosophila* and vertebrates, but it is less clear whether BMP acts in a similar way in other species, particularly in those with cell lineage-dependent embryogenesis. To see how BMPs act in lineage-driven DV patterning, we characterized the roles of BMPs in DV patterning of segmental ectoderm in the leech *Helobdella*. Segmental ectoderm of the leech arises from four bilateral pairs of teloblasts (N, O/P, O/P and Q). The N and Q lineages give rise to the ventralmost and dorsalmost portions of the segmental ectoderm respectively; their fates are specified as soon as the teloblasts are born. The ipsilateral O/P lineages are positionally specified to adopt either the ventrolateral (O) fate or the dorsolateral (P) fate. We identified *Hau-BMP5-8*, expressed specifically in the dorsalmost Q lineage, as a short-range signal that induces the P fate. Moreover, BMP signal upregulates *Hau-gremlin*, a secreted BMP antagonist. We showed that *Hau-gremlin* selectively antagonizes *Hau-BMP2/4* and *Hau-DVR*, both of which are broadly expressed in normal development. In contrast, *Hau-BMP5-8* is not sensitive to *Hau-gremlin*-mediated antagonism. Hence, we propose that the dorsally localized *Hau-BMP5-8* specifies the dorsolateral P lineage and upregulates *Hau-gremlin*, which in turn prevents the ventrolateral O lineage from adopting P fate by inhibiting the globally distributed *Hau-BMP2/4* and *Hau-DVR*. The mechanism by which BMPs patterns leech ectoderm has apparently deviated significantly from the paradigmatic morphogen gradient models.

P2.10 KUMAR, A.; LARSON, R.; BROWN, C.; CARR, J.A.*; Texas Tech Univ., Lubbock; james.carr@ttu.edu

Evidence for evolutionary reductions in both the ligand and receptor that regulate rapid skin darkening in the Texas toad, *Bufo speciosus*.

Two mechanisms regulate skin darkening in the South African clawed frog *Xenopus laevis*: a rapid response mediated by beta-adrenergic receptors on melanophores and a slower more sustained skin darkening resulting from MSH. Presumably these pathways have evolved as a response to predation, however it is unclear how these pathways operate in anuran species that would derive no benefit from the ability to mount a rapid melanophore response. *Bufo speciosus*, the Texas toad, is a desert adapted species that is nocturnal during the spring and summer but estivates underground the rest of the year. Compared to *X. laevis*, skin darkening is much slower and not as pronounced in *B. speciosus*. The dopamine neurotoxin 6-OHDA produced skin darkening in *B. speciosus* that amounted to 85% of the maximum achieved during long term dark adaptation. The dopamine receptor antagonist haloperidol had no effect while administration of the dopamine receptor agonist apomorphine significantly reduced skin darkening. Interestingly *B. speciosus* exhibited a strongly attenuated response to isoproterenol compared to *X. laevis*, and skin darkening in white adapted *Bufo* after transfer to a dark background was not affected by propranolol. To investigate the basis for the lack of response to beta-adrenergic agents, we examined differences in beta-adrenergic binding sites and skin catecholamine content between the two species. Skin from *X. laevis* had significantly more [3H]dihydroalprenolol binding sites as well as greater amounts of both dopamine and epinephrine compared to skin from *B. speciosus*. We conclude that *B. speciosus* appears to lack a mechanism for rapid skin darkening due to reductions in both the ligand and receptor controlling this response.

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Taxonomic Identification of Tetrapods Using Bone Microstructure

Taxonomic identification of fossil tetrapods has traditionally been achieved by evaluation of the presence, absence, and overall form of the gross morphology of the skeleton. New research suggests that tetrapods can also be distinguished taxonomically using quantitative measurement of a set of microstructural features found in cortical bone. Results were produced from a dataset consisting of 15 measurements taken from each of 37,000 microstructures that were distributed across 12 extant mammals. Patterns of microstructural identification within the dataset were detected using Principal Components Analysis (PCA) and confirmed to a $\leq .05$ confidence interval using Multiple Discriminant Analysis (MDA). Using the PCA-MDA method, 76% of the microstructures were correctly re-classified to the taxon of origin. These results are the first to quantitatively confirm a course of research that was suggested in 1849 by John Quekett of the Royal College of Surgeons London. Because the tetrapod fossil record is populated with an abundance of incomplete skeletons, this new method of taxonomic identification has far-reaching capabilities to assist in the identification of fossil specimens that would not otherwise be identifiable because of the lack of diagnostic character traits. The cosmopolitan nature of bone microstructures throughout the Tetrapoda combined with the ability to measure a sufficient number of microstructures from even a small fragment of bone makes this method a powerful identification tool that can be used to augment the established methods and increase the robusticity of the faunal data used for paleoecological reconstruction.

P2.127 LACY, E.L.*; WOODLEY, S.K.; Mars Hill College, Duquesne University; elacy@mhc.edu

Activity, but not mating behavior is suppressed by an acute stressor in male and female *Ocoee salamanders*.

Chronic stress has clear suppressive effects on reproductive hormones and mating behavior. The effects of acute stressors on reproductive hormones and mating behavior have been less studied. Further, behavioral responses to acute stressors include species and perhaps context-specific changes in mating behavior and activity. Few studies have examined these two classes of behavior in a single species, using the same acute stress paradigm. It is well-known that confinement stress rapidly and significantly suppresses male mating behaviors in rough-skinned newts. Suppression is due to release of glucocorticoid hormones that act through a nonclassical receptor mechanism. It is unknown whether the suppression of mating behavior by acute stress is restricted to newts, or whether it is a widespread response. We determined whether handling stress suppressed mating behavior and individual activity in the *Ocoee salamander* (*Desmognathus ocoee*). Mating behavior was observed for a duration of 5.5 hrs, beginning 35 minutes after the onset of the handling stressor. Overall, 88% of the pairs mated. There was no effect of handling stress on the latency to various stages of courtship or female insemination. We also examined activity in animals alone in testing chambers and found that females were more active than males and handling stress strongly reduced activity in both sexes. Plasma CORT was elevated in animals bled at 30 and 60 minutes after handling compared to baseline. Plasma testosterone in males, but not estradiol in females, was significantly reduced after handling compared to controls. Thus, handling stress suppressed activity, but did not suppress mating behaviors despite eliciting elevated plasma corticosterone and reduced testosterone.

P3.125 LARSON, R.*; AHMED, N.; SHOUKFEH, O.; BULIN, S.; BERGFELD, N.; LUSTGARTEN, J.; CARR, J.A.; Texas Tech Univ., Lubbock; richard.larson@ttu.edu

Intrinsic neurons contribute to CRF innervation of the anuran optic tectum

The 41 amino acid peptide corticotropin-releasing factor inhibits visually guided feeding in anuran amphibians, but the targets for CRF action within sub-cortical visual pathways are unknown. We examined the distribution and origin of CRF immunoreactivity in the anuran optic tectum, a brain area at the interface of sensorimotor integration. CRF immunoreactive perikarya and fibers were observed in the optic tectum of three representative anuran amphibian species, the Texas toad *Bufo speciosus*, the South African clawed frog *Xenopus laevis*, and the Korean fire bellied toad *Bombina orientalis*. Intrinsic CRF-immunoreactive neurons were observed in tectal layer 8 in all species. These neurons were pyriform in shape, and had clearly stained projections directed laterally within layer 8 or directed vertically toward tectal layer 9. The optic tectum expressed mRNA for CRF, CRF R1 receptor, and urocortin-1. CRF was detected in toad optic tectum by radioimmunoassay, although tectal CRF content was considerably less than that of the hypothalamus and forebrain. The rank order for CRF content in toad brain as determined by radioimmunoassay was forebrain, hypothalamus > brainstem > optic tectum >> olfactory bulb. Unilateral eye ablation did not affect CRF content of the contra lateral optic tectum. We conclude that neurons in the anuran optic tectum express mRNA for CRF and CRF R1 and that CRF immunoreactivity in the optic tectum arises from intrinsic CRF neurons.

P2.34 LARSON, K.W.*; BENSCH, S.; MÅLLER, N.; ÅKESSON, S.; Lund Univ., Lund; keith.larson@zoekol.lu.se

Secondary contact zone in central Sweden for Willow Warblers *Phylloscopus trochilus* identified using stable isotopes, AFLP molecular markers, and morphometrics

Willow warblers (*Phylloscopus trochilus*) are one of the most abundant Palaearctic-Africa migrants that breed throughout Eurasia and winter in sub-Saharan Africa. On their breeding grounds in Sweden there exist two subspecies. Bensch et al. (1999) documented that these two subspecies use different migration routes using ringing recovery data forming a migratory divide at the secondary contact zone. *P. t. acredula* breeds in northern Scandinavia and follows a southeasterly route during autumn migration and to spend the winter in southern Africa. In contrast, *P. t. trochilus* breeds in south Scandinavia and migrates towards southwest in autumn to winter in western Africa. Adult birds from the two subspecies meet and potentially mix in a narrow secondary contact zone in central Sweden between 61° and 63° north latitude. We used stable carbon- and nitrogen-isotopes, two AFLP (amplified fragment length polymorphism) markers, and morphometrics to more precisely identify the secondary contact zone. With the contact zone identified, we plan to investigate the consequences of mate choice on population dynamics, assortative mating, breeding performance and consequences of inter-breeding on the genetic migration programs of individual birds.

P2.99 LARSON, Paul G*; FRANCIS, Lisbeth; The Ohio State University, Columbus; larson.309@buckeyemail.osu.edu

Phylogeny of Pacific Brooding Anemones in *Epiactis* (*Actiniaria*, *Actiniidae*).

Sea anemones in the genus *Epiactis* (Verrill, 1869) brood their offspring. Reproductive strategies in *Epiactis* are varied, including internal and external brooding, hermaphroditism, and gonochorism. This is a cosmopolitan genus that broods in arctic, Antarctic, and temperate waters. On the Pacific coast of the United States, four species of *Epiactis* exhibit the possible combinations of the reproductive traits mentioned above. Previous phylogenetic work done on only these four species using allozyme and DNA fingerprinting data found the group to be paraphyletic and was unable to make inferences about the evolution of these characters based on the tree topology. Increased taxonomic sampling and incorporation of other types of data should offer the resolution necessary for illuminating the evolutionary relationships between species and their respective reproductive modes. This study of diversity and phylogeny of *Epiactis* uses nuclear and mitochondrial DNA sequence data in a phylogenetic analysis and includes other brooding species thought to be closely related to *Epiactis* in an effort to better understand the evolution of this behavior.

P1.37 LAU, F.O.*; TAYLOR, K.N.; BAATZ, J.E.; DEAROLF, J.L.; Hendrix College, Conway, AR, the Medical College of Charleston, S.C.; lauf@hendrix.edu

Do guinea pig fetuses express lung surfactant proteins after being exposed to betamethasone at seventy-percent gestation

Glucocorticoids are used in clinical medicine because they stimulate the development of the lungs, which decreases the incidence of breathing problems in premature infants. But, the effects of these steroids on the development of other body systems are not as well known. Guinea pigs are an excellent model system to determine the effects of glucocorticoids on development, because they share physiological and developmental features with humans. However, the appropriate length of and earliest effective exposure to these steroids for guinea pigs have yet to be determined. The purpose of this study is to test the hypothesis that two intramuscular injections of betamethasone given to pregnant guinea pigs (0.5 mg/kg) twenty-four hours apart at 70% gestation is an effective steroid exposure protocol for these animals. To test this hypothesis, fetal lung samples were assessed for the presence of surfactant protein B. Lung samples from control (sterile water) and treated fetuses were prepared for polyacrylamide gel electrophoresis. The proteins were separated on 4-12% Tris/Glycine SDS-PAGE gels that ran at 200V for 50 minutes and transferred to nitrocellulose membranes at 25V for 90 minutes. This transfer allowed for Western Blots with membrane exposure to anti-lung surfactant protein B antibodies, which were then developed for chemiluminescence. Images of the blots were analyzed using Scion Image to measure sample density levels, which will be used to calculate the percent SP-B per milligram of protein in each fetal lung sample. These values will be compared to determine if all of the fetuses in the treated litters express SP-B, a finding that would support the hypothesized steroid exposure protocol for guinea pigs.

P3.124 LAWSON, B.K.*; MALISCH, J.L.; BREUNER, C.W.; University of Montana; brennalawson@gmail.com

Social stress in Potter traps

Acute capture and handling protocols are commonly utilized to characterize the glucocorticoid response to unpredictable stress in free-living vertebrates. In small passerines a common capture technique is seed-baited Potter traps. Each Potter trap is separated into two compartments, each with its own treadle triggered door. In white-crown sparrows (WCSP) glucocorticoid levels do not increase in response to trap containment within the first 15 minutes of capture. However, Potter traps contain two independent trapping units and it is possible for two birds to be captured per trap. It is not known if visual contact with a trapped conspecific elicits a glucocorticoid response. Here we compared baseline corticosterone (CORT; the primary glucocorticoid in birds) from male WCSP that were captured alone (n=25), with a conspecific male (n=14) or with a conspecific female (n=16). Baseline CORT levels were obtained during the egg-laying and incubation phase (June and July) from multiple years (2002-2008) of a long-term study population of WCSP at Tioga Pass Meadow, CA. Data was analyzed using a one-way ANCOVA with the main effect of trap occupant and the covariates date and maximum possible time in trap. We found that baseline CORT does not differ between males trapped alone and males trapped with a conspecific male. This finding is consistent with a previous study of male WCSP; staged-territorial intrusions did not elicit an increase in circulating CORT (Lynn et al., 2007, *The Condor* 109:173-180). Interestingly, males trapped with a conspecific female had significantly elevated baseline CORT as compared to males trapped alone or males trapped with a second male. There was not a significant effect of date nor time spent in the trap.

P3.33 LAUMER, Christopher E.; Harvard University Museum of Comparative Zoology; claumer@oeb.harvard.edu

Insights into the Kytorrhynchidae ("Typhloplanoida": Platyhelminthes) from the marine sediments of Sardinia

During an investigation of sublittoral marine sediments and other habitats from three localities in Sardinia, a considerable number of small flatworms related to the enigmatic Kytorrhynchidae were encountered, which probably represent new species. This group evinces a minuscule but functional "false" proboscis whose structure has led some authors to suggest its relationship to the more-developed proboscis of the eponymous Kalyptorrhynchia; hence, these are phylogenetically important animals. Nonetheless, the taxonomy of this cosmopolitan family remains in a primitive state. Abundant material was collected from several localities of two seemingly related new species of *Kytorrhynchus*, distinguishable on the basis of the shapes of their sclerotized penis stylets, their gonopores, and other anatomical features readily visible on live animals; a description of these animals is forthcoming. Both species display a combination of characters which prevents their placement into either of Rieger's (1974) subgenera; assignment to a subgenus, new or old, is eschewed until such time as an explicit cladistic analysis can be performed on the Kytorrhynchidae. Also discussed (but too lacking in material to be formally described) are an aberrant *Kytorrhynchus* with a single testis known from two individuals, as well as a *Kytorrhynchella* with a very large, ornate penis stylet known from a single individual. Given the seeming Mediterranean endemicity of these animals, the relative ease with which they were discovered, and their scarce coverage in the literature, it seems reasonable to conclude that zoologists today understand only the barest fraction of the diversity of these little worms.

P2.67 LAYTON, Jenny Estes; WIBBELS, Thane*; JACOBSON, Elliot; BRISSETTE, Micahael; University of Alabama at Birmingham, University of Florida, Quantum Resources, In Water Research; twibbels@uab.edu

Evaluating the sex ratios of juvenile loggerhead sea turtles inhabiting the Atlantic coastal waters of Florida

All sea turtles have temperature-dependent sex determination (TSD). This type of sex determination has the potential of producing biased sex ratios which are of ecological and evolutionary interest. The loggerhead sea turtle population inhabiting the coastal waters of the southeastern U.S. is one of the largest loggerhead populations in the world. The current study utilizes a testosterone-based sexing technique to evaluate juvenile sex ratios in this population. It is advantageous to evaluate juvenile sex ratios because they represent a condensation of many years of hatchling production. In the current study, several hundred juvenile loggerheads were captured at the St. Lucie Nuclear Power Plant on the Atlantic coast of Florida. This area represents a major nesting location and juvenile foraging ground for loggerheads. Blood samples were taken immediately after capture and the turtles were released into the Atlantic. A radioimmunoassay for testosterone was used to evaluate the sex of the captured turtles. Previous studies of sea turtle sex ratios indicate that TSD can produce a variety of sex ratios including significant biases. Further, a previous study of loggerheads in this same location over two decades ago indicated a significant female bias. The results of the current study are consistent with those of previous studies. The results provide insight on the temporal stability of the population's sex ratio in a species with TSD. Further, the results have implications for ecological and evolutionary significance TSD.

P2.86 LEASER, Anne/E*; CRAWFORD, Emily/A; GAY, Daniel/M; DILLAMAN, Richard/M; University of North Carolina at Wilmington; ael5075@uncw.edu

Ultrastructure and immunocytochemistry of the apodemes and associated tissue in the chelae of the blue crab, *Callinectes sapidus*

In the chelae of the blue crab, are two invaginations of the cuticle (apodemes) providing attachment sites for muscle. The morphology and composition of intermolt, premolt, and postmolt apodemes and associated tissue was revealed using light microscopy, immunocytochemistry, and transmission electron microscopy (TEM). Three polyclonal antibodies to *C. sapidus* cuticle proteins were used to determine the nature of the apodeme. Two of the antibodies are associated with calcified cuticle (CsCP8.5 and CsCp14.1) and one (CsAMP8.1) with uncalcified cuticle (arthrodial membrane). All 3 bound to the medial layer of the apodeme. Acridine orange (AO) staining of the apodeme differentiated the medial and lateral layers, with the fused epicuticular regions staining red and the adjacent cuticle staining green. AO staining of the epithelium showed a patchy distribution of red fluorescence indicating enhanced ribosomal activity in the portions of the cells during premolt and postmolt. A β -tubulin antibody and TEM confirmed the presence of bundles of microtubules interspersed with the secretory regions of the cells. TEM also revealed that these microtubules were attached to tonofibrils, which anchor the cuticle to the epithelium. The other end of the microtubule bundles forms a terminal z-band with the myofibrils of the muscle. The pattern of AO staining, the affinity for cuticle protein antibodies, as well as other ultrastructural features indicate that the apodemes are a unique cuticle type, with affinities to both calcified and uncalcified cuticle. Clues as to how muscle maintains function until very late in premolt is also revealed by examination of the cuticle-epithelial boundary over the molt cycle.

P2.92 LEHMAN, HK*; BERRY, N; BERTINO, S; BRODSKI, A; CHAPONIS, S; Hamilton College; hlehman@hamilton.edu
TbhR: A Novel Gene Family Related to Tyramine Beta-Hydroxylase

In a previous study focused on age-related division of labor in honey bee colonies we have observed that octopamine (OA) may play a role in controlling behavioral plasticity in honey bees. OA is specifically elevated in the brains of forager bees; we detected higher levels of the OA synthetic enzyme tyramine beta-hydroxylase (Tbh) mRNA in forager bees relative to nurse bees and the locations of Tbh mRNA containing neurons are consistent with the location of OAergic neurons in the bee brain. In contrast, Tbh activity was not correlated to Tbh mRNA levels. Our results indicate that OA plays a role in controlling behavioral plasticity in honey bees, however our Tbh activity results remain puzzling. We have examined the possibility that another gene exists in insects that encodes a protein structurally similar to Tbh. A bioinformatic study was used to identify genes that encode proteins similar to tyramine beta-hydroxylase. We have discovered a novel group of genes contained in all insects examined to date that encodes an approximately 70 kDa protein with ca. 30% identity to Tbh. Insect tyramine beta-hydroxylase related protein (TbhR) has many structural similarities to Tbh and dopamine beta-hydroxylase, including conserved copper binding active sites and Cys residues necessary for intramolecular disulfide bonds. Furthermore, RT-PCR studies have revealed that TbhR mRNA is expressed very early during insect development and is present later in larvae, pupae and adults. Moreover, TbhR is widely expressed in the insect nervous system, gut, salivary glands and fat body tissues, and TbhR is located within specific regions of the insect optic lobes, antennal lobes and mushroom bodies. We speculate that TbhR encodes a novel protein with putative monooxygenase activity that may be vital for nervous system development.

P3.137 LEE, Sabrina/SM*; BIEWENER, Andrew/A; DE BOEF, Maria; FORSMAN, Karen; WAKELING, James/M; Simon Fraser University, Harvard University; sabrina_lee_4@sfu.ca

Designer Wavelets for EMG Analysis

The mechanical output of a muscle is dictated by factors such as biochemistry, architecture, fiber composition, and recruitment patterns. The contribution of recruitment patterns to force production during dynamic tasks has not been well established. Slow and fast motor units generate action potentials with varying shape, intensity, and conduction velocity and these affect the frequency components within the myoelectric signals. High and low frequency bands have been attributed to fast and slow motor units, respectively. Here we use in situ measurements to verify the frequency response of the motor unit action potentials observed in vivo, and we demonstrate how wavelets can be optimized to their characteristic frequencies. Using wavelet analysis, a time-frequency decomposition technique, we investigated the myoelectric signals and corresponding force output during in situ measurements of supramaximal and submaximal twitches and during in vivo measurements of tendon-tap stretch reflexes in the goat. During a supramaximal twitch all motor units are recruited whereas during a submaximal twitch fewer slow motor units are recruited. In addition, slow motor units are primarily excited during a tendon-tap stretch reflex. Examination of the EMG intensity spectra, mean frequency, twitch times, and force rise times of the myoelectric signal and force output revealed that those properties correspond to the expected recruitment patterns during the supra- and sub-maximal twitches and tendon-tap stretch reflex. Bursts of high and low frequency components occurred in a consistent pattern during in vivo jumping. These findings allow "designer" wavelets to be optimized to the EMG signals from the fast and slow motor units that permit tracking of their activity in vivo.

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Differential regulation of mRNAs encoding vasotocin and its receptors in the teleost hypothalamus following acute stress

The nonapeptide hormones vasotocin/vasopressin (AVT/AVP) have been implicated in several vertebrate taxa as regulators of the HPA axis. In fish, AVT/AVP synergize with corticotropin-releasing hormone to stimulate secretion of adrenocorticotrophic hormone (ACTH). Accordingly, hypothalamic pro-AVT mRNA expression has been shown to be regulated by stress in fishes. Recently, multiple receptors for AVT - two distinct receptor paralogs (V1a1 and V1a2) in the mammalian V1a-type receptor family and a single V2-type receptor - were identified in the teleost *Cyprinodon nevadensis amargosae*, the Amargosa pupfish. It remains unclear, however, which of these receptors are involved in AVT regulation of the physiological stress response. In this study, quantitative real-time PCR was used to examine changes in mRNAs encoding pro-AVT and its receptors in the hypothalamus of sexually-mature Amargosa pupfish following acute capture stress. Hypothalamic pro-AVT mRNA levels increased 1.8-fold in both male and female pupfish over a 2 hr period following capture stress. In males, transcripts for the V1a1 and V1a2 receptors declined up to 50% within 40 min of capture from pre-stress baseline levels. In females, however, hypothalamic V1a1 mRNA levels were briefly elevated at 40 min following capture only to decline below baseline levels at 80 min and 120 min after capture, while transcripts for the V1a2 receptor were unaltered. Transcript abundance for the V2 receptor was not affected by acute capture stress in the hypothalamus of either sex. Taken together, these findings indicate sex differences in hypothalamic V1a1 and V1a2 mRNA regulation following acute stress, and suggest that these V1a-type receptors might mediate AVT's influences on how fish respond physiologically and behaviorally to stress.

P2.137 LEMASTER, M.P.*; STEFANI, A.C.; MASON, R.T.;
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Heavy-bodied vs. Light-bodied - Does it Matter? Size Dependent Mate Selection and Pheromone Production in Garter Snakes

Many populations of garter snakes live in regions that limit the ability of females to reproduce on an annual basis due to feeding constraints. Because courtship is very energetically expensive for male garter snakes, it would benefit males to be able to discriminate between females with high energy stores that will reproduce that year (i.e., 'heavy-bodied' females) versus those females with low energy stores that will not reproduce (i.e., 'light-bodied' females). Utilizing the red-sided garter snake (*Thamnophis sirtalis parietalis*) as a model system, we first examined whether males can discriminate between heavy-bodied and light-bodied females during the breeding season. Results from courtship trials demonstrate that males indeed can differentiate among females based on body condition, preferring heavy-bodied females over light-bodied females. In addition, chemical analyses were performed to examine whether the female sexual attractiveness pheromone might be responsible for mediating the observed male preference. Comparisons of skin lipid samples from females of varying body conditions show that heavy-bodied females have a pheromone profile that is qualitatively different to that of light-bodied females. Together, these results support the hypothesis that male garter snakes are able to discriminate among females based on their potential reproductive output and suggest a role for the female sexual attractiveness pheromone in mediating this preference.

P1.116 LEMENAGER, L.A.*; TRACY, C.R.; MALONEY, N.;
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Comparison of water potential in two anuran species, Anaxyrus boreas and Pseudacris sierra

Experiments were performed to determine the ability of western toads (*Anaxyrus boreas*) and pacific tree frogs (*Pseudacris sierra*) to obtain water from sucrose solutions differing in osmotic potential. A standard body mass was measured as the mass of a hydrated frog with an empty bladder. The frogs were dehydrated to 90% of their standard body mass and experimentally rehydrated in a series of varying sucrose solutions. The data were used to estimate (by regression) the water exchange rate for each frog in each solution. The means and standard deviations of these rates were plotted against the water potential of the sucrose solutions to find the x-intercept of the resulting plot, which represents the conditions at which no water is exchanged, and thus, the water potential of the frog. The water potential of *A. boreas* and *P. sierra* were similar to water potentials of their blood under the experimental conditions, so it appears that control of whole-animal water potential is not different from osmotic potential of blood under the conditions of this experiment.

P1.168 LEMELIN, P.; Univ. of Alberta; plemelin@ualberta.ca
Locomotor mechanics of the kinkajou (Potos flavus)

Kinkajous are highly arboreal South American procyonids that travel and feed on relatively thin branches (1 to 5 cm in diameter) for mammals of that body size (1.4 to 4.6 kg). In several ways, kinkajous converged with primates in behavior and ecology. Therefore, they represent a critical species to test functional links between primate-like biomechanics and arboreal locomotion. Synchronized high-speed digital video (125 Hz) and force platform data were recorded in two individuals of similar body mass when walking quadrupedally on a 25-mm pole and runway. Over 200 strides were analyzed and locomotor parameters were measured, including footfall pattern, limb kinematics, and substrate reaction forces on the limbs. Like primates, kinkajous relied primarily on diagonal-sequence and trotting gaits during walking. At forelimb touchdown, arm protraction was well within the range reported for primates. Slightly more body weight (bw) was borne by the hindlimbs (66.9% bw on pole; 69.1% bw on runway) comparatively to the forelimbs (64% bw on pole; 68.6% bw on runway). Overall, the locomotor profile of kinkajous resembles that of primates. However, differences in limb force and duty factor ratios parallel fundamental differences in pedal structure between primates and kinkajous. Funded by NSERC.

P2.27 LESCH, M.A.*; GRIVAS, J.A.; FROUNTFELTER, T.;
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Structure, Inflammation, and Repair in a Giant danio (Danio aequipinnatus) Model of Heart Injury

The ultrastructural characteristics of the heart, the wound repair response and the ability to regenerate following injury were studied in the adult Giant danio (*Danio aequipinnatus*). The ventricular myocardium of the Giant danio displays a compact outer layer as well as a spongy inner layer typical of teleost hearts. Electron microscopy studies revealed myocyte ultrastructure and organization similar to that observed in the zebrafish (*Danio rerio*). Apical cauterization resulted in injury to 25% of the ventricle as assessed by a tetrazolium chloride assay. We observed a robust inflammatory response with early recruitment of heterophils and mast cells, and the persistence of inflammation past the second week post-injury. PCNA-positive cells were present adjacent to the site of injury over three weeks. Collagen accumulation was observed during the second and third week but had returned to baseline level at the end of the repair process by 45 days when the ventricle appeared completely regenerated. Our data suggest that like the zebrafish, the Giant danio possess robust repair mechanisms in the heart.

P3.76 LESOWAY, M.P.*; COLLIN, R.; McGill University, Montreal, Canada, Smithsonian Tropical Research Institute, Panama; maryna.lesoway@mail.mcgill.ca

Particle capture and ingestion abilities in larvae of calyptraeid gastropods with different modes of development

For marine invertebrate larvae, it is thought that larval feeding structures, once lost, are difficult or impossible to regain (Strathmann 1974, 1978; Hart 1996), owing to lack of stabilising selection once these complex structures have been lost. Recent work with calyptraeid gastropods indicates that mode of development (planktotrophy, lecithotrophy, direct development or direct development with nurse eggs) changes quickly and frequently, and suggests the re-evolution of larval planktotrophy from direct developing lineages in three instances (Collin 2004, Collin et al. 2007). The possible re-evolution of larval feeding in this group represents a unique opportunity to investigate the evolutionary consequences of the loss of complex structures, such as the velum; the gastropod larval organ used for swimming and feeding. We investigated the particle capture and ingestion abilities of several species exhibiting different modes of development. Larval size, velum size, prototrochal ciliar length, food groove length, and mouth width were compared across two planktotrophs, a lecithotroph and two direct developers. Larvae were exposed to a suspension of microspheres (ranging from 2 - 90µm) to observe size selectivity and the rate of particle ingestion. The mechanisms of particle capture were also observed. In all species velum size increased after the initiation of the velar ridge in early development. In the direct developers the velum decreased in size and was absorbed prior to hatching. In the other species the velum continued to grow until hatching. In all species embryos and larvae ingested beads. Details of the differences in the size and number of particles ingested will be discussed in terms of transitions between different modes of development.

P3.113 LIN, C.-C.*; HUANG, H.-D.; LIU, H. C.; Dept. of Ecology, Providence Univ., Taiwan, National Museum of Natural Science, Taiwan; hduhuang@nmns.edu.tw

Orientation mechanisms of larval release migration by the sesarid crab, *Metasesarma aubryi*

Metasesarma aubryi lives under the maritime forest and ovigerous females need migrate to surf for larval release. The breeding season of *M. aubryi* is variable, depending on the beginning and ending of the rainy season, between May and November. In the season, *M. aubryi* release larvae during the last quarter of the lunar cycle. In southern Taiwan, migration of ovigerous *M. aubryi* commences after midnight from the highland forest, and wait until the time before dawn for larval release. We hypothesize that *M. aubryi* use geomagnetic field, light, and chemical cues for navigation. In laboratory, crabs were tested in a circular arena for orientation mediated by geomagnetic and light cues; a four-chambered apparatus was employed for testing chemical cues from seawater, and congeners. In the dark, ovigerous crabs oriented seawards but randomly after larval release, which indicated geomagnetic fields as primary cues for seaward orientation. Spot lights from directions changed orientation of ovigerous crabs in the arena, which implied crabs may also use skylight in navigation. Scents of seawater and congeners showed weak influence in orientation of crabs. We conclude that, ovigerous crabs mainly use geomagnetic fields to navigate seawards; after larval release, they randomly move possibly for proximate shelters and may wait for slow resume of the landward orientation. Ovigerous crabs near the beach may use twilight at dawn as a signal for seaward orientation and larval release. Artificial illumination at the route may cause negative effect on migrating crabs.

P2.83 LIMONCELLI, K.A.*; PREHODA-WYERS, M.M.; DEAROLF, J.L.; Hendrix College, Conway, AR; limoncellika@hendrix.edu

Effects of betamethasone on the extensor digitorum longus in fetal guinea pigs

Studies indicate that in skeletal muscle tissue, the process of differentiation includes the disappearance of fetal and neonatal myosin heavy chain (MHC) expression and replacement of these developmental myosins by adult MHC IIA, IIX, and IIB. It is also known that glucocorticoids are responsible for activating differentiation in tissues, and synthetic glucocorticoid administration is a common protocol used to increase the survival rate of premature newborns. This study is designed to determine the effects of synthetic glucocorticoids on myosin expression and myogenesis in fetal guinea pig muscle tissue, specifically the extensor digitorum longus (EDL). Two injections of betamethasone or sterile water were administered to pregnant females (0.5 mg/kg) at 70% gestation (day 47 and 48). EDL muscle samples were collected from treated and control fetuses, frozen, and prepared for 7% polyacrylamide, 30% glycerol SDS gels. Three bands (fetal, neonatal/IIA/ IIX, and slow) were identified and the proportion of each myosin present relative to the total myosin expressed by the fetal EDLs was determined using SCION image. If our results support the hypothesis, more adult fast myosin will be present in the treated muscles, indicating that the transition from fetal and neonatal myosin to the adult myosins occurs faster in treated fetuses. These findings may indicate an alteration of contractibility and fatigability in treated muscles. Studies show, as adult fast myosin increases, the contractile force and fatigability increase, suggesting that treated muscles will have better contractile properties than control. However, high fatigue resistance might be a necessary trait in postnatal development into adulthood, suggesting a possible negative outcome from exposure to the drug.

P2.6 LIU, Qin; CHEN, Yun; THAKKAR, Mitesh; LONDRAVILLE, Richard/L.*; University of Akron; londraville@uakron.edu
Expression Pattern of Leptin and Leptin Receptor in Developing and Adult Zebrafish

Interactions of leptin and leptin receptors play crucial roles during animal development and in regulation of appetite and energy balance. We analyzed the expression pattern of a zebrafish leptin, and leptin receptor mRNA in both developing and adult zebrafish using in situ hybridization and quantitative PCR methods. Zebrafish leptin message (*lep*) was detected in very early embryos (15 min.-6 hours post-fertilization) and continued through 72 hpf with an apparent spike in concentration at 24 hpf. Zebrafish leptin receptor message (*lepr*) was detected in all embryonic and larval stages examined, and in adult zebrafish. In embryonic zebrafish, *lepr* was mainly expressed in the notochord. As development proceeded, *lepr* expression in the notochord decreased, while its expression in several other tissues, including the trunk muscles and gut, became evident. In both larval and adult brains, large *lepr* expressing cells were detected in similar regions of the hindbrain. In adult zebrafish, *lepr* expression was also observed in several other brain regions including the hypothalamic lateral tuberal nucleus, the fish homolog of the arcuate nucleus. RT-PCR experiments confirmed *lepr* expression in the adult fish brain, and also showed *lepr* expression in a subset of adult tissues including liver, muscle and ovary tissues. Our results show that *lepr* expression was both spatially and temporally regulated.

P1.67 LOEFFLER, J.*; MARTINDALE, M.Q.; Kewalo Marine Laboratories, University of Hawaii at Manoa; jorik@hawaii.edu
Origins Of Triploblasty: What Corals Can Tell Us.

In bilaterians, a single embryonic endomesodermal tissue segregates into mesoderm and endoderm during gastrulation. The evolutionary origin of this tissue and its derivatives is unknown. The sequencing of the genome of the sea anemone *Nematostella vectensis* (Cnidaria, Anthozoa) has revealed that a large set of genes involved in forming endomesodermal and subsequently mesodermal tissue in triploblasts are also present in this basal metazoan. Expression of these genes occurs at the blastopore early during gastrulation and for some, extends into the developing gastrodermis. This observation, and the fact that the gastrodermis has bifunctional capacities, absorptive and contractile, led to the idea that an ancestral endomesoderm existed in the last common cnidarian/bilaterian ancestor. Genes involved in formation of this tissue were recruited to perform novel roles in specifying endoderm and mesoderm in the evolving triploblasts. Anthozoans are thought to be the earliest branching cnidarians. To further investigate ancestral endomesodermal genes, it is important to examine different members of this class. We identified and characterized *brachyury*, *snail*, *foxA*, *moxC* and *otx* in the coral *Fungia scutaria*. Bilateral homologs of these genes are associated with endomesoderm formation or mesoderm differentiation. In *Fungia*, they are expressed around the blastopore and, all but *brachyury*, in the developing gastrodermis, a pattern similar to what has been observed in *Nematostella*. This supports the idea that these genes had ancient functions in tissue specification before the origin of mesoderm. We are investigating spatial and temporal expression patterns of additional endomesodermal genes in *Fungia* to gain deeper insight into the ancestral endomesodermal network.

P3.106 LOPES, P.C.*; BENTLEY, G.E.; University of California, Berkeley and GABBA, University of Porto, Helen Wills Neuroscience Institute and University of California, Berkeley; pclopes@berkeley.edu

Neural Pathways of Sickness Behavior in Songbirds

Sickness behavior refers to a suite of behavioral symptoms exhibited as a result of infection. Endotoxin-induced sickness behavior can be induced in experimental animals by exposure to the non-pathogenic cell wall product of gram-negative bacteria, lipopolysaccharide (LPS). The behavioral responses to this kind of immune challenge include decreased appetite, adipisia, lethargy and somnolence. The neural pathways involved in the expression of sickness behavior in songbirds are not known. With the purpose of identifying these pathways in male zebra finches (*Taeniopygia guttata*), we administered either LPS to mimic infection, or saline as a control. Behavioral observations were performed before and after injection, and the brains were collected at approximately 2h after injection. The brains were processed immunohistochemically for the protein products of Immediate Early Genes (IEGs). Our results indicate that LPS-injected birds exhibited sickness behavior, and that specific brain areas showed increased IEG expression in response to LPS treatment versus controls. These data are the first in songbirds to describe the brain areas activated by peripheral immune stimuli. The findings provide us with a basis for further investigation into neural and endocrine mechanisms regulating behavioral and physiological responses associated with immune challenges.

P2.102 LOH, T.-L.*; LOPEZ-LEGENTIL, S.; SONG, B.K.; PAWLIK, J.R.; Univ. of North Carolina Wilmington; tl7275@uncw.edu

Molecular phylogenetic analysis of the sponge genus Mycale (Demospongiae; Poecilosclerida)

Sponge systematics is largely based on morphological characteristics, specifically the skeletal elements such as spicule and spongin architecture. This presents a challenge as sponges are very plastic morphologically, and change in response to environmental or biotic influences. Molecular studies of sponge taxa have revealed that certain groups were not properly classified and needed to be revised. This study is the first phylogenetic analysis of the genus *Mycale* using genetic data. *Mycale* is defined by the presence of these spicules- the palmate anisochela microsclere, which occurs together with a single type of megasclere, usually subtylostyles. As the genus contains approximately 200 species, it is further divided into 11 sub-genera. Fragments of the 18S and 28S rRNA genes were amplified for 12 *Mycale* species from various sub-genera, with a specific primer designed for the 18S fragment. The 18S and 28S fragments followed the same evolutionary model and were combined to increase the total number of variable sites. Phylogenetic analyses were carried out using neighbor-joining, maximum parsimony, maximum likelihood and Bayesian methods with 4 other poecilosclerid sequences and one haplosclerid sequence as the outgroup. Results showed that *Mycale* is a monophyletic group within Poecilosclerida, but the existence of some sub-genera was not supported. Additionally, the white morph of *M. laevis* did not group with the other morphotypes of this species and could correspond to a cryptic species. The presence of palmate anisochelae in the *Mycale* genus is a valid taxonomic character to identify this taxon, but the skeletal architectural characters show homoplasy across different clades within the genus, and should not be used to determine *Mycale* sub-genera.

P2.103 LOPEZ, Alessandra I*; GOSLINER, Terrence M; JOHNSON, Rebecca F; California State Polytechnic University, Pomona, California Academy of Sciences; ailopez@csupomona.edu

Slugs with an Identity Crisis: phylogenetic analysis of the Hypselodoris bullocki complex

Nudibranch mollusks are shell-less snails that utilize warning coloration for defense. Their color patterns are often species-specific and can be used to distinguish closely related species. There are several competing hypotheses concerning the *Hypselodoris bullocki* complex. Some taxonomists have suggested that the complex is a single species that exhibits a great deal of variation, while others consider the complex to be made up of several distinct species. We investigated the *Hypselodoris bullocki* complex with two main questions in mind; how many distinct species are in the complex and how important is color variation in species delineation? We examined specimens representing seven color morphologies that have been considered members of the *Hypselodoris bullocki* complex. The molecular data consisted of three different genes, H3, 16S and CO1. While the morphological data included the comparison of radulae, jaws, rhinophoral lamellae, gills, mantle glands, and the reproductive system. It is clear the complex is made up of more than one species. Color pattern is a strong indicator for species identification. Trees were constructed using molecular data and morphological features were mapped onto the resulting molecular tree. Further research is still needed to investigate some color forms of the *Hypselodoris bullocki* complex, as alcohol preserved material accompanied by photos is not yet available for every observed color pattern.

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BMP and Delta/Notch signaling control the development of amphioxus epidermal sensory neurons

Cephalochordates (lancelets, or amphioxus) are marine invertebrates that are grouped with vertebrate animals in the Chordate phylum because of shared features including the dorsal nerve chord, notochord, segmented somites, and pharyngeal gill slits. In addition to the central nervous system, amphioxus has a peripheral nervous system comprising several types of sensory neurons. One population of these sensory neurons, the type I receptors, originate near the ventral side of the embryo and then migrate dorsally in the neurula. These cells can be recognized by expression of some neuronal differentiation genes, including *Hu/elav*, and their morphology has been described by EM and dye labeling studies. However, the developmental mechanisms underlying the formation of these amphioxus sensory neurons are largely unknown, and their possible homology with the peripheral sensory neurons of other chordates remains elusive. We find that in amphioxus embryo, Delta/Notch signaling is involved in the specification of these sensory neurons from neighboring epidermal cells. Blocking Delta/Notch signaling pathway during late gastrula/early neurula stage results in a dramatic increase of sensory neurons along the flanks of the embryos. We further show that BMP signaling works upstream of Delta/Notch signaling to induce a ventral epidermal domain for generating these sensory neurons. Elevating BMP signaling level during blastula stage expands this domain dorsally. This intriguing similarity in patterning mechanism of these amphioxus epidermal sensory neurons with that of vertebrate neurogenic placodes, as well as ascidian ventral epidermal sensory neurons, supports their possible homology.

P2.111 LUQUE, J*; DOUGLASS, J.K.; JARAMILLO, C.A.; Université de Montréal, Département de sciences biologiques, Québec, Canada; Smithsonian Tropical Research Institute, Panamá, Smithsonian Tropical Research Institute, Panamá ; javierluque@gmail.com

How much have raninid crab eyes changed after 94 m.y. of evolution?

Raninid crabs, commonly known as "frog crabs" are an ancient group of marine crabs with the oldest fossil records extending back to the Cretaceous Period (100 mya). The combination of ancestral and advanced features of raninid crabs and the incomplete preservation of most fossil raninids makes them a phylogenetically controversial group, thus knowledge of primitive raninids is important for understanding taxonomic relationships among the principal crab groups. The functional morphology of fossil and extant raninids indicates they have been well suited to a soft sediment burying lifestyle since their appearance, therefore optical adaptations are expected to be conservative throughout time. Until now, fossil raninid compound eyes possessing preserved facets have not been reported. We describe the compound eyes of fossil specimens which are close to the oldest records of raninids and compare them to optically relevant characteristics of extant genera *Raninoides*, *Notosceles*, and *Symethis* to examine whether such optical features have changed over 94 m.y. The highly preserved fossil raninids used in this study possess unique and primitive features including extremely large eyes relative to extant raninids and at least one fossil possesses a facet type not observed in extant specimens. This comparison could provide insights into the relationships among some primitive lineages of Podotremata Raninoids, providing valuable taxonomic, taphonomic, and paleoecological information, which enhances the understanding of tropical ocean communities during Cenomanian-Turonian times.

P1.130 LUCKENBACH, J.A.*; METZGER, D.C.; DICKEY, J.T.; SWANSON, P.; BECKMAN, B.R.; Northwest Fisheries Science Center, Seattle, University of Washington, Seattle; Adam.Luckenbach@noaa.gov

Development and Validation of a Quantitative, Multiplex Gene Expression Assay for Components of the Endocrine Growth Axis in Salmon

Previous studies have shown that liver mRNA and/or circulating levels of the hormone, insulin-like growth factor 1 (IGF1), may reflect the specific growth rate of salmon. It is possible, however, that a broader and more complete indication of growth status might be achieved by assessing multiple components of the endocrine growth axis. This study compared two methods for quantification of salmon growth-related mRNAs: quantitative PCR versus a custom QuantiGene® Plex (QGP) assay. The QGP technology by Panomics Inc. permits the simultaneous quantification of multiple mRNA targets within a single tissue homogenate using sequence-specific probes and requires no RNA isolation, reverse transcription, or amplification. Using liver homogenates from coho salmon (*Oncorhynchus kisutch*) under fed and fasted conditions, we compared detectable changes in mRNA levels between the QGP and quantitative PCR assays for insulin-like growth factors (*igf1* and *igf2*), IGF binding proteins (*igfbp1*, *igfbp2a*, and *igfbp2b*), somatotactin receptor (*slr*) and growth hormone receptors (*ghr1* and *ghr2*). A significant, positive correlation was found between results from the QGP and quantitative PCR assays for all mRNA targets. Coefficients of variation for technical replicate samples measured with the QGP assay were low, ranging from 0.7-2.6%, suggesting this is a suitable method for quantification of endocrine growth-related transcripts in salmon tissues.

P3.122 LUTTERSCHMIDT, D.I.*; MASON, R.T.; Georgia State University, Atlanta, Oregon State University, Corvallis; lutterschmidt@gsu.edu

Temporally distinct effects of stress and corticosterone on diel melatonin rhythms of red-sided garter snakes (*Thamnophis sirtalis*)

Circadian and circannual rhythms in physiology and behavior are temporally organized via hormonal signals that reflect changing environmental cues. Interactions between endocrine signals are in turn important in integrating multiple physiological and behavioral rhythms. In the present study, we examined interactions between melatonin, the hypothalamus-pituitary-adrenal (HPA) axis, and corticosterone in a well-studied population of red-sided garter snakes (*Thamnophis sirtalis parietalis*). We demonstrate that 4 h of capture stress, but not exogenous corticosterone (15 and 60 µg), significantly increases photophasic melatonin and decreases scotophasic melatonin concentrations of male snakes. To determine if the effect of stress on scotophasic melatonin is due to a depletion of the precursors necessary for melatonin synthesis, we used a paradigm in which snakes were treated with the melatonin precursor 5-hydroxytryptophan (0.6 and 1.2 mg) to elevate melatonin concentrations. Pretreatment of snakes with both capture stress and exogenous corticosterone abolishes the 5-hydroxytryptophan-induced increase in scotophasic melatonin. These experiments indicate that the different phases of an acute physiological stress response have temporally distinct effects on pineal melatonin synthesis: activation of the HPA axis increases melatonin, while increased glucocorticoid concentrations inhibit melatonin synthesis. Collectively, we demonstrate that a physiological coupling between melatonin, glucocorticoids, and the HPA axis is conserved in this ectothermic model and propose that such a coupling plays a functional role in integrating seasonal rhythms.

P1.24 LYONS, Deirdre C*; WEISBLAT, David A; University of California, Berkeley; delyons1@gmail.com

Coordinating cell cleavage pattern and fate determination in the leech *Helobdella*

Spiral cleavage is a unique cell division program seen in the embryos of animals as diverse as annelids, molluscs and polyclad flatworms. Comparing spiral cleavage in extant species provides insight into how changes in the program have influenced body plan evolution. An experimentally accessible example of evolutionary flexibility within the spiral cleavage program is D quadrant specification. In spiral cleavage, the first two cell divisions are roughly meridional with respect to the animal-vegetal axis, establishing four embryonic quadrants (A-D). The D quadrant is of particular interest because, by convention, D is defined as the dorsal quadrant, which produces bilaterally symmetric trunk mesoderm and ectoderm. *Helobdella* embryos undergo a modified version of spiral cleavage in which unequal first and second cleavages are critical for setting up the axes of the adult. Prior to first cleavage, cytoplasmic rearrangements form domains of yolk-free cytoplasm (teloplasm) which is segregated to the D macromere at the 4-cell stage. Teloplasm has been shown to contain the determinants that render the D macromere capable of generating the precursors of segmental mesoderm (DM) and ectoderm (DNOPO). The extent to which teloplasm plays a passive role in development (merely being sequestered into the largest cell) versus an instructive role (e.g. influencing the cleavage pattern itself) is an outstanding question. Here we report a systematic analysis of teloplasm movements and interaction with the mitotic apparatus up to the 7-cell stage, when DM and DNOPO are born. These data reveal that teloplasm movements during the early cell cycles are highly dynamic and very stereotyped and support the hypothesis that teloplasm is indeed influencing the spiral cleavage program in this species.

P1.79 MACHADO, Heather*; JOYCE, Domino; LUNT, David; RENN, Suzy; Reed College, Portland OR, University of Hull, UK; renns@reed.edu

Genomic Architecture of Adaptive Radiation: the Role for Gene Duplication in African Cichlid Fishes

The adaptive radiations of African cichlid fishes offer an elegant system with which to study the processes that influence the ever-changing diversity of life. Specifically, these fish provide several independent, recent and rapid diversifications accompanied by some lineages that have existed in relative stasis. Through comparison of radiated and non-radiated lineages we look at how one specific process, gene duplication, may contribute to these phenomenal radiations and to the evolution of adaptive phenotypes in general. Using array based comparative genomic hybridizations (CGH) we compare the prevalence of gene duplication in three Lake Malawi species (*Metriaclichthys estherae*, *Protomelas similis*, *Rhamphochromis chilingali*) resulting from three different recent cichlid radiations and one species from a lineage that has not undergone recent radiation (*Astatotilapia tweddlei*). We found an increased number of duplicated genes in the radiated lineages compared to the non-radiated lineage. Genes found duplicated include major histocompatibility (MHC) genes and pituitary adenylate cyclase activating polypeptide receptor (PAC1), which have previously undergone duplication and may be more prone to duplication, and several others of various function, including cytochrome P450 aromatase (*cyp19*), nuclear receptor DAX1, and fish virus induced tripartite motif gene (*finTRIM* gene). The preponderance of gene duplications in the radiated lineages supports the hypothesized role for gene duplication in the adaptive radiation of African cichlids and suggests that gene duplication may be an important process in diversification and speciation in general.

P2.169 MACESIC, L.J.*; BLEVINS, E.; Florida Atlantic University, Harvard University; lmacesic@fau.edu

Pectoral and pelvic fin coupling during augmented punting in the freshwater stingray, *Potamotrygon laticeps*

Punting, a form of aquatic locomotion performed by stingrays and hippos alike, involves depressing paired limbs into the substrate, then pushing off and gliding until the next limb depression cycle. In batoids (skates and rays), punting is performed either entirely with the pelvic fins, termed true punting, or in concert with the pectoral fins, termed augmented punting. The freshwater stingray, *Potamotrygon laticeps*, performs the latter, pairing pectoral fin undulation, a common swimming locomotion, with pelvic punts. We used high-speed video to quantify the motor patterns of the pectoral and pelvic fins during this locomotion to test whether the fins acted synchronously to generate a uniform thrust vector. We filmed ventrally to quantify pelvic fin punting cycles and laterally to quantify the maximum and minimum amplitude of each pectoral undulation (i.e. crest and trough of each wave). We found that the start and end of each pelvic cycle coupled with both the maximum and minimum amplitude of a single pectoral undulation within individuals ($n=4$; $p<0.05$, $p<0.01$, respectively). Moreover, the minimum amplitude, likely the thrust generating portion of the wave, coincided with the end of the pelvic fin thrust for all rays ($p<0.01$). This may be an efficient thrust generator, as pectoral undulation could add to the thrust generated by the pelvic fins. There was no consistency of timing in maximum pectoral fin amplitude among the rays ($p=0.64$). Pectoral fin undulation frequency during punting ($\text{mean}=2.25\text{Hz}\pm 0.56\text{SD}$) was similar to previously published values during swimming for the blue-spot stingray ($\text{mean}=2.32\text{Hz}\pm 0.42\text{SD}$), which suggests that the pectoral fin motor pattern may be fixed regardless of the type of locomotion being performed.

P2.70 MAJEWSKA, Ania*; MARTIN, Thomas/E; University of Montana; ania1.majewska@umontana.edu

The importance of embryonic development for offspring and adult immune function

Why species differ in rate of development and quality of offspring is a central question in life history theory. Longer developmental period is widely believed to enhance offspring quality and adult longevity by allowing greater development of intrinsic features (locomotor performance, immune function, neural networks). For example, long development may be critical in ontogeny of immune function by yielding greater cell differentiation and proliferation of immune tissues during the embryonic stage. This hypothesis was recently supported by a finding of a correlation between embryonic period length and a measure of adult immune function. Although accepted as a standard measure of development, the length of the embryonic development is not necessarily representative of embryonic development rate. In birds, development rate is a function of temperature, thus incubating parents may influence developmental period and offspring immune function by inducing fluctuation in egg temperatures. Indeed, studies of passerine birds show that decreased average egg temperatures result in extended embryonic periods and decreased offspring quality. Here we report the results of a comparative study using 12 co-occurring passerine species of Coconino National Forest, Arizona. We examined whether longer incubation period, corrected for incubation temperatures, has an effect on immune function and parasite prevalence of nestling and adult birds.

P2.170 MANDECKI, Joanna L.*; REID, Duncan; DOMENICI, Paolo; University of Chicago, University of Washington, CNR-IAMC; jmandeck@uchicago.edu
Synchrony of pectoral fin locomotion and eye movement in shiner perch (*Cymatogaster aggregata*)

Fishes must simultaneously employ multiple functional systems in order to navigate, locomote, and feed in an aquatic environment. We examined the integration of locomotor and sensory systems in shiner perch (*Cymatogaster aggregata*). The shiner perch is a labriform swimmer that generates sporadic eye movements (around 250-550 deg/s) while scanning the water for passing plankton. We investigated the synchrony of these saccades with the cycling of the pectoral fins, hypothesizing that eye movements tend to occur during relatively "undisturbed" moments of the fin cycle, i.e. the refractory period and the transition between abduction and adduction. Data were collected using high-speed video of fish swimming in a flume at a flow speed of 10 cm/s, and analysis was performed with circular statistics. The results indicate that eye movements show a non-uniform distribution throughout the swimming cycle, with most events occurring during the abduction phase. Nevertheless, the relatively high angular deviation suggests a loose synchronization, most likely due to a behavioral mechanism rather than a physiological one (i.e. with strict phase locking). One potential advantage of this synchronization is that it would allow the fish to perform a saccade, process the visual input in relation to the presence of prey, and make a decision about whether to initiate a motor response prior to adduction, the phase during which maneuvering is commonly initiated. We also found that the oscillatory rhythm of the pectoral fins remains relatively constant, independent of the eye movement event. If the fish's swimming motion was adjusting in order to be in synch with the saccade, amplitude or frequency of the fin cycle would be expected to vary. Our results therefore suggest that the fish synchronize saccades to the fin beat rather than the reverse.

P2.76 MARCHETTO, N.M.*; CARLTON, E.D.; MAUCK, R.A.; HAUSSMANN, M.F.; Bucknell Univ., Lewisburg, Kenyon College, Gambier; mfh008@bucknell.edu

Red Hot: Lipid peroxidation and color based assortative mating in black guillemots (*Cepphus grylle*)

Exaggerated traits can be costly to produce, but benefit the carrier by signaling its individual quality. The bright red feet of the monomorphic Black guillemot (*Cepphus grylle*) may act as such a signal. Our lab has previously shown that *C. grylle* mates assortatively based on the red intensity of foot color. However, the physiological and genetic significance underlying this signal remains unknown. Recognizing the association between bright red color and certain dietary antioxidants, *C. grylle* may be signaling information about oxidative stress levels. Peroxides and free radicals are a consequence of aerobic metabolism and cause oxidative damage in DNA, proteins and lipids. Oxidative damage, such as lipid peroxidation, is responsible for many diseases and is widely considered to be a main contributor to the aging process. We propose that increased intensity of red foot color is an honest signal of health with regard to oxidative stress. The increased red intensity may be related to lower levels of oxidative damage. To assess intensity of red foot color, we digitally photographed the right foot of 21 *C. grylle* during the breeding season of 2007 on Kent Island, New Brunswick, Canada and analyzed RGB values using Adobe Photoshop. The plasma isolated from blood samples was used to run a TBARS Assay for lipid peroxidation. We found that red intensity of guillemot feet was negatively correlated with lipid peroxidation levels ($P=0.0138$). Although the specific mechanism is unclear, lower lipid peroxidation levels suggest increased resistance to oxidative damage. The value of foot color as a signal of oxidative stress may help explain the previously demonstrated assortative mating by foot color in *C. grylle*.

P1.12 MANOUSAKI, TEREZA*; FEINER, NATHALIE; BEGEMANN, GERRIT; MEYER, AXEL; KURAKU, SHIGEHIRO; Univ. of Konstanz; tereza.manousaki@uni-konstanz.de
Relation of Pax4 gene to the legendary Pax6/eyeless orthology

In many scenes in Evo-Devo studies at the molecular level, validation of orthology/paralogy should precede comparison of functional aspects. However, it was not until genomes of diverse organisms are sequenced that we are given opportunities to demonstrate fine-scale orthology/paralogy annotation for many of already well-characterized regulatory genes. Our analysis on *Pax4* and *Pax6* genes also provide one of these examples. These genes both encode transcription factors containing a homeobox and a paired box and are categorized in the *Pax* gene family whose members usually function as 'toolkit' genes. Their structural similarity has traditionally made researchers group these two genes together, but their phylogenetic relationship, especially the timing of the gene duplication, has never been explored in the modern methodological framework. Interestingly, since mid-90s, when mammalian *Pax4* genes were first identified, their orthologs have not been reported for any non-mammalian vertebrate. Recently, we have identified putative *Pax4* orthologs in teleost fish genome sequences, and analyzed their positions in molecular phylogenetic trees and embryonic expression patterns. In this presentation, we report results of our analysis and insights into further related topics on secondary gene losses, evolutionary modification of embryonic expression patterns and comparative genomic strategy to date gene duplications.

P1.82 MARGOTTA, J.W.*; HRANITZ, J.M.; BARTHELL, J.F.; BRUBAKER, K.D.; Bloomsburg Univ., PA, Univ. Central Oklahoma, Edmond; jwm10722@huskies.bloomu.edu
Evolutionary Genetics of Heat Shock Cognate 70 in the Leafcutting Bee, *Megachile apicalis* (Hymenoptera: Megachilidae)

Among members of a solitary bee community in the Central Valley of California, differences in nesting niche, HSP70 expression, offspring survival of abiotic stress, and geographic distribution suggest interspecific variation in thermotolerance. Two leafcutting bees, *Megachile apicalis* and *M. rotundata*, in this community display eurythermal nesting niches and differences in offspring HSP70 expression as well as survival to heat stress. Because HSP70 plays a pivotal role stress protein pathways, interspecific differences in temperature at the onset of expression and offspring survival suggest that HSP70 may function at different temperatures in each species. The goal of this project was to evaluate how interspecific variation in thermotolerance may be related to *Hsc70* gene structure. We cloned and sequenced 1418 bp of the *Hsc70* gene of four *M. apicalis* larvae and compared sequences to three other hymenopteran *Hsc70* sequences (*M. rotundata*, *Apis mellifera*, and *Pteromalus puparum*) in a bioinformatic analysis. This analysis showed relatively small nucleotide variation between the two leafcutting bees. Interestingly, the honey bee differed substantially (139 aa substitutions, 3 deletions and 1 insertion) from the leafcutting bees and wasp at the *Hsc70* gene. In *M. apicalis*, conserved *Hsc70* gene regions contained seven protein motifs. Tajima's D revealed stabilizing selection at 10 regions within the *Hsc70* gene for *M. apicalis*. In contrast to honey bees, leafcutting bees may possess highly conserved (pleisomorphy) *Hsc70* gene structure and function. Alternatively, comparisons with solitary bees adapted to cooler habitats may reveal the similarities between leafcutting bees and the wasp outgroup to be caused by convergent evolution in similar habitats.

P3.11 MARLON, A.J.*; GEFEN, E.; RAJPUROHIT, S.; GIBBS, A.G.; Univ. of Nevada, Las Vegas, Haifa University - Oranim; anthonyj.marlon@gmail.com

Microarray analyses of larval fat body in desiccation-selected *Drosophila melanogaster*

Drosophila populations that have been selected for adult desiccation resistance exhibit a longer third-instar feeding period than non-selected controls. Selected flies pupariate 8 hours later than controls and eclose with greater energy stores, water content and desiccation resistance. To investigate transcriptome differences associated with delayed development, we performed microarray gene expression profiling of larval fat body collected at 88, 96, 112 and 120 hr stages in selected and control populations. We identified gene sets that were differentially expressed at each time point, as these are prime candidates for genes responding to stress selection. Genes involved in amino acid and carbon metabolism were significantly overrepresented, as were protein synthetic genes. An analysis using DAVID (Database for Annotation, Visualization and Integrated Discovery) indicated greater differences at 120 hr, when selected lines were still feeding, but controls had begun the wandering phase. We are now performing metabolite assays to test hypotheses generated from our microarray results. Our main focus will be to find associations between genes expressed under physiologically stressful conditions and basic metabolic processes involved therein. Supported by NSF award 0719591 to D. K. Hoshizaki and A. G. Gibbs.

P3.138 MARTIN, Gary G.*; MARTIN, Alanna M.; TSAI, Whitney; Occidental College, Los Angeles; gmartin@oxy.edu
Journey through the digestive system of *Megathura crenulata*, the giant keyhole limpet: morphology and enzyme activity.

The morphology of the prosobranch gut has been examined at the anatomical and light microscope levels by early researchers and reviewed by Voltzow (1994). The role of each region of the gut is poorly understood. The first goal of this study was to provide a complete view of the ultrastructure of the digestive tract, identifying regions secreting materials into the gut lumen. We found that in addition to the salivary glands, a common cell type makes up the epithelium of the esophagus, style sac, and intestine, and shows apocrine secretion. The digestive gland is composed of two cell types described in other mollusks that are involved with the digestive process. Our second goal was to test each region for the presence of digestive enzymes. API ZYM results for 17 hydrolases are presented and compared with results from the abalone. Kits from Molecular Probes were used to test for protease, α -amylase, lipase, lysozyme and cellulase. Our results show the morphology of the gut as food passes along its entire length and the levels of digestive enzymes released from the secretory epithelium at each region. Unlike some reports, the esophagus and intestine seem capable of secreting enzymes that may work on food trapped within the mucus strands carried through the gut. The style sac and crystalline style show high levels of cellulase and lysozyme and the interplay of these enzymes require further investigation. *M. crenulata* is commercially important as the source of KLH, its respiratory pigment, which shows promise in the treatment of cancer and allergy. Information on its digestive physiology should help with the health of this animal in aquaculture settings.

P1.146 MARSHALL, CD*; HIGGINS, BM; FLANAGAN, JP; KANE, EA; NEUENHOFF, RD; Texas A and M University, NOAA Galveston, The Houston Zoo, Clemson University, Pacific States Marine Fisheries Commission; marshalc@tamug.edu

Bite Force and In Vivo Stimulation of the Loggerhead Sea Turtle (*Caretta caretta*) Adductor Mandibulae Complex

Voluntary bite force measurements can vary according to the motivation state of subjects. To test whether voluntary bite force data collected for loggerheads were within the physiological range of maximum performance, and to characterize tetanic muscle fusion of the adductor mandibulae complex, we conducted an *in vivo* muscle stimulation study in 3 loggerhead turtles. All subjects were deeply anesthetized and bipolar stimulation electrodes were inserted percutaneously into the body of the adductor mandibulae muscle complex bilaterally. Bite force plates of a "bite meter" incorporating a Kistler force transducer (type 9312A) were placed between the jaws of the subjects. A hand-held charge amplifier with output to a channel on Biopac MP150 system recorded the stimulus response of the force transducer. Stimulator output was recorded onto a second channel. Force output curves were visualized using Acknowledge software. Stimulations included single twitch (500 ms), square-wave stimulus trains of 10-70 Hz, and ramping voltages from 5 to 30V. Stimulus train frequency and voltage was varied until tetanic fusion was attained, as represented by bite force output curves. Maximum train rate, voltage, and bite force at tetanus for each of the 3 subjects were: Cc2005-82 (SCL=43.1cm; 11kg): 20Hz, 20V, 81.8N; Cc2003-45 (SCL=49.3 cm; 18.6kg): 17Hz, 20V, 114N; Cc2004-28 (SCL=57.1; 23.7kg): 17Hz, 30V, 194N. Maximum bite forces measured during stimulation trials were in accordance with voluntary bite force measurements collected previously.

P3.139 MARTIN, G.G.; MARTIN, A.M.*; WATANABE, K.; Occidental College, Los Angeles; gmartin@oxy.edu
Morphology of the heart-kidney complex in *Megathura crenulata*, the giant keyhole limpet: the hunt for hematopoietic tissue and HCN storage sites

The intricate anatomy of the heart and kidney complex in prosobranch gastropods has been investigated in several species. In vetigastropods, the left kidney is highly reduced and its function is unclear although it may be involved with ion, pH, and water balance. The right kidney is enlarged and wraps around most organs in the body creating the largest cavity in the body. This space is continuous with the pericardium which receives an ultrafiltrate that passes through the auricles via pericardial glands. The heart and kidney are therefore involved with filtration and excretion and both organs release fluid into the mantle cavity. We describe the morphology of these tissues in the giant keyhole limpet, *Megathura crenulata*. Our interest is in specialized regions within this complex which are possibly involved with hematopoiesis and the storage of the respiratory pigment KLH (keyhole limpet hemocyanin). Hemocytes are important for immune defense reactions and KLH is the protein of commercial value extracted from limpets in culture. KLH shows promise in the treatment of cancer and allergy. Non-lethal bleedings of cultured limpets remove up to 20% of the body weight. The body weight returns to original levels within 12 hours and by 24 hours KLH levels in the blood are back to normal. The goal of this poster is to describe the anatomy, histology and ultrastructure of regions of this complex highlighting areas where it has been proposed and where we have found sites of hematopoiesis and KLH storage.

P1.41 MARTIN, K.L.M.*; MORAVEK, C.L.; Pepperdine Univ., Malibu, CA; kmartin@pepperdine.edu

Heterochrony in Development During Extended Incubation in California Grunion

Embryos of California Grunion *Leuresthes tenuis*, a beach-spawning marine fish, are hatching competent within two weeks post fertilization, but do not hatch until triggered by environmental cues. Oviposition occurs out of water at the highest semilunar tides, and embryos develop terrestrially, buried under damp sand. When waves of the subsequent semilunar tide wash the embryos out, they hatch immediately and begin larval development. Embryonic development to hatching competence occurs in a sequence similar to other Atheriniform fishes, and hatchlings are at an advanced stage prepared for free swimming and feeding. Subsequent larval development resembles that of other Atheriniformes. If the waves fail to reach the shore height of the buried embryos, they do not hatch but continue to incubate for up to 35 days post fertilization. During this time the embryos are metabolically active and behaviorally alert. They may be triggered to hatch by agitation in seawater at any time, and they hatch within seconds. Whenever hatching occurs, larval life begins. However, when hatching is delayed for *L. tenuis* beyond the time of hatching competence, development dramatically slows. The embryo does not develop in the same way as a hatchling of the same chronological age. The delayed embryo appears to arrest most aspects of development at the stage of hatching competence, including organogenesis and fin development. Careful examination reveals continued development and growth only in the melanophores, the saggital otoliths, and the teeth when embryonic incubation is extended. Thus it is possible to obtain *L. tenuis* siblings of the same chronological age but very different stages of development, depending on hatching date. Funding provided by NOAA, National Marine Fisheries Service, California Coastal Commission, and National Geographic Society.

P3.93 MATSON, K.D.; BLOM, M.P.K.*; LOZNIK, B.; TIELEMAN, B.I.; MAUCK, R.A.; University of Groningen, Kenyon College; k.d.matson@rug.nl

Rearing environment, nest sanitation and chick growth and development

Rearing environment can influence young birds in many ways. We investigated how experimental manipulations of rearing environment, with a focus on nest sanitation, shape growth and immunological development in altricial chicks. Over the last half century, research on the precocial chicks of domestic poultry has revealed a positive relationship between improved animal housing sanitation and increased chick growth. The growth advantage is thought to result from a decreased need to divert energy towards background inflammation caused by the antigenic milieu. In wild birds, nestling growth is important for survival, so a cleaner rearing environment may impact offspring fitness. In this experiment we compared Eastern bluebird (*Sialia sialis*) chicks that were raised in natural nests in re-used nest boxes with chicks that were raised in artificial nests in sterilized nest boxes. Additionally, one chick in each nest was challenged with sheep red blood cell injections; injected chicks were compared to size-matched control chicks. We evaluated our nest box cleaning technique by enumerating microbial colonies on agar contact-slides. We measured chick growth in terms of mass, tarsus length and wing length as measured on days 2, 4, 8 and 15 post-hatch. We assayed several immunological parameters using small blood samples collected on days 8 and 15. Initial results clearly demonstrate our ability to sanitize nest box environments but simultaneously highlight the challenges associated with immunological studies in young chicks and with confounding factors associated with our sanitation treatment. In the future we will employ molecular techniques to analyze samples of chick-associated bacterial communities in an effort to elucidate any differences in microbiological status between the treatment and control groups.

P2.26 MASHANOV, V.S.; ZUEVA, O.R.*; ROJAS-CARTAGENA, C.; GARCIA-ARRARAS, J.E.; University of Puerto Rico; zuevaolga@yahoo.com

Expression pattern of anti-apoptotic genes survivin and mortalin in the regenerating digestive tube of a sea cucumber

Apoptosis has been known to play an important role in a variety of developmental processes and to prevent various pathological abnormalities, including cancer. It has also been shown to be involved in post-traumatic regeneration in a variety of organisms. Regeneration is a highly complex process of secondary development, where cell proliferation and cell death must be precisely orchestrated. An essential part of this regulatory machinery are genes, whose expression prevents cells from entering the programmed cell death pathway. These genes are vital for embryogenesis to occur properly, but their over-expression in adult organisms is usually associated with cancerogenesis. Using quantitative real-time PCR and in situ hybridization techniques we show the expression of two anti-apoptotic genes, *survivin* and *mortalin*, in the regenerating digestive tube of the sea cucumber *Holothuria glaberrima* (Echinodermata: Holothuroidea). The most significant over-expression of both genes, when compared to intact animals, is observed in the gut mesothelium (outer layer of the gut wall) during the second week after visceral autotomy, i.e. during the stage of the extensive growth of the regenerate. The gut mesothelium is a complex tissue composed of specialized cell types, including peritoneocytes, myoepithelial cells, and also contains the basiepithelial nerve plexus. During the first two weeks following injury, this tissue is known to undergo a sequence of drastic changes in organization, such as de-differentiation, a morphogenic phase (including cell division, death, and migration), and re-differentiation. Activation of *survivin* and *mortalin* coincides with those processes and, therefore, seems to be important for tissue remodeling during regeneration.

P1.53 MATSON, P.G.*; HOFMANN, G.E.; Univ. of California, Santa Barbara; matson@lifesci.ucsb.edu

Ecological genomics of ocean acidification: habitat-related differences in response to elevated CO₂ in larval sea urchins.

Little is currently known about how anthropogenic induced climate change will impact marine organisms. Ocean acidification (OA) may have a strong effect on the physiology of many species, particularly at high-latitudes. Genomic applications such as DNA microarrays offer an excellent tool to explore these potentially sub-lethal effects of OA on physiological processes in marine larvae. Using an oligonucleotide microarray containing 1,057 genes from the *Strongylocentrotus purpuratus* genome, recent work in our lab has found genes from several physiological pathways that are responsive to elevated CO₂. However, little is known about how this response varies between populations in different habitats. The goal of this study is to use this genomic approach to explore gene expression responses to elevated CO₂ in larvae of the green sea urchin, *Strongylocentrotus droebachiensis*, from adults at different depths. Adult urchins were collected from shallow (5-7 m depth) and deep (120 m depth) habitats in the San Juan Channel, WA, USA, and larvae developed under three levels of elevated CO₂ to the 4-arm echinopluteus stage. In addition to providing new information on physiological effects of elevated CO₂ on an ecologically important high-latitude species, we hope that this work will shed light on habitat-related differences in susceptibility to OA. This work is supported by a University of Washington Alan J. Kohn Endowed Fellowship to PGM and NSF grant OCE-0425107 to GEH.

P3.59 MCCLARY, M.*; SANTIAGO, O.; ARGUEDAS, S.; SALEM, H.; Fairleigh Dickinson Univ., North Bergen High School, North Bergen High School; mcclary@fdu.edu

Effects of dissolved oxygen concentration on the respiration rates of larval and adult *Daphnia pulex*

The effect of temperature on the respiration of adult *Daphnia* has been studied. However the effect of dissolved oxygen concentration on larvae and adults has not. In general it is known that when dissolved oxygen concentrations are high, respiration rates are independent of the dissolved oxygen concentration and proceed at a constant rate until reaching very low dissolved oxygen concentrations. When dissolved oxygen concentrations are low, respiration rates are dependent on the dissolved oxygen concentration and decrease as the dissolved oxygen concentration decreases. It is also known that respiration rates of small organisms are faster than the respiration rates of large organisms and have rates that are dependent on the dissolved oxygen concentration and decline as the dissolved oxygen concentration declines. Respiration rates of large organisms are slower than the respiration rates of small organisms and have rates that are independent of the dissolved oxygen concentration and proceed at a constant rate until reaching very low dissolved oxygen concentrations. The purpose of this study was to determine the effect of dissolved oxygen concentration on the respiration rate of larval and adult *Daphnia*. Larval and adult *Daphnia pulex* were placed in 2 ml of spring water that was saturated with oxygen prior to measurements of dissolved oxygen concentration over time in a closed system to determine their respiration rates. Both larval and adult respiration rates were always dependent on the dissolved oxygen concentration and declined as the dissolved oxygen concentration declined. Future studies will measure respiration rates of larval and adult *D. pulex* at higher dissolved oxygen concentrations to determine if respiration rates can be independent of dissolved oxygen concentration.

P1.169 MCELROY, Eric J*; BAUR, Anna; MCBRAYER, Lance D; College of Charleston, Georgia Southern University; mcelroye@cofc.edu

Functional morphology of acceleration in the phrynosomatine lizard, *Sceloporus woodi*

Studies of locomotor performance have historically focused on maximum sprinting speed and its morphological and functional correlates. However, there has been far less focus on how animals reach their maximum speed (i.e. acceleration capacity). Likewise, it remains unclear how acceleration and speed are inter-related and which functional and anatomical traits underpin these aspects of burst locomotion. To address these issues, we quantified maximum sprint speed and acceleration in twenty individuals of the ground-dwelling phrynosomatine, *Sceloporus woodi*, as they accelerated from a standstill to maximum speed. To elucidate the possible functional correlates that may mediate the relationship between speed and acceleration, we measured 3D ground reaction forces and limb and axial kinematics for each trial. Additionally, we sacrificed a subset of individuals to measure aspects of musculoskeletal anatomy (muscle mass, fiber length, PCSA, in and out lever lengths, and bone lengths) relevant to these performance traits. Results show a positive correlation between maximum speed and acceleration in agreement with previous studies of small lizards. However, considerable variation also exists in these data, suggesting that some individuals may achieve similar maximal speeds via different functional mechanisms than other individuals.

P2.140 MCDERMOTT, CG*; POPE, D; Mount Holyoke College; mcder20c@mtholyoke.edu

Effects of mangrove pneumatophore density on *Uca crenulata*

An organism's habitat plays a large role in the types of behavior they exhibit as an individual, particularly in the context of signaling to attract mates. In my study site in Sonora, Mexico, the fiddler crab *Uca crenulata* builds burrows within and close to areas of mangrove pneumatophores, unlike many fiddler crab species that live in more open mudflat habitat. I investigated whether the behavior of males of this species varied in areas with different levels of pneumatophore density, since the structure of pneumatophores and the visual noise they create may affect with many of their common behaviors. Over one lunar cycle I studied the behavioral patterns of *U. crenulata* by tracking the above-ground activity of females and males of different sizes as well as recording the behavior of focal males. I found that the ratio of males to females as well as male waving activity significantly increases at and after low tide. I also conducted an experiment to investigate whether males are attracted to pneumatophores by giving them a choice between open areas and areas with artificial pneumatophores. Nineteen out of twenty males chose pneumatophore areas, suggesting that males are strongly attracted to these structures. I determined that larger males tended to live in higher density pneumatophore areas and that these areas had a lower percentage of males waving in general. These trends in behavior are useful in explaining how males balance increased conspicuousness to predators with the necessity to attract a mate.

P1.103 MCGOWAN, Luke*; STRIEDTER, Georg; University of California, Irvine; lukemcgowan1@yahoo.com

Species differences in early patterning of the avian brain

Adult brain region proportions vary across taxa—e.g., parrots have a proportionally larger telencephalon than galliformes, while having a proportionally smaller optic tectum. How do such species differences evolve? What differences in brain development account for such differences in adult morphology? We here examine species variation in early brain patterning as a possible mechanism underlying brain proportion evolution. In particular, we look at differences in early tissue territory allocation of the developing optic tectum in parakeets and bobwhite quail. Published embryonic morphometric data from our lab show that tectal growth curves in parakeets and bobwhite quail run roughly parallel all the way back to the time when tectal morphology first becomes apparent. Backward extrapolation from these data suggests that the parakeet's tectum is smaller than the quail's from the outset—that is from the time of initial tectal territory allocation or regionalization. To examine this regionalization difference we look at the expression domains of transcription factors *Pax6* and *Gbx2*, which are expressed in the forebrain and hindbrain, respectively. These expression domains are known to form rostral and caudal borders with the presumptive midbrain tectum at around Hamburger Hamilton stages 8-12 when the tectal territory is specified. These borders allow us to measure and compare the sizes of a molecularly defined presumptive tectum in the two species. Our hypothesis predicts that the molecularly defined tectal territory is significantly smaller, in absolute size and relative to the remaining brain, in parakeets compared to bobwhite quail. Supported by NSF grant IOS-0744332.

P2.165 MCGREGOR, Anna E.*; FISH, Frank E.; NOWACEK, Douglas P.; Duke Univ. Marine Laboratory, Beaufort, NC, West Chester Univ., PA; anna.mcgregor@duke.edu

Finding the window of energetic opportunity: traveling North Atlantic right whales use dive depths that avoid surface drag

Swimming immediately under the water's surface incurs the maximum amount of drag for a body, which can be up to 5 times greater than in free stream conditions. Cetaceans must swim at the water's surface to breathe or use energy to dive away from the surface, which then requires overcoming drag and buoyancy forces. We investigated whether traveling North Atlantic right whales (*Eubalaena glacialis*) dive to depths based on the amount of surface drag experienced. Suction-cupped archival tags (Dtags) were attached to free-ranging whales in their northern summer foraging habitat, the Bay of Fundy, Canada (BoF), and in their southern winter calving habitat, the South Atlantic Bight, US (SAB), over five years, recording a total of 439 surface dives, those less than 50 m in maximum depth, from 25 individual whales. Surface dives averaged 8.2 m in depth in the BoF and 10.3 m in the SAB. Body depth of an adult right whale is estimated to be approximately 3 m, which would cause them to experience surface drag effects when submerged to depths less than 9 m. In addition, the majority of dives made in the SAB waters were from one pregnant individual, and its dives were to significantly deeper depths than those of nonpregnant animals in the BoF, although they were still close to the calculated depth of minimal drag. During pregnancy, right whales undergo abdominal distension, which likely increases body depth and could influence the depth at which surface resistance becomes negligible. This initial analysis suggests that right whales may dive to depths that minimize both surface drag and travel time to the surface, thereby decreasing their energetic expenditure during horizontal travel.

P2.63 MEREDITH, Dawn; SHUBERT, Christopher; BOLKER, Jessica*; VESENKA, James; KRAUT, Gertrud; Univ. of New Hampshire, Univ. of New England, Univ. of Southern Virginia; jbolker@unh.edu

Creating a Physics Course for Life Science Majors

Most undergraduate students in the life sciences are required to take physics; few understand why, or realize much benefit. Some may see the light later on if they take a specialized course on biomechanics or biophysics, but for most, the required physics course is a missed opportunity both to learn physics, and to gain a new perspective on biology. To address this issue, we are transforming a traditional one-year algebra-based college physics course populated primarily by such students, by integrating biological examples that both demonstrate and motivate the physics. We describe several strategies: emphasizing topics of particular importance to biologists; including examples of physics-rich biological research; developing homework and exam problems built around biological phenomena; and designing concept questions that encourage students to think about biology in a physical frame. Transforming an existing course in a physics department from within offers an alternative to stand-alone biophysics and biomechanics classes taught in biology departments. Our approach is useful in programs where faculty time or expertise are not available to support a stand-alone course, and allows significant changes in pedagogy and content without the need to rewrite curriculum requirements. Finally, the collaboration between physicists and biologists that goes into developing a physics course for life science majors offers our students a working demonstration of interdisciplinary teamwork.

P3.105 MCPHERSON, Duane R; SUNY at Geneseo; mcperso@geneseo.edu

Modulatory influences of anterior cerebral neurons on fictive swimming in *Melibe leonina*

The opisthobranch mollusc *Melibe leonina* swims by rhythmic lateral bending of the body, and the swim movements are driven by a central pattern-generating circuit located in the central ganglia of the nervous system. The isolated central ganglia (pedal and cerebropleural ganglia) can spontaneously produce the neural analog of swimming (fictive swimming). In this study I explored the influence of neurons in the anterior region of the cerebral ganglia on neurons in the pedal ganglia, including putative motoneurons (neurons having peripheral axons and/or firing in stable relation to pedal nerve activity during fictive swimming). A number of anterior cerebral neurons were found to have mild excitatory effects on pedal neurons, and these effects appeared to be indirect. In preparations that exhibited fictive swimming, some anterior cerebral neurons were found which enhanced the rhythmicity of the motor activity. Some of these cerebral neurons were themselves rhythmically active in stable phase relation to pedal nerve activity. Thus, they may be linked to the swim pattern-generating neural circuit. Supported by a Mid-Career Summer Fellowship from the SUNY Geneseo Research Foundation.

P3.83 MICHAELSON, Jessi-Ann B.*; POWERS, Donald R.; FRIESEN, Chris R.; MASON, Robert T.; George Fox Univ, Newberg, OR, Oregon State Univ, Corvallis, OR, Oregon State Univ, Corvallis, OR; dpowers@georgefox.edu

Energy Investment during Courtship by Male vs. Female Red-Sided Garter Snakes (*Thamnophis sirtalis parietalis*)

Male red-sided garter snakes (*Thamnophis sirtalis parietalis*) incur large energetic costs during reproduction (about 18X SMR) due to prolonged courtship of females and direct male-male competition. This is not surprising since reproductive success is a primary component of male fitness. In most sexually reproducing species energy expended during reproduction differs between males and females as females spend more energy on production of young. However when females are courted by many males it might also be necessary for females to spend energy on courtship activity in order to increase fitness through female choice. If true then interesting evolutionary questions arise as we try to understand what reproductive success means to females when faced with fixed energy availability. We assessed energy expenditure of both males and females and ventilation patterns (VP) of females during courtship and mating. Trials involved either a receptive or nonreceptive female that was courted by either a small (6 males) or large (12 males) mating group. Metabolic rate (MR) was measured using open-circuit respirometry (VO_2) and VP measured using whole-body plethysmography. Females did not upregulate their MR or changed their VP in response to male courtship. Thus courtship and mating does not appear to be a major component of a female's reproductive costs. Further, if females are exercising choice in mate selection then they are likely doing so by some other means. Males courting receptive females had $MR > 2X$ males courting nonreceptive females. This adds support for the importance of chemical cues provided by females in the efficient selection of potential mates.

P3.9 MILLER, A L; FERNANDES, J*; University of Tampa, St. Petersburg College; *Fernandes.Jennifer@spcollege.edu*
Sexual Dimorphism in the Sensory Structures of the Northern Scorpion, *Paruroctonus boreus*

We investigated the sexual dimorphism and geographical variation in sensory structures used to locate mates in the northern scorpion *Paruroctonus boreus*. Males respond to the presence of conspecific pheromones from the same population but not to conspecific pheromones from allopatric populations. Mature males actively search for females during the mating season and therefore, thought to have greater selection pressure on the pectines, which contain the sensory receptors. We investigated sexual dimorphism of the pectines within and among populations using scanning electron microscopy. Four measurements were used to assess these differences. All measured variables were significantly larger in males than females, but only one variable significantly varied among populations. Our results suggest that *P. boreus* males have developed larger sensory structures to facilitate mate localization and the pressures driving the increase in size is not population specific.

P2.12 MILLER, TC*; MACKENZIE, D; JAQUES, JT; DELOVIO, ML; Dept. of Biology, Texas AM University, Texas Veterinary Medical Diagnostic Laboratory, Texas Veterinary Medical Diagnostic Laboratory; *tcmliller@tamu.edu*

Biological activity of mammalian thyrotropins in goldfish
 Little is known about the structure or function of teleost thyrotropin (TSH), a glycosylated pituitary hormone that stimulates the thyroid gland. As a first step towards production of recombinant teleost TSHs, we developed a bioassay which could be used to assess the *in vivo* biological activity of mammalian TSH. Goldfish received a single injection of TSH and resulting plasma TSH and thyroxine (T_4) were measured by immunoassay. Time course studies found that circulating TSH peaks between 2-5 hours after bovine TSH (bTSH) injection and that resulting T_4 is elevated from 5-20 hours. The linear T_4 dose response (from 0.1-10 mU bTSH/gBW) at 5 hours post-injection was consistent across 9 assays using the same group of fish over 2 years. Because TSH can be synthesized by expression systems using various cell lines which differ in their ability to glycosylate TSH, we examined the effects of glycosylation on the T_4 response. The removal of carbohydrates from bTSH increased the clearance rate of TSH while abolishing the T_4 response. Recombinant canine TSH (rcTSH) expressed using a baculovirus system with enhanced glycosylation capabilities produced a dose dependent increase in T_4 between 1 and 20 ng/gBW at 5 hours post-injection. In contrast, rcTSH produced using a baculovirus system without the capability of processing carbohydrate moieties into mature mammalian forms had 9% as much biological activity. Thus, the goldfish TSH bioassay is a sensitive and stable bioassay which can be used to determine the biological activity of both pituitary-derived TSH and recombinant TSH. Moreover, these experiments demonstrate that the carbohydrate composition of TSH is important for *in vivo* biological function in goldfish as in mammals.

P2.88 MILLER, T.M.*; KRAJNIK, K.G.; Southern Il. Univ. Edwardsville; *tylmill@siue.edu*
The Intestinal FMRFamide Receptor in the Earthworm *Lumbricus terrestris*

The motility of the earthworm digestive tract is modulated by the neuropeptide FMRFamide. Our lab has shown that this peptide has an effect on the muscular activity of both the crop-gizzard and the intestine. FMRFamide increased the rate of contractions in both organs. The focus of this project was to determine whether the same FMRFamide receptor regulates both tissues using a series of FMRFamide analogs. The intestine was removed from the animal and placed in a tissue bath. Contractions were measured with a force transducer, and analyzed using LabScribe. Increasing concentrations of peptide were added to the tissue bath and the resulting changes in contractions were used to generate a log-dose response curve. To determine which amino acids in the FMRFamide sequence were critical for biological activity we used peptides in which one of the amino acids was changed from the normal L-conformation to the D-conformation. The resulting dose-response curves were compared to that of the standard FMRFamide. FMRFamide caused an increase in the rate of contractions of the intestine with a threshold between 0.1 to 1 nM. When the C-terminal phenylalanine was changed to the D-conformation there was no response from the intestine to concentrations as high as 10 μ M. The same responses were observed in the isolated crop-gizzard. Thus the receptor in both organs requires a C-terminal L-phenylalanine for biological activity. We are currently examining the effects of D-conformational substitutions in the other three positions.

P1.33 MILLER, B.*; SCHREIBER, A.M.; St. Lawrence Univ., Canton NY; *aschreiber@stlawu.edu*

Treatment of *Xenopus laevis* tadpoles with pharmacological inhibitors of matrix-metalloproteases (MMPs) suppresses metamorphic intestinal remodeling

During frog metamorphosis the herbivorous tadpole transforms into a carnivorous frog. Tadpole intestinal development is characterized by a 75% shortening of its length, thickening of the muscle and mesenchyme, and the development of extensive luminal folds. All metamorphic changes are mediated by thyroid hormone (TH) and its nuclear receptors that function as gene transcription factors. Several MMPs are up-regulated in the intestine by TH during metamorphosis. However, the actual functions of MMPs in intestinal development remain unclear. We have developed a simple and effective method to pharmacologically inhibit tadpole intestinal MMP activity *in vivo*, and study the effects of this suppression on subsequent TH-mediated intestinal development. Premetamorphic tadpoles (NF 51) were treated for 2 days with a broad-spectrum MMP inhibitor (doxycycline, 100 μ g/ml) added to the water. Intestinal remodeling was then induced by adding 3 nM triiodothyronine (T3) to the water in the presence or absence of MMP inhibitor for 4 days. Gut lengths were measured, and gut cross-sections were analyzed histologically. Gut lengths of tadpoles treated with MMP inhibitor only (9.6 ± 0.2 mm) were not different than for untreated tadpoles (9.3 ± 0.3 mm). Gut lengths of tadpoles treated with T3 only (6.7 ± 0.2 mm) were significantly shorter compared with untreated animals. However, guts of tadpoles treated with MMP inhibitor+T3 failed to shorten, with lengths (8.9 ± 0.3 mm) not significantly different compared with untreated animals. Whereas treatment with T3 only produced a constricted intestinal cross-section and thickening of the mesenchyme compared with untreated tadpoles, gut cross-sections of animals treated with T3+MMP inhibitor were similar to those of untreated tadpoles.

P1.68 MININ, Vladimir N*; OAKLEY, Todd H; SUCHARD, Marc A; University of Washington, Seattle, University of California, Santa Cruz, University of California, Los Angeles; vminin@u.washington.edu

A Bayesian approach to testing the independent origin hypothesis

Estimating the number of times a discrete evolutionary trait changed its state is one of the fundamental questions in evolutionary developmental biology. Often, researchers are interested in testing a so called independent origin hypothesis that asserts that the number of changes of a certain type exceeds a predefined threshold. Testing such a hypothesis in a formal statistical framework requires a model of trait evolution and a phylogenetic tree along which the evolutionary trait evolves. We use a fairly unrealistic, but mathematically and computationally convenient, Markov model of trait evolution, parameterized in terms of rates at which the trait changes its state. Next, we assume that the phylogenetic tree of organisms under study can be inferred using molecular data. However, such estimation remains imprecise and the resulting phylogenetic uncertainty must be accounted for when testing the independent origin hypothesis. Both, the phylogenetic tree and rates of the Markov evolutionary model are nuisance parameters for our purposes. We propose to test the independent origin hypothesis in a Bayesian framework, because the Bayesian paradigm naturally allows for integration over nuisance parameters. We demonstrate how to construct and to calculate a Bayes factor to perform the desired test. We evaluate our test via simulations and apply the developed method to study evolution of a compound eye in arthropods.

P3.47 MOODY, K.N.; KAWANO, S.M.; PTACEK, M.B.; MAIE, T.; JULIUS, M.L.; SCHOENFUSS, H.L.; BLOB, R.W.*; Clemson Univ., Clemson Univ., St. Cloud Univ.; rblob@clemson.edu
Morphological divergence between subpopulations of newly recruited juvenile climbing gobies from different Hawaiian islands: implications for local adaptation

Variation in selective pressures across the range of a species can generate phenotypic differences between subpopulations, but intermixing of individuals may hinder such divergence via gene flow. The amphidromous lifestyle of the Hawaiian goby fish *Sicyopterus stimpsoni* provides a system for examining the interaction of these forces. Juveniles returning to freshwater from the ocean face two major pressures: (1) avoiding predators in lower stream reaches, and (2) climbing waterfalls to reach adult habitats. Shapes of adult fish differ between islands where different pressures predominate: adults from Kaua'i have deeper bodies, improving thrust for predator escape in long estuaries on the way to waterfalls, but adults from the Big Island have shallow bodies, reducing drag in waterfalls that are scaled shortly after juveniles enter streams. Because juveniles from different islands may intermix in the ocean, it is possible that fish arriving at each island are morphologically similar, and that the application of different selection regimes across islands to new recruits leads to adult phenotypic divergence. We tested this possibility with discriminant function analysis of 17 morphological measurements from new recruits of *S. stimpsoni* from Kaua'i (N=80) and the Big Island (N=100). Body height was shallower and anal width was narrower in juveniles from the Big Island vs. Kaua'i, matching adult phenotypes and differences in functional pressures on each island. These results suggest the potential for local entrainment of recruits and possibly sustained selection across generations that could facilitate genetic differentiation between islands. NSF IOS-0817794, 0817911.

P1.22 MIZRAHY, O.; BEN-HAMO, M.*; BAUCHINGER, U.; PINSHOW, B.; Ben Gurion University ; ortalmi@bgu.ac.il
The effects of water availability on tissue rebuilding in migratory blackcaps during stopover

We examined whether migrating blackcaps (*Sylvia atricapilla*), refeeding after a period of simulated in-flight starvation, replace lean mass (m_l) and pectoral muscle mass (PM) faster with access to drinking water than without. Ten birds were randomly assigned to each of three groups: water *ad libitum*; 0.5 h/d access to water; no water; all were fed mealworms (~60% water) *ad libitum* for 6 d. Thirty other birds were divided into two groups and offered either water *ad libitum* or access to water for 0.5 h twice a day along with a standard insect based diet (~33% water) *ad libitum* for 6 d. In both experiments, we measured body mass (m_b), PM index (PMI), food (DFI) and water intake (DWI). Also, m_l and fat mass (m_f) were measured using dual energy x-ray absorptiometry. Mean DWI was significantly different among the groups in both experiments (RM-ANOVA $F_{2,28} = 27.6$, $p < 0.00001$ and $F_{1,21} = 24.2$, $p < 0.0001$). Despite this, no differences found in mass specific DFI in either experiment ($F_{2,28} = 0.7$, NS and $F_{1,21} = 0.05$, NS). PMI was not affected by water availability when mealworms were provided ($F_{2,28} = 0.49$, NS), but when fed the standard diet, the effect on PMI was positive ($F_{1,21} = 4.90$, $p < 0.05$). The change in m_l did not differ among groups fed mealworms ($F_{2,28} = 1.92$, NS), but was positively affected by the availability of drinking water in birds fed the standard diet ($F_{1,15} = 9.85$, $p < 0.01$). The data support our prediction in that, when blackcaps were fed a relatively low water content diet, drinking water positively affected the bird's PMI and m_l gain. Although preformed and metabolic water gained through eating mealworms is apparently sufficient for blackcaps to rebuild lost tissues, given access to water the birds drink prodigiously, perhaps allowing more time for activity.

P1.62 MORAN, Meghan M.*; GEORGE, Craig; THEWISSEN, JGM; Department of Anatomy and Neurobiology, Northeastern Ohio Universities College of Medicine and Pharmacy, Department of Wildlife Management, North Slope Borough, Barrow, Alaska; mmoran1@neoucom.edu
Development of the Sacrum in Land Mammals and Cetaceans

The sacrum of mammals consists of up to 13 fused vertebrae that form part of the bony pelvis and provide support for the hind limb. In some marine mammals the hindlimb and innominate are absent and the synostoses between sacral vertebrae are absent. The evolution of the bony pelvis in cetaceans is well documented by morphological intermediates and includes the reduction of the innominate (loss of acetabulum, loss of obturator foramen) and the reduction of synostoses between the four sacral vertebrae. Interestingly, whereas vertebral synostoses of the sacrum are absent in modern cetaceans, they do occur in the cervical vertebrae of many taxa (Delphinidae, Balaena). To understand the developmental mechanisms associated with sacral evolution in cetaceans we examine developmental controls of sacral synostoses in mouse vertebrae and compare this to protein signaling in the sacrum of cetaceans. We first determine the timing and location of signaling proteins using an ontogenetic series of CD-1 mice ranging from postnatal Day 1 to Day 60. Histological sections of the cervical, lumbar and sacral regions in each murine ontogenetic stage were investigated for expression of Wnt, β Catenin, FGF8, Shh, BMP4, and Pax1. To further understand cervical and sacral fusion in cetaceans, we undertook a morphological study of the intervertebral area in cetaceans. Preliminary CT-scan data indicate that fusion of cetacean vertebral epiphyses begins in the neck and tail, and proceeds toward the thoracolumbar area from these regions. Unlike most large land mammals, several cetaceans undergo vertebral epiphyseal fusion only long after sexual maturity, or forego it altogether.

P1.31 MORGAN, S; NGUYEN, M; ONOURA, C*; RICHARDSON, T; TRAN, HT; DAVENPORT, IR; Xavier University of Louisiana; idavenpo@xula.edu

Follicle Cell Processes in the sandbar shark *Carcharhinus plumbeus*

Elasmobranch fishes (sharks, skates and rays), are among the dominant predators in the marine environment. Apex predators typically have low fecundity but to compensate produce large, precocial offspring. Producing larger offspring requires more maternal input i.e. increasing the amounts of yolk stored within the egg (lecithotrophy), or by supplementary nutrition supplied to the developing embryo from the mother (matrotrophy). Lecithotrophy has finite limits as the egg is a single cell and thus is confined by physical properties; the egg has to maintain its physical integrity. There is also the question of how to get vast amounts of nutrients to these large egg cells. To produce very large offspring the mother needs to supply additional nutrition to the developing embryo throughout gestation. In elasmobranchs this is achieved in a variety of ways including the secretion of uterine milk, oophagy and ultimately the evolution of the yolk sac placenta. Our interests are in the production of large egg cells; in elasmobranchs they can reach 10 cm in diameter. In recent years we have indicated the presence of a novel, actin-based, tube-like framework embedded in the zona pellucid. This framework may well aid in the production of these extremely large egg cells. This framework has so far been described in two species of carcharhinid, the dusky smoothound *Mustelus canis* and the Atlantic sharpnose shark *Rhizoprionodon terraenovae*. We termed these structures Follicle Cell Processes (FCP). We are continuing to explore the phylogenetic distribution of these structures and their ultimate role in oogenesis. We have found FCP in a fourth species of carcharhinid, the sandbar shark *Carcharhinus plumbeus*.

P3.23 MORTON, M. L.*; PEREYRA, M. E.; Univ. of Tulsa; marty-morton@utulsa.edu

Bushy-tailed Woodrats: Making hay the rodent way

Haying is the cutting, curing, and storing of herbaceous vegetation, and among small mammals this behavior is generally attributed only to pikas (*Ochotona* spp., Lagomorpha). We found, however, that a rodent, the Bushy-tailed Woodrat (*Neotoma cinerea*, Rodentia), living near the northernmost limits of its distribution, sometimes engages in fully developed haying behavior. Haying took place only during hours of darkness, as verified by records from trail cameras (Cuddeback Digital with infrared flash). Cuttings of leaves and stems were stacked on bare ground or rocks, usually within a meter or two of the host plant. After drying in the sun for a few days (longer if rain intervened) the dried vegetation was removed, usually within one night, and transported to den sites. Fourteen species of plants, some of them known to be poisonous, were identified within 149 examined hay piles. We hypothesize that drying food plants before storage within the dry, cold cliff-face crevices used for dens may reduce perishability by inhibiting microbial decomposition. The drying process may also promote degradation of secondary plant compounds, such as alkaloids, making the vegetation less toxic and more palatable.

P1.170 MORRISON, David*; JINDRICH, Devin L; Arizona State University; djmorri2@asu.edu

Contributions of active muscles to joint impedance in rats

During legged locomotion, the mechanical properties of joints and legs (i.e. force, impedance) are modulated to achieve task-level movement dynamics. A 'tuned' musculoskeletal system can contribute to stable locomotion. Joint and leg mechanics reflect both passive properties and the properties of active muscle. However, the sensitivity of joint-level impedance to different patterns of muscle activity have not been well characterized in rodents. Therefore, we examined the relationship between muscle activity and ankle joint impedance in the laboratory rat. In deeply anesthetized animals, we stimulated the tibialis anterior (TA) and gastrocnemius (GAS) muscles with acute implanted electrodes, using 50 Hz trains of 0.2 ms square wave pulses while the ankle joint was attached to a position-controlled force transducer. The ankle was subject to sinusoidal angular displacements at 5 frequencies between 1-10 Hz. TA and GAS were stimulated using currents ranging from 0.0-10.0 mA for 3 seconds, with 30 second rest periods between trials. Static forces were estimated by averaging transducer output, and impedance properties calculated from force changes and phase relative to the position changes. Joint mechanics were dominated by position-dependent 'stiffness' properties; the contribution of damping was relatively less than stiffness. Whereas mean forces increased with increasing muscle activation, dynamic stiffness remained nearly constant over different levels of muscle force.

P2.139 MOSS, AL*; ROSTAL, DC; Georgia Southern University; mandiluck5@yahoo.com

Use of Ultrasound, X-ray, and Oxytocin to Determine Reproductive State of Female *Trachemys scripta* not Collected at the Nesting Site.

Traditionally, projects involving turtles and oxytocin have used time consuming and labor intensive capture methods such as drift fencing with pit-fall or bucket traps. Once a female is collected, palpitation is the typical means in determining egg developmental state. Though this is a sufficient method for detection of calcified eggs, it lends no information pertaining to existence of follicles or under calcified eggs. Here, we set out to determine if use of x-ray and ultrasound could prove useful in determining reproductive state in females not captured at or near the nesting site. Ninety female *Trachemys scripta* were collected from two sites in Southeastern Georgia (George L. Smith (GLS) and Magnolia Springs (MS) State Parks) from Feb-Aug 2009. Females were captured by dip netting (primarily at MS) and hoop-trapping (primarily at GLS). State of reproductive development was designated in six categories for each female: (1) no follicular or egg development, (2) very small (<0.60cm) follicles present, (3) follicles (0.61cm-1.20cm) present, (4) enlarged follicles (>1.21cm) but no eggs present, (5) eggs and follicles present, and (6) only eggs present. Females categorized as 5 or 6 were brought back to the lab for x-ray. Clutch size, size of pelvic aperture, and level of calcification were determined from x-rays. Category 6 females were found as early as February from MS, and category 1 females persisted as late as August at both sites. Only category 6 females (N=20) were injected with oxytocin (20IU/kg). Of those injected, less than 50% showed successful deposition (i.e. 2 or fewer eggs retained after injection, as verified by x-ray). Our findings show that ultrasound and x-ray alone may not prove useful in detection of ovipositional state for females captured away from the nesting site.

P2.19 MUELLER, Irina A*; O'BRIEN, Kristin M; University of Alaska Fairbanks; iamueller@alaska.edu

The Effect of Mitochondrial Ultrastructure on Function in Antarctic Notothenioid Fishes

The loss of hemoglobin (Hb) and myoglobin (Mb) in the heart ventricle of Antarctic icefishes (Family Channichthyidae) is correlated with striking alterations in mitochondrial ultrastructure. The aim of this study was to determine if the differences in mitochondrial structure affect function, close to physiological temperature (2°C) and at the elevated temperature of 10°C. State III respiration rates and proton leak rates were measured in mitochondria isolated from the heart ventricle of *Chaenocephalus aceratus* (-Hb/-Mb), *Chionodraco rastrospinosus* (-Hb/+Mb), *Notothenia coriiceps* (+Hb/+Mb) and *Gobionotothen gibberifrons* (+Hb/+Mb) at 2°C and 10°C. Rates of production of reactive oxygen species (ROS) were also measured at 2°C and 10°C in mitochondria isolated from *C. aceratus* and *N. coriiceps*. State III respiration rates were not significantly different among the species at 2°C or 10°C. Rates of proton leak increased in response to an increase in temperature in all species, but mitochondria from icefishes were always more tightly coupled than mitochondria of red-blooded notothenioids. Differences in mitochondrial coupling were not reflected in differences in transcript levels of uncoupling protein 2. Mitochondrial ROS production increased as temperature increased yet was not significantly different between *C. aceratus* and *N. coriiceps*. Addition of respiratory chain inhibitors resulted in a greater increase in ROS production in mitochondria from *C. aceratus* compared to *N. coriiceps*, which was correlated with a higher mitochondrial membrane potential in *C. aceratus*. Summarized, the differences in mitochondrial ultrastructure between icefishes and red-blooded notothenioids affect proton leak, but not state III respiration rates or ROS production under normal physiological conditions.

P1.120 MUNOZ-GARCIA, Agusti*; REICHARD, Jonathan ; RO, Jennifer; WILLIAMS, Joe; KUNZ, Thomas; Ben-Gurion University, Boston University, Ohio State University, Ohio State University; agustimg@gmail.com

Cutaneous Water Loss and Lipids of the Stratum Corneum in two sympatric species of bats

The lipid matrix of the stratum corneum (SC), the outer layer of the epidermis of mammals, constitutes the barrier of water vapor diffusion through the skin. The lipids of the SC are structured in the intercellular spaces of the mammalian epidermis in ordered layers, called lamellae, which prevent water loss. The main lipid classes in the SC of mammals are cholesterol, free fatty acids and ceramides, which form the backbone of lamellae. However, our knowledge on how the lipid composition of the SC alters cutaneous water loss (CWL) in mammals is rudimentary, and derived from studies on laboratory animals and humans. We measured CWL of individuals of two species of sympatric bats, *Tadarida brasiliensis* and *Myotis velifer*. We then correlated CWL with the lipid composition of the SC, measured by thin layer chromatography and high-performance liquid chromatography coupled with atmospheric pressure photoionization and mass spectrometry, in the first study of its kind on wild mammals. Surface-specific CWL was higher in *Myotis* than in *Tadarida*. Individuals of *Tadarida* had more classes, and a higher amount, of polar ceramides in the SC, a feature associated with lower CWL in other species of mammals and birds. We conclude that qualitative and quantitative modifications of the lipid composition of the SC led to significant changes in CWL of bats.

P1.75 MUNOZ, Elyse E*; VANDENBROOKS, John M; HALE, Jennifer A; HARRISON, Jon F; Arizona State University; elyse.munoz@asu.edu

Effects of Atmospheric Oxygen on Body Size, Development Time, Growth Rate, and Tracheal Systems in *Blattella germanica*, the German Cockroach

Unlike some giant insect species that lived during the high oxygen period of the Paleozoic era, maximum cockroach body size has remained relatively unchanged over the last 300 million years. To better understand this phenomenon, 350 *Blattella germanica* were reared in seven different oxygen levels ranging from 12%-40% from hatch to adulthood. Adult mass, growth rate, and development were measured. Mild hyperoxia (up to 31% oxygen) showed no effect on body size, while oxygen levels above 31% reduced body size and growth rates, though extended development times. Hypoxia reduced size, growth rate and extended development time. Thus 21% oxygen is the optimal condition for *Blattella germanica*. The lack of a positive effect of hyperoxia on size may explain why historical hyperoxia did not stimulate gigantism in this group of insects. A subset of these cockroaches (12 from each oxygen) were imaged at Argonne National Labs using phase contrast x-ray synchrotron imaging, with emphasis on the dimensions of their leg tracheal system which are currently being analyzed. This research was partially supported by NSF EAR07463522 to JFH.

P2.91 MURRAY, S.*; HERNANDES, A.; CARROLL, M.A.; CATAPANE, Edward, J.; Medgar Evers College; catapane@mec.cuny.edu

Neurotoxic Actions of 6-OHDA, 5,7-DHT, Manganese and Denervation on Serotonergic and Dopaminergic Innervation of Lateral Ciliated Cells of Gill of *Crassostrea virginica*

Cilia of the lateral cells of gill of *Crassostrea virginica* are innervated by serotonin (HT) and dopamine (DA) nerves that increase or decrease beating rates, respectively. 5,7-Dihydroxytryptamine (5,7-DHT) is a neurotoxin that destroys HT neurons. 6-Hydroxydopamine (6-OHDA) destroys DA neurons. Manganese (Mn) is an environmental toxin causing Manganism. Mn affects dopaminergic systems but the mechanism is unclear. Our studies show Mn disrupts dopaminergic control of lateral ciliated cells of gill of *C. virginica*. The present study contrasts actions of 6-OHDA, 5,7-DHT, Mn and denervation of the branchial nerve (BN) on ciliary activity. Animals were treated for 3-7 days with 6-OHDA or 5,7-DHT by injecting 500 µg into posterior adductor muscles and placed in containers of artificial sea water (ASW). For Mn treatments, right shells were removed and animals placed in containers of ASW with or without 500 µM of Mn. Denervation was done by cutting the BN. Beating of cilia was measured by stroboscopic microscopy. 6-OHDA caused supersensitivity to DA, an inability of inhibitory electrical stimulation (ES) of the BN to slow down beating, but no impairment to serotonergic innervation. 5,7-DHT treatment resulted in supersensitivity to HT, an inability of ES of the BN to speed up cilia, but no impairment to dopaminergic innervation. Mn resulted in inability of DA and inhibitory ES of the BN to slow down cilia, but no impairment of serotonergic innervation. Denervations resulted in supersensitivity to DA. The study shows the 3 neurotoxins have different mechanisms of action. This is helpful to understand causes of and treatments of the disorders. This work was supported by grants 2R25GM06003-05 of NIGMS, 0516041071 of NYSDOE, 0622197 of NSF and P382A080040 of the USDE

P1.47 MURRELL, E.G.*; JULIANO, S.A.; Illinois State University, Normal, IL; egmurre@ilstu.edu

Succession of dipterans in container communities: Is the IFC hypothesis supported in an animal community?

Many hypotheses for mechanisms of ecological succession focus on terrestrial plant communities, but could also potentially apply to animal communities. We used aquatic macroinvertebrate container communities (larval dipterans) as a model system to study succession because of their small size, simple community structure, and rapid species turnover. To determine if succession occurs in this system, we arranged 128 water-filled containers in groups of 4 in a forested area. One-fourth of the containers were destructively sampled each week, and the abundances of 6 dipteran taxa were counted per container. We also tested whether Egler's initial floristic composition hypothesis – or for our study, initial faunistic composition (IFC) – could explain changes in community composition. We allowed one week for initial oviposition, then covered half of our containers and compared community composition of covered and uncovered containers for the remainder of the study. We used MANOVA and profile analysis to compare relative abundances of taxa across treatments (open vs. closed), week, and all relevant interactions. Relative abundances of taxa were significantly affected by week ($p < 0.0001$) and by week*treatment interaction ($p = 0.0287$), indicating that succession patterns differed for our two treatments. Diversity was lower in covered containers ($p = 0.0108$), with 2 taxa present in only open containers. Thus, the data do not support the IFC hypothesis. We also tested the effects of changing abiotic conditions (temperature, volume, and dissolved sodium concentrations) on diversity and relative abundances of taxa. None of these covariates were significant. We describe our plans to further use container systems in order to test other succession hypotheses.

P2.113 MYERS, Edward A*; WEAVER, Robert E; ALAMILLO, Hugo; Washington State University; edward_myers@wsu.edu
Historical Demography of *Hypsiglena chlorophaea* in the Great Basin

Hypotheses about the effects of glacial mass movement during the Pleistocene (0.01–1.8 mya) have proposed differential responses across taxa. One hypothesis suggests that much of the herpetofauna of the Great Basin would have kept a similar range distribution as what is seen today, while the vegetation changed from a desert scrub community to one dominated by pinyon-juniper woodlands. This hypothesis is in opposition to another prominent hypothesis that relies on more restricted distributional ranges within 'Mexican refugia' during this epoch. Given the heterogeneous effects during the Pleistocene, we set out to investigate the response of a clade of *Hypsiglena* to the recession of the Cordilleran ice sheet and look for evidence supporting either of the two prominent hypotheses. Using mtDNA markers and Bayesian Skyline Plots we show that *Hypsiglena chlorophaea* experienced a growth in effective population size that began 65 kya and ended 12 kya. This suggests southern regions were not refugia for this clade and that population growth happened earlier than expected.

P1.163 MYERS, Marcella J*; BOEFF, Kelsey A; WALL-SCHEFFLER, Cara M; St Catherine University, Seattle Pacific University; mjmyers@stkate.edu

Effect of Age, Walking Speed, and Frontal Load on Step Width and its Variability

Step width (StW) has been proposed as a determinant of the cost of walking via affects on step-to-step transitions involved in redirecting the center of mass. Increased StW variability has been linked to frailty and/or fear of falling in older people, while increases in mean StW potentially compensate for lateral instability. The passive dynamic (PD) model of walking predicts that walkers are more stable in the fore-aft direction due to passive stability but less stable laterally, requiring active control of foot placement – an activity that might become less precise as sensory and motor systems age. A simple prediction of the PD model is that older walkers should have wider StW and greater StW variability than young walkers. We tested this prediction in a sample of 10 young (Y) females (mean=20.9, range 19-23 yr) and 10 older (O) females (mean=51.4, range 40-64 yr) as they walked on a treadmill unloaded and front-loaded (16% of body mass, such as experienced during pregnancy or post-menopausal shifts in visceral abdominal fat) at four speeds centered around optimal walking speeds. Although dividing StW by limb length (LL) is a common normalization technique, we found sharply different patterns between StW and LL in the two age cohorts (Y: StW vs LL virtually flat, O: StW increased directly and significantly with LL, $r = 0.64$, $p < 0.0001$). With speed and load in the model, StW was wider in the older group, but StW variability was less. We found that older walkers could be even more precise in their foot placement than younger walkers, although they did compensate with wider steps. Supported by NIH EARDA Grant G11HD039786 and the Center of Excellence for Women, Science & Technology at SCU.

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Yolk and albumin corticosterone concentrations in eggs laid by white versus brown laying hens

Animals respond to stressful conditions with variable intensity. When stress is imposed on laying females, permanent trans-generational effects can also occur through the transmission of corticosterone (CORT), the primary avian stress hormone, to offspring through the egg. So, when examining the effects of stress on laying females, it is also important to determine how that stress impacts offspring as well. Previous studies have shown that white leghorn hens show a heightened response to stress compared to Hyline brown hens, producing significantly more corticosterone and displaying longer bouts of tonic immobility after handling, while baseline levels of CORT are similar between the strains. We tested the hypothesis that higher stress responsiveness would correspond to chronic accumulation and thus higher concentrations of CORT in egg yolks following exposure to stressors associated with routine maintenance. Eggs were collected from white and brown hens that were undisturbed except for daily feeding and routine egg collections. CORT was quantified in plasma, egg yolks, and albumin and compared between strains. We predicted that CORT concentrations in yolk would be higher in eggs from white versus brown hens, but that short-term measures including plasma and albumin CORT would not differ between strains. As predicted, yolk CORT concentrations were significantly higher in eggs produced by white hens, nearly twice those found in eggs laid by brown hens. Plasma and albumin concentrations of CORT were similar between groups. These results suggest that offspring hatching from eggs laid by white leghorn hens are exposed to significantly more stress hormones through concentration in the egg yolk, which could permanently imprint offspring physiology and behavior.

P3.51 NÄ DL, Marie T.*; DE COUET, H. Gert; Department of Theoretical Biology, University of Vienna, Austria, Department of Zoology, University of Hawaii at Manoa; couet@hawaii.edu
A conserved role of the homeobox transcription factor Tinman during heart development of the bobtail squid *Euprymna scolopes*

The heart is a key morphological innovation in the evolution of animals. Despite differences in morphology and function of blood pumping systems, the basic molecular mechanisms involved in early patterning of the heart appear to be conserved in bilaterian taxa. The conserved homeodomain transcription factor Tinman is crucial for early patterning of the mesoderm giving rise to the heart. Loss of *tinman* function leads to loss of dorsal mesodermal structures, including cardioblasts and pericardial cells in the fly, and a dominant-negative variant of the orthologous Nkx2-5 protein blocks cardiogenesis in frog embryos. Cephalopods possess a remarkably effective, closed circulatory system capable of maintaining a high blood pressure. In addition to the systemic heart two accessory branchial hearts function to move blood through the gills and ensure that all blood leaving the systemic heart is oxygenated. In order to understand the mechanisms that led to the evolution of this unique circulatory system within the mollusks we examined the expression of a *tinman* ortholog during the development of *E. scolopes* by in situ hybridization. Expression was first observed in the dorsal mesoderm, restricted to the systemic as well as both branchial hearts. Surprisingly, during later developmental stages *tinman* was also expressed within most major blood vessels of the circulatory system. Our data support the idea that the homologies between blood pumping organs exist at the level of myocytes that underlie organ function, and which are patterned by conserved developmental genes such as *tinman*. In addition, *E. scolopes* Tinman has apparently been co-opted for the formation of the vascular system in the squid.

P2.89 NELSON, M.*; ADAMS, T.; CARROLL, M.A.; CATAPANE, E.J.; Medgar Evers College, Brooklyn; catapane@mec.cuny.edu
Correlation of Membrane Potential and Ciliary Activity of Lateral Ciliated Cells of Gill of the Bivalve *Crassostrea virginica* and the Neurotoxic Effects of Manganese

Cilia of the lateral cells of gill of *Crassostrea virginica* are controlled by serotonin (HT) and dopamine (DA) nerves. HT is cilio-excitatory, DA cilio-inhibitory. The pharmacology of this system has been well studied but the fast movement of the cilia has prevented microelectrode studies of membrane potentials other than the elegant studies of Murakami and Takahashi in the 1970s. Voltage sensitive fluorescent probes are now available that change fluorescent intensity in relation to cell membrane potential. In this study we observed membrane potentials of lateral ciliated cells of gill of *C. virginica* while measuring beating rates. Applying HT to gill or a 5 Hz electrical stimulation (ES) to the branchial nerve (BN) caused prolonged membrane depolarizations, similar to plateau potentials, and increased beating rates. Applying DA to gill or a 20 Hz ES to the BN after exciting the cilia, repolarized the cell membrane and decreased beating rates. Manganese (Mn) is a neurotoxin causing Manganism in people exposed to high environmental levels. Previously we showed Mn disrupts the dopaminergic, cilio-inhibition in *C. virginica*. We now show Mn prevented the cilio-inhibitory response and corresponding repolarization when DA was applied to gill or the BN stimulated at 20 Hz. The effects of Mn were prevented by co-treating gills with p-Aminosalicylic Acid, a potential therapeutic drug for Manganism. This study shows a correlation between membrane potential and actions of HT and DA. It helps elucidate the neurotoxic mechanism of Mn by showing the site of action of Mn is postsynaptic. This information is helpful in understanding causes and potential treatments of the disease. This work was supported by grants 2R25GM06003-05 of NIGMS, 0516041071 of NYSDOE, 0622197 of NSF and P382A080040 of the USDE.

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The Effect of 5-hydroxytryptamine on Each Region of the Alimentary Canal of *Lumbricus terrestris*

Previously our lab has shown that neurotransmitters modulate the motility of the isolated crop-gizzard of the earthworm *L. terrestris*. 5-hydroxytryptamine (5-HT) was found to inhibit spontaneous contractions of the combined crop-gizzard. Since the role of 5-HT in controlling the rest of the digestive tract has yet to be explored, we decided to examine the effects of this neurotransmitter on the isolated pharynx, esophagus, crop, gizzard, and intestine. The organ of choice was removed from the animal and placed in a tissue bath. Contractions were measured with a force transducer, and analyzed with [LabScribe](http://www.labscribe.com). Aliquots of 5-HT, increasing in concentration, were added to the tissue bath, and the resulting changes in contractions were used to create log-dose response curves. We found that 5-HT decreased contraction amplitude and frequency of the pharynx (threshold between 0.1 and 1.0 μ M), and crop (threshold between 0.1 and 1.0 μ M). The esophagus responded with two phases of inhibition, during the first phase threshold was between 0.1 and 1.0 μ M and during the second phase threshold was between 10 and 100 μ M. 5-HT increased frequency and decreased amplitude of intestinal contractions (threshold between 0.1 and 1.0 μ M). We are currently investigating the effects of 5-HT on the motility of the gizzard.

P2.32 NEMETH, Z.*; LUO, Y.; OWEN, J. C.; CAO, Z.; MOORE, F. R.; Univ. of Southern Mississippi, Hattiesburg, Univ. of Maryland, Baltimore, Michigan State University, East Lansing; znemeth05@gmail.com

Seasonal Variation in Memory Formation in First-Year Migratory Songbirds as Revealed by Hippocampal CREB Immunoreactivity

Given the largely unfamiliar and unpredictable conditions experienced along migratory routes, natural selection should favor cognitive processes that reduce en route risks and uncertainties in migratory birds. These cognitive processes, however, are poorly understood. We used two intercontinental nocturnal migrants, the long-distance migrant Veery (*Catharus fuscescens*) and the shorter distance migrant Wood Thrush (*Hylocichla mustelina*), to assess the levels of spatial learning during the first year of songbird migrants, a critical period in constructing their navigational map. To estimate long-term memory formation, we measured immunoreactivity to cAMP response element binding protein (CREB) in hippocampal samples collected at autumn and spring stopover sites and at a breeding site. CREB-responsive transcription in the hippocampus plays a central role in long-term memory formation thus CREB up-regulation could potentially indicate increased learning and memory formation at a given ecological setting. CREB expression overall was lower in the long-distance migrant and showed seasonal low levels during autumn (first) migration whereas high levels during the breeding season. Our findings suggest that young migratory birds may store relatively little spatial information until their global navigational map is fully developed and gain the ability to compensate for displacement. Moreover, the adaptive value of spatial memory may differ in short- and long-distance migrants due to differential time and energetic constraints, which may result in differential cognitive demands.

P1.171 NGUYEN, C.*; DAVIDSON, B.; KANG, J.; KOH, S.; AHN, A.; Harvey Mudd, Claremont; *cassie.nguyen@hmc.edu*

Variability of Walking: Size and Neural Activation Patterns in Calf Muscles of Runners

Almost all humans walk, but the morphology of their leg muscles and their gait patterns differ visibly between individuals. In a previous study, sedentary adults used two patterns of neural signals. Half of the subjects used their medial gastrocnemius muscles (MG) more strongly than their lateral gastrocnemius muscles (LG) at most walking speeds ("MG-biased"). The other half walked activating both muscles equally ("unbiased"). The MG-biased subjects also had thicker MG muscles and smaller mechanical advantage at the ankle. In this study, we hypothesized that regular training results in the convergence of the neural recruitment patterns and relative size of the calf muscles despite differences in mechanical advantage. In recreational runners, we measured muscle thickness of the MG and LG muscles at rest and mechanical advantage. Then, we obtained joint kinematics (Qualysis, 125 fps) and recorded muscle activity patterns using surface electromyography, normalized to maximum voluntary contractions while walking on a treadmill at 6 speeds. Of the 17 runners, 7 subjects used an MG-biased recruitment strategy and 10 subjects used an unbiased strategy while walking. Additionally, when normalized to lower leg length, MG-biased runners had thicker relative MG muscles (0.059 ± 0.004) than unbiased runners (0.052 ± 0.005 ; $p = 0.05$). The mechanical advantage about the ankle, however, was larger for MG-biased subjects (0.23 ± 0.05) than for unbiased subjects (0.19 ± 0.05 ; $p = 0.05$). Despite these morphological differences, the two groups had similar kinematics while walking. The two recruitment strategies in runners suggest that training reinforces the different neural recruitment patterns also observed in sedentary individuals. Training may alter the influence of mechanical advantage on neural recruitment strategies and muscle size. This study was supported by the Barbara Stokes Dewey Endowment and HHMI.

P1.129 NIMITKUL, Sukkrit*; MYKLES, Donald L.; CHANG, Ernest S.; Bodega Marine Laboratory, University of California, Davis, Colorado State University; *snimitkul@ucdavis.edu*

Feedback Regulation of Ecdysteroid Analog on Y-organs of the Green Crab *Carcinus maenas*

Crustaceans have a rigid exoskeleton that cannot be expanded when the animal needs to increase in size. To solve this problem, crustaceans shed their old exoskeleton and make a new one. This process is known as molting. The process of molting is highly regulated by hormones, especially ecdysteroids or molting hormones that are secreted by the thoracic Y-organs. The ecdysteroid level increases very rapidly during early premolt, reaches its peak, and then drops to a low level before molting (Chang and O'Connor, 1988). However, little is known about the regulation of ecdysteroid secretion. The incubation of green crab Y-organs in different concentrations of an ecdysteroid analog (Tebufenozide) was used in this experiment to elucidate the regulatory process. Tebufenozide was used instead of the authentic ecdysteroids ecdysone or 20-hydroxyecdysone due to their potentially confounding effects since presence in the incubation medium would crossreact with the ecdysteroid ELISA used for quantification of the hormone. Our results show that when incubated with high concentrations of analog (50 and 200 pg/ul), Y-organ secretion rate is significantly lower than the controls. In low concentrations of analog (1, 2.5, 5 and 10 pg/ul) the secretion rate is not significantly different from the controls. These results suggest that high levels of ecdysteroid analog have a negative feedback effect on the Y-organ and thus reduce the capability of the Y-organ to secrete more ecdysteroid. Further experiments will be conducted to determine the effects of Tebufenozide upon molting and ecdysteroid levels *in vivo*.

P2.142 NIENOW, T.E.*; WHITTINGTON, A.C.; GROVE, T.J.; Valdosta State University, Florida State University; *tjgrove@valdosta.edu*

Homology model of *Fundulus heteroclitus* calsequestrin reveals structural differences that may contribute to thermal adaptation of *F. heteroclitus*

Calsequestrin (CSQ) is an acidic calcium-binding protein in the sarcoplasmic reticulum. Calcium stabilizes three thioredoxin-like domains within CSQ and causes dimerization and polymerization at higher calcium concentrations. While CSQ structure and function have been studied in mammals, the temperature dependence of CSQ in poikilothermic teleosts has yet to be explored. To investigate the structural basis of thermal adaptation of CSQ, we determined the full length cDNA sequence of skeletal muscle CSQ from *F. heteroclitus*, a small intertidal fish adapted to dramatic seasonal and tidal temperature changes. Using the deduced amino acid sequence we created a homology model based on the crystal structure of rabbit skeletal CSQ (1A8Y). *F. heteroclitus* and rabbit CSQs share 67% identity, indicating that rabbit CSQ crystal structure provides a good template above the "twilight zone" threshold. Excluding the signal sequence and negatively charged tail, *F. heteroclitus* CSQ has fewer acidic residues (79) and more basic residues (38) than rabbit CSQ (87 acidic, 30 basic), leading to an overall smaller negative charge on *F. heteroclitus* CSQ. Interestingly, the acidic tail in *F. heteroclitus* CSQ is longer than in rabbit, which gives fish CSQ a larger negative charge at pH 7 (-97.6 and -65.5, respectively). Additionally, *F. heteroclitus* CSQ has more aromatic residues buried in the interior of the protein, including five conserved tryptophans in the third domain. Continued investigation of the effects these differences have on non-covalent interactions within the tertiary structure may reveal the molecular basis for adaptation of *F. heteroclitus* in the face of an unstable thermal environment. Supported by NSF IOS-0817805.

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Regulation of the Growth Hormone-Insulin-like Growth Factor System by Cortisol and Thyroxine in Rainbow Trout

Previously, it was shown that cortisol and thyroxine (T4) modulate the growth of teleost fish. In this study we used rainbow trout (*Oncorhynchus mykiss*) to examine the influence of cortisol and T4 on the growth hormone (GH)-insulin-like growth factor (IGF) system. The direct effects of cortisol and T4 were examined in liver pieces (ca. 1 mm³) and isolated gill filaments incubated *in vitro*. Expression of mRNAs encoding GH receptor 1 (GHR1), GHR2, IGF-1, IGF-2, IGF type 1 A receptor (IGFR1A), and IGFR1B were determined by quantitative real-time PCR. Cortisol up-regulated GH-IGF system components in a time- and concentration-related manner. In liver, cortisol increased steady-state levels of mRNAs encoding GHR1 and GHR2. Cortisol also increased hepatic expression of both IGF-1 and IGF-2 mRNAs. In gill, cortisol increased levels of GHR1 and GHR2 mRNAs as well as levels of IGFR1A and IGFR1B mRNAs. T4 also up-regulated components of the GH-IGF system in a time- and concentration-related manner. In liver, T4 increased levels of mRNAs encoding GHR1, GHR2, IGF-1, and IGF-2. In gill, T4 increased the expression of both GHR1 and GHR2 mRNAs as well as of both IGFR1A and IGFR1B mRNAs. These results indicate that cortisol and T4 affect growth by modulating the GH-IGF system at several levels, including increasing sensitivity to GH, increasing IGF production, and increasing peripheral sensitivity to IGF. (Supported by NSF IOS 0920116)

P1.172 NORTON, E.*; ELLERS, O.; JOHNSON, A.S.; Bowdoin College; enorton2@bowdoin.edu

Testing an inverted pendulum model for underwater walking in the crab *Carcinus maenus*.

Terrestrial walking has been well studied, but underwater walking has not. We use an underwater version of the inverted pendulum and a dynamic underwater Froude number to model underwater walking in the green crab *Carcinus maenus*. We model the motion of an underwater inverted pendulum taking into account buoyancy, added mass, drag and effective leg length of crabs. We overlay predicted theoretical time-dependent horizontal and vertical velocities over velocities measured for walking crabs. Crabs of varying sizes were videotaped while walking, and their centers of mass were tracked using image analysis software. The center of mass moves up and down, which is consistent with an inverted pendulum model of walking. The underwater Froude number is well within the range for a walking gait. The step frequency is also consistent with an inverted pendulum model modified for underwater conditions. The vertical and horizontal velocities at the ends of the strides, however, are clearly modified by forces from the legs.

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High resolution measurements of intertidal relative humidity

Intertidal organisms are subjected to thermal and desiccation stresses during the aerial part of the tidal cycle. Temperatures in this habitat have been well quantified at a variety of spatial and temporal scales. Desiccation stress, however, is less well understood due to the complexity of measuring relative humidity at appropriate temporal and spatial scales. Biotic and abiotic features of intertidal habitats, such as crevices and patches of algae, are known to retain water during low tide creating protected microhabitats. In this study we documented the relative humidity environment around crevices and algae patches throughout low tides to document the extent to which these microhabitats ameliorate stressful conditions at low tide. Consistent with expectations, crevices and the region beneath algae were more humid than bare rock throughout the tidal cycle resulting in a refuge from high temperature and desiccation. The resulting data provide useful basis to parameterize heat budget models.

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Rapid Horizontal vs. Vertical Locomotion in the Mouse Lemur (*Microcebus murinus*)

Primates use both the ground and trees for traveling, feeding and escaping from predators. Their musculoskeletal systems must meet the competing demands for speed and economy on horizontal surfaces compared to the need for speed and power on vertical surfaces. Understanding how speed, economy and power are modulated during these different locomotor tasks provides insight into the limits of musculoskeletal function in primates and other mammals. Few data exist, however, that directly quantify how locomotor mechanics are altered during rapid horizontal vs. vertical locomotion. Video (250 Hz) and force data (2500 Hz) were collected from five adult mouse lemurs (*Microcebus murinus*) ($M_b=0.062$ kg) at the Duke Lemur Center, Durham, NC. Each lemur was encouraged to run at its fastest speed on a level horizontal runway and an instrumented 13 mm diameter vertical pole. Video data were used to determine speed, while forces were integrated to calculate whole-body center of mass (COM) work and power. *M. murinus* used bounding-galloping gaits on both substrates, with periods of foot-substrate contact separated by long (ground) or short (pole) aerial phases. The use of an aerial phase during rapid vertical climbing was unexpected, but is consistent with other forms of high-speed locomotion in primates (i.e., bipedal runs, gallops, ricochet brachiation). Locomotor speeds were greater on horizontal than vertical surfaces, and this difference is significant ($P < 0.05$). COM work and power were also greater in vertical locomotion. Taken together, these data suggest that differential performance limits may exist for rapid horizontal and vertical locomotion. The implications of these data for estimates of whole-body energetic efficiencies will also be discussed. NSF BCS0749314.

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D-glucose and D-fructose transport across lobster intestine

Dietary sugars are the main source of energy in many living organisms, and they play an essential role in the proper functioning of organs. The mechanisms of transepithelial absorption of dietary D-glucose and D-fructose in crustaceans have not been extensively studied and therefore were examined using the intestine of the lobster, "*Homarus americanus*", in the present investigation. Lobster intestines were isolated and mounted in a perfusion chamber to determine the mucosal to serosal (MS) mechanisms of "³H-D-glucose and "³H-D-fructose transport across the apical membrane. The results indicated that "³H-D-glucose transport was dependent on sodium and was carrier mediated. Furthermore, "³H-D-glucose transport was inhibited by phloridzin, but was neither inhibited by phloretin nor cytochalasin B. In contrast, "³H-D-fructose transport was carrier mediated, but there was no difference in the rate of "³H-D-fructose uptake in the presence or absence of sodium. In addition, "³H-D-fructose transport was not inhibited by phloridzin, phloretin or cytochalasin B. Taken together, these results suggest that on the apical membrane of the lobster intestine, (1) an SGLT1-like transport protein may be responsible for transepithelial D-glucose uptake; (2) transepithelial D-fructose transport may occur through a separate transport protein independent of sodium; and (3) a GLUT2-like carrier protein may not be involved in transepithelial transport of either sugar. The proposed mechanisms of transepithelial transport of D-glucose and D-fructose across the lobster intestinal epithelium from lumen to blood are similar to the standard models proposed for D-glucose and D-fructose uptake in mammalian intestine. Supported by NSF Grant number: IBN 04-21986.

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Pinpointing termination of diapause in apple maggot flies by reconciling metabolic increase with resumption of cell division and development

Diapause, or dormancy, is a state of developmental arrest that buffers an insect against harsh conditions and synchronizes active stages with favorable conditions. The timing of diapause termination is critical to this synchronization, and variation in timing is often adaptive. We are interested in identifying the mechanisms underlying rapid evolution of timing between putatively speciating populations of apple maggot flies (*Rhagoletis pomonella*) that terminate diapause at different times of the year to exploit different host fruit resources. Two key markers of diapause termination are a marked increase in metabolism and resumption of active cell cycling and development. We have previously characterized the metabolic trajectory of diapause termination, and in this study we are testing whether markers of cell cycling coincide precisely with metabolic increase. Characterizing the timing of this developmental marker in relation to metabolic markers will allow us to identify the most important sampling points for future genetic and functional genomic dissection of the diapause termination process. We measured pupae at intervals prior to and following metabolic increase for two prominent molecular indicators of active cell division: 1) protein expression of Proliferating Cell Nuclear Antigen (PCNA), and 2) chromatin content of brain nuclei via flow cytometry. We show that diapausing pupae arrest in the G0/G1 phase of the cell cycle, present a time series for diapause termination and resumption of development, and discuss implications for future work in this system.

P3.111 OLBERDING, J.P.*; RILEY, M.A.; JAYNE, B.C.; University of Cincinnati; olberdjp@mail.uc.edu

Snakes that go bump in the night

Haptic exploration, which is the use of touch to obtain information about surfaces and objects in the environment, is well studied for humans but not for many other species for which it is probably ecologically relevant. The importance of this sensory mode also probably increases in dark environments. For example, many species of snakes move in environments where vision is probably ineffective. Many snakes also move in challenging arboreal habitats where the risk of falling makes the choice of surfaces and branches to support locomotion paramount. Data on the haptic behavior of snakes are lacking, however. Thus, we studied the exploratory behaviors of juvenile boa constrictors, which are often nocturnal and move readily in arboreal habitats. All experiments were in a dark chamber and used infrared video to quantify the three-dimensional movements and behaviors of the snakes. Some experiments determined the searching patterns used by snakes to encounter an object, and others manipulated the size, shape, orientation, and mechanical properties of objects that snakes encountered. The perches upon which snakes were placed were one meter above the floor and did not allow the snakes to crawl down. Exploratory movements below the perch were more numerous and had greater vertical amplitudes than those above the perch. Most exploratory movements were much closer to the edges of the perches than the maximum distance that snakes could cantilever, especially horizontal movements perpendicular to the long axis of the horizontal cylindrical perch. Unexpectedly, the snakes did bridge some gaps by crawling onto surfaces that made locomotion extremely difficult. Some preferences were shown, however, for surfaces that were less compliant and had higher coefficients of friction. Thus, haptic information does appear to influence choice of substrate.

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Body Plan Evolution in Birds: Postcranial Skeletal Pneumaticity and its Role in Relaxing Constraints on Body Size and Locomotor Potential

Extant birds represent the only living sauropsid group in which pulmonary air sacs aerate the postcranial skeleton. The degree of variability in birds is notable, ranging from taxa that are completely apneumatic to those characterized by air within most of the postcranial skeleton. Although numerous factors (e.g., body size) have been linked with 'relative' pneumaticity, comparative studies examining this system remain limited. This project sought to (1) examine whole-body patterns of pneumaticity in select nonpasseriform neognath birds and (2) evaluate relationships among relative pneumaticity, body size and locomotor specializations (e.g. diving, soaring). Species-specific pneumaticity profiles were established for 68 species representing 10 higher-level groups. Although comparisons reveal relatively conserved patterns within most lower-level clades, both size-threshold and locomotor behavior impart predictable deviations from the clade norm. For example, the largest flying birds (bustards, vultures, pelicans) exhibit hyperpneumaticity relative to smaller members of their respective clades. In contrast, skeletal pneumaticity has been independently lost in multiple lineages of diving specialists (e.g., loons, penguins, diving ducks). Such reductions in skeletal pneumaticity result in decreased buoyancy in birds specialized for dive foraging. Conversely, aerating the postcranial skeleton offers a mechanism that allows volumetric increases in bone (and thus, the underlying support framework dictating whole-body volume) without concomitant increases in body mass. Thus, the potential to differentially pneumatize the postcranial skeleton may have played a role in relaxing constraints on body size evolution and/or habitat exploitation during the course of avian evolution.

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Investigation of Cadherin Expression During Secondary Neurulation in the Chick Tail Bud

Cadherins are a group of cell adhesion molecules that help mediate cell interactions involved in cell migration and organogenesis during development. Cadherin expression has been studied in the development of the primary neural tube (NT) and migrating neural crest cells in chicken, mouse, and rat, but not during secondary neurulation in the chick. Following formation of the primary NT during embryonic development, secondary neurulation occurs at three days by cavitation in the mesenchyme of the tail bud, a process that is expected to require dynamic changes in cell adhesion. We investigated the expression patterns of N-cadherin (N-cad), E-cadherin (E-cad), cadherin-6B (cad-6B), cadherin-7 (cad-7), and cadherin-11 (cad-11) in the tail bud during Hamburger and Hamilton stages 15, 17, and 19-21 using immunolocalization. At stage 15, only E-cad staining was found. At stage 17, low to medium staining of only N-cad and cad-11 was documented in the secondary NT. By stage 19 (17 hours later) N-cad was highly expressed in the secondary NT, notochord, and tail bud somites. Positive staining for E-cad was still observed in the epithelium of the skin, as expected. Cad-6B was positively stained in the dorsal secondary NT and in the floor plate at the distal end of the tail bud. Cad-7 was expressed with low to medium intensity in the dorsal-most region of the secondary NT. Cad-11 expression was observed in the tail bud somites, the secondary NT, and the mesenchyme of the tail bud. Our findings show that expression of cadherins becomes more abundant in the secondary NT as development progresses suggesting an involvement in cell organization. We are investigating the intervening stages to further define the dynamic pattern of cadherin expression during secondary neurulation.

P2.143 ORCZEWSKA, Julieanna I*; O'BRIEN, Kristin M; University of Alaska Fairbanks; jiorczevska@alaska.edu
Timecourse for Metabolic Remodeling in Response to Cold Acclimation in Threespine Sticklebacks

This study sought to determine the molecular basis of metabolic remodeling in response to cold acclimation in the threespine stickleback, *Gasterosteus aculeatus*. Animals were maintained at 20°C for 12 wk, then acclimated to 8°C for 9 wk or held at 20°C for an additional 9 wk. Animals were harvested on days 1-4 and wks 1, 4 and 9 of cold acclimation. The extent of mitochondrial biogenesis was determined in oxidative pectoral adductor muscle and liver tissue by measuring mitochondrial volume density, the ratio of mitochondrial DNA-to-nuclear DNA, and both transcript levels and maximal activities of citrate synthase (CS) and cytochrome c oxidase (COX). Transcript levels of the known regulators of mitochondrial biogenesis in mammals, PGC-1 α , PGC-1 β , NRF-1 and TFAM were also measured. While the activity and mRNA levels of CS and COX increased in response to cold acclimation in both liver and oxidative muscle, mitochondrial volume density only significantly increased in oxidative muscle from 12.5% \pm 1.8 to 23.7% \pm 1.8 (P < 0.05). Transcript levels of PGC-1 α and PGC-1 β did not increase in oxidative muscle in response to cold acclimation, suggesting that these factors may not play a role in mitochondrial biogenesis in fishes. However, mRNA levels of TFAM and NRF-1 significantly increased in oxidative muscle on day 2 of cold acclimation and again after 9 wks at 8°C. Transcript levels of PGC-1 α , PGC-1 β and TFAM increased in liver after 1 wk at 8°C and although not triggering mitochondrial biogenesis, may be important for increasing the expression of COX subunits and the copy number of mitochondrial DNA. These results suggest that the response to cold acclimation differs among tissues and that only some components of the pathway regulating mitochondrial biogenesis are similar between fishes and mammals.

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Elemental and Energy Assimilation in the round stingray, *Urobatis halleri*

The elasmobranch digestive system contains a spiral fold that is believed to enlarge the exploitable surface area for digestion while maintaining a relatively short intestine. This leads to the question: does the addition of spiral folding have an effect on the elemental absorption efficiency of elasmobranchs? We addressed this question by measuring the elemental absorption and caloric assimilation of *Urobatis halleri*, the round stingray, fed a diet of de-shelled shrimp. Following total gut clearance, rays were fed 2% of their body weight in peeled shrimp and their subsequent feces collected. Both the food source and ray feces were dried, homogenized, and run through a CHN Elemental Analyzer. To calculate the average percentage of elemental assimilation in *U. halleri*, simple calculations were performed subtracting the average percentage of elemental carbon, hydrogen, and nitrogen found in fecal samples from the percentage of elemental abundance in the food source, and then dividing that by the initial food source. Ray elemental assimilation was approximately 75% of the available carbon and 90% of the available nitrogen. Shrimp and fecal samples were also subjected to semi-micro bomb calorimetry to determine total caloric (energy) uptake. Rays assimilated approximately 80% of the caloric energy available during these trials. Finally, three whole stingrays (a neonate, a juvenile, and an adult) were dried, homogenized and semi-micro bombed to assess the differences in total caloric value and to calculate the energy needed for somatic growth. There was an 828Cal/g difference between adult and neonatal stingrays. These results are similar to the high assimilation efficiencies of other carnivorous fishes including the lemon shark, *Negaprion brevirostris*, which has an energy assimilation efficiency between 62-83% and organic assimilation between 76-88%.

P2.78 OWERKOWICZ, T.*; EME, J.; GWALTHNEY, J.; BLANK, J.M.; HICKS, J.W.; Uni. California, Irvine; towerkow@uci.edu
Cardiac shunting does not constrain aerobic capacity of the American alligator

All extant archosaurs possess a four-chambered heart, but differ widely in their aerobic capacity - birds rely more on aerobic metabolism during activity. We investigated whether this is due to differences in outflow tract design, which allows for cardiac shunting in crocodilians, but not in birds. Cardiac shunting - whereby deoxygenated blood from the right ventricle is sent to the systemic, instead of pulmonary, circulation - may place a constraint on oxygen supply to the tissues at times of increased O₂ demand. We hypothesized that removal of cardiac shunt will improve aerobic capacity (VO₂max) by forcing the entire right ventricular ejection volume to the lungs. We surgically occluded the left aorta in hatchlings of the American alligator, to render them incapable of shunting. After 17 months of growth and exercise training, we subjected the animals to a graded treadmill exercise test and measured their VO₂max. We found no significant difference in VO₂max between surgically-altered (7.7 mlO₂/kg/min) and sham-operated (8.0 mlO₂/kg/min) alligators. To further test whether cardiac shunting occurs during exercise, we measured blood flow in the left and right aortae of juvenile alligators. Shunting (net forward flow in the left aorta) occurred at rest in undisturbed animals, disappeared at the onset of forced exercise, and returned slowly during undisturbed recovery. This suggests cardiac shunting ability does not limit aerobic performance in crocodilians, because the shunt is turned off during exercise. We propose that non-avian theropods may have continued to enjoy benefits of cardiac shunting, even as they evolved a more superior aerobic capacity. Funded by NSF IOB 04445680 to JWH.

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Progesterone metabolites, "xenobiotic-sensing" nuclear receptors, and the metabolism of maternal steroids

During development, embryos utilize steroid signals to direct sexual differentiation of tissues necessary for reproduction. Modulation of these signals by exogenous substances (both natural and synthetic) frequently produces phenotypic effects that can persist into adulthood and influence reproduction. In both oviparous and viviparous amniotes, embryos may be exposed to active steroid signals from the maternal environment. Understanding how embryos process maternal steroids is important to deciphering the evolutionary consequences of these steroid signals. Here we present evidence that during embryonic development, progesterone metabolites and xenobiotic-sensing nuclear receptors may interact to increase the expression of numerous enzymes responsible for steroid metabolism and illustrate how such a system can operate in both oviparous and placental amniotes. In these groups, embryonic development is characterized by 1) elevated progesterone concentrations, 2) 5 β reduction being the primary metabolic pathway of progesterone, 3) the presence of xenobiotic-sensing nuclear receptors that can bind 5 β metabolites of progesterone, and 4) increased expression of a suite of enzymes responsible for the metabolism of multiple steroids. We propose that xenobiotic-sensing nuclear receptors initially evolved to buffer the developing embryo from the potentially adverse effects of various maternal steroids on sexual differentiation.

P1.76 PANG, K.*; RYAN, J.F.; MULLIKIN, J.C.; BAXEVANIS, A.D.; MARTINDALE, M.Q.; Univ. of Hawaii at Manoa, National Institutes of Health, NHGRI; kpang@hawaii.edu
Wnt and TGF-beta signaling in the ctenophore, *Mnemiopsis leidyi*

Of all the non-bilaterian animal groups, the gene content and complexity of ctenophores is the least known. While some information is known about transcription factors belonging to the T-box, Sox, and Homeobox families, nothing is known about the developmental signaling pathways. Cell-signaling pathways play important roles in bilaterian axis specification and development. Recent studies have shown that the Wnt/Beta-catenin and TGF-beta family evolved early in animal evolution, as evidenced their presence in the genomes of cnidarians, sponges, and the placozoan. Studies on their expression patterns and function suggest they play integral roles in early axis specification in both cnidarians and sponges. Unlike the other non-bilaterians, ctenophores display a highly stereotyped cleavage program, with cell fates determined early in development. Experimental manipulation studies have shown that the site of first cleavage sets up the major body axis of ctenophores, the oral-aboral axis. We sought to understand the roles of Wnt and TGF-beta signaling during ctenophore development to determine if they are involved in early axis specification. We utilized next-generation sequencing technologies and are in the process of sequencing and assembling the genome of the lobate ctenophore, *Mnemiopsis leidyi*. All essential components of both Wnt and TGF-beta pathways are present in the genome. We were able to identify and isolate 4 Wnt and 9 TGF-beta ligands and examined their expression pattern during development. All 4 Wnt genes are expressed in discrete regions of the aboral pole late in development, whereas a set of TGF-beta genes are expressed at the onset of gastrulation in discrete regions along the oral-aboral axis.

P2.130 PARKER, M. ROCKWELL*; FRIESEN, CHRIS R.; MASON, ROBERT T.; Oregon State Univ., Corvallis; parkermi@science.oregonstate.edu
Associated reproduction in a model dissociated breeder, the red-sided garter snake

Most vertebrates exhibit an associated reproductive pattern, where maximal sex steroid production, mating behavior, and gametogenesis occur simultaneously or at least in close proximity. The other pattern, dissociated reproduction, is typified by the uncoupling of one of the aforementioned components from the others. The red-sided garter snake (*Thamnophis sirtalis parietalis*) has long been described as a model dissociated breeder. Maximal courtship and mating in this species occur in the spring of every year following winter dormancy while sex steroid levels are basal (or at least decreasing) and no gametogenesis is occurring. Following the spring mating season, all snakes disperse from the den to various lakes and ponds of the Interlake Region of Manitoba, Canada, where they will undergo gametogenesis and/or vitellogenesis and parturition with a concomitant increase in sex steroid synthesis. Over the past two summers, we have surveyed male snakes for courtship behavior at a specific summer site (Fish Lake) and found that ~50% of the males exhibit courtship behavior (chin rubbing and body alignment). We bled all of the males to measure their total androgen levels via radioimmunoassay. Males that exhibit courtship behavior in the summer have higher total androgen levels than non-courting males, suggesting that androgens may be directly activating courtship behavior during the summer feeding period concomitant with gametogenesis. Though the intensity of late summer mating behavior pales to that induced by prolonged low temperature dormancy, this species may be unique in that it exhibits *both* associated and dissociated reproductive patterns.

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Reduced herbivory by Caribbean sea urchins in response to chemical cues of a known predator

Non-consumptive, indirect effects can contribute to trophic cascades as well as to changes in prey species morphology, yet many ecological studies only consider direct consequences of predation when examining predator-prey relationships. To test for trait-mediated indirect interactions (TMIIs), we examined a system on Caribbean coral reefs where herbivorous urchins, including *Diadema antillarum* and *Echinometra viridis*, decrease macroalgae and thereby increase juvenile coral survival. *Diadema antillarum* and *E. viridis* are preyed upon by fishes as well as invertebrates, yet no previous study has examined whether these urchins change their behavior in response to chemical cues from predators. To test this hypothesis, urchins were placed in individual 38 L buckets down current of a separate aquaria housing a helmet shell *Cassia tuberosa*, a known urchin predator. Each trial was paired with a control aquarium in which no predator was up-current of urchins. Urchins were fed a known amount of the red alga *Acanthophora spicifera ad libitum* for 24 h. The amount of *A. spicifera* consumed was calculated by the difference between initial and final weights. In two experiments TMIIs were demonstrated: *D. antillarum* and *E. viridis* consumed significantly less algae in the perceived presence of *C. tuberosa* (t-test, $p < 0.001$). Both small and large *D. antillarum* and *E. viridis* reduced foraging rates in the assumed presence of *C. tuberosa*. *Diadema antillarum* and *E. viridis* altered their behaviors in response to chemical cues from potential predators, which may have positive indirect effects on macroalgae communities through a release in grazing pressure.

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THE GENERATION OF TROPHIC NOVELTY THROUGH HYBRIDIZATION

The macro- and micro-evolutionary generation of novelty has long been a topic of interest in biology. Recently a line of research has focused on interspecific hybridizations as a vector for producing novel characteristics. Although long thought to be an evolutionary "dead-end" hybridization has been found to be fundamental to adaptation and speciation in several groups of organisms, and potentially a strong driving force during adaptive radiations. Hybrid offspring that exhibit transgression in traits (values outside the parental ranges) have gained interest in these studies as recent evidence suggests that transgression is a relatively common result of hybridization. Transgression appears to be most prevalent among hybrids in which parental species are more similar in the trait(s) of interest and in which the trait is complex and/or modular in its design and function. Here we examine several traits in interspecific hybrids from two Lake Malawi cichlid species. We focus on a set of trophic traits that are similar and disparate between parental species and investigate the frequency of transgression in them as well as the potential for genetic and developmental links among them.

P2.2 PASCH, Bret*; GEORGE, Andreas; HAMLIN, Heather J.; GUILLETTE, JR., Louis J.; PHELPS, Steven M.; University of Florida; bpasch@ufl.edu

Androgens activate advertisement songs of Neotropical singing mice (*Scotinomys*)

Androgens are important hormones that mediate vocalizations associated with sexual behavior and aggression in many vertebrates. However, the influence of androgens on mammalian vocalizations is not well characterized, especially in non-model organisms. We manipulated androgen levels in Alston's singing mouse (*Scotinomys teguina*) to elucidate hormonal control of singing and aggression. Singing mice are diurnal insectivorous rodents that inhabit montane cloud forests of Central America. Males commonly emit an audible (dominant freq. ~22 kHz) stereotyped song that appears to function in male-male aggression. Adult males were assigned randomly to 4 treatment groups: castrate plus empty implant, castrate plus DHT implant, castrate plus 1mm testosterone, and castrate plus 2mm testosterone. Implants and castrations were performed synchronously, and animals were tested 14 days before and after surgery. We recorded spontaneous song rate, measured response to a conspecific song, and presented intruders to the home cage of focal animals pre- and post-treatment to assess changes in aggression. Mice with empty implants sang less, had longer latencies to respond to conspecific song, and engaged in more submissive displays. Conversely, mice with DHT and testosterone implants increased song rates and showed no differences in aggression pre- and post-treatment. Our results indicate that androgens maintain song and that hormonal state shapes motivational state in singing mice.

P2.33 PAXTON, Kristina*; MOORE, Frank; IRWIN, Darren; The University of Southern Mississippi, University of British Columbia; kristina.l.paxton@usm.edu

Migratory Connectivity: A multi-marker approach to identify migratory individuals during the non-breeding season

A comprehensive understanding of the biology of migratory species – their life histories, adaptations and population dynamics – requires knowledge of all phases of the annual cycle and the geographic connectivity among phases. That said, following individuals throughout their annual cycle poses a serious challenge, and our understanding of the physiology, behavior and ecology of migratory birds during stopover has been constrained by our lack of knowledge of a bird's destination not to mention its point of departure. The utilization of intrinsic markers of population structure (i.e. stable isotopes, genetics) can be a powerful approach to geographically link individual migrants captured during stopover with breeding area destinations. We present the results of a Bayesian model that incorporates multiple markers (stable hydrogen isotopes, genetics, and plumage coloration) to assign Wilson's warblers (*Wilsonia pusilla*) of known origin to different breeding areas. A preliminary model suggests that individuals captured during stopover can be assigned to breeding areas with an accuracy greater than 90%. The use of a multi-marker approach enhanced assignment accuracy – where one piece of information potentially had difficulty discerning between two regions, another allowed separation. The ability to identifying the spatial and temporal distribution of migratory birds utilizing intrinsic markers now allows us to integrate essential information about a bird's general breeding destination with factors known to be important to a successful migration for a more comprehensive, integrated understanding of the stopover biology of landbird migrants.

P1.58 PASCUA, M. T.*; HOLLAND, B. S.; University of Hawaii; mapascua@hawaii.edu

Juvenile Density and Birth Rate in the Endangered Hawaiian Tree Snails *Achatinella lila* and *A. fuscobasis*

Two species of the federally listed endangered tree-snail genus, *Achatinella*, occur in the Ko'olau mountain range of O'ahu and face threat of extinction due to factors including loss of habitat due to deforestation and, most urgently, alien predators. In an effort to preserve and restore the Hawaiian tree snails, a captive propagation program at the University of Hawaii has successfully yielded high numbers of *A. lila* and *A. fuscobasis*. These two species have shown highest fecundity of the 15 species in the program: a lab population of *A. lila*, started with 7 individuals in 1997, has increased to approximately 640 individuals; and a population of *A. fuscobasis*, started with 11 snails in 1991, has grown to about 350 individuals. This study aims to determine whether density of juveniles is associated with higher birth-rates. Results of the study will have direct relevance to captive-propagation management procedures, specifically whether to separate snails by size-class. We applied three treatments consisting of: (1) no juveniles present; (2) low-density of juveniles; and (3) high-density of juveniles. Results suggest that birth rates are similar among the first and third treatments, with reduced birth-rates in the second treatment. While analyses of past records reveal some level of birth-rate decline after cage-splitting, they do not provide strong evidence that juvenile presence/density correlates with higher birth-rate, because birth-rate data are inconsistent among the cages and adults may become senescent.

P3.141 PAYNE, S.L.*; VICKARYOUS, M.K.; University of Guelph, Ontario, Canada; spayne@uoguelph.ca

A histological investigation of cranial kinesis in geckos: testing predictors of joint type

Cranial kinesis is a widespread feature of gekkotan lizards. Based on previous biomechanical studies, it is speculated that most joints involved in cranial kinesis are synovial (defined by the presence of a synovial cavity lined with articular cartilage). However, detailed investigations of tissue structure of most cranial joints are lacking. We examined the anatomy and histology of cranial kinesis in three representative species of geckos: *Eublepharis macularius*, *Tarentola annularis*, and *Chondrodactylus bibronii*. Particular focus was given to the articulations of the quadrate bone, whose anterior-posterior rotation is responsible for the movement known as streptostyly. Heads were non-invasively imaged using micro-computed tomography (microCT), and then serially sectioned and stained with Masson's Trichrome. For all species investigated, the histology clearly demonstrates that many joints involved in cranial kinesis are not synovial. More specifically, the quadrate-articular and epipterygoid- pterygoid joints are synovial, whereas the frontal-parietal and quadrate-ptyerygoid joints are syndesmoses (fibrous), and the epipterygoid-prootic and quadrate-otooccipital joints are synchondroses (cartilaginous without a synovial cavity). Our data indicate that the osteology cannot conclusively predict the presence of a synovial joint. For instance, the condyle-like skeletal structure at the cephalic end of the quadrate, while suggestive of a synovial joint, was not found to correspond to one. Available data also indicates that synovial joints are difficult to predict based on the degree of mobility. We conclude that in geckos, multiple synovial joints are not required for streptostyly. In addition, we propose that synovial joints are exclusive to elements derived from the neural crest.

P3.142 PEDERSEN, Scott*; RIEDE, Tobias; NGUYEN, Son; LU, Hongwang; MA, Jianguo; YAN, Zhen; HE, Weikai; ZHANG, Zhiwei; WANG, Fuxun; MUELLER, Rolf; PEDERSEN, ; PEDERSEN, ; South Dakota State University, Brookings, University of Utah, Salt Lake City, Institute of Ecology & Biological Resources, Hanoi, Shandong University, Jinan, Virginia Tech, Dalton; *scott.pedersen@sdstate.edu*

Reconstruction of the Rhinolophid Vocal Tract

One-third of extant microchiroptera emit their echolcative calls through their nose. The evolution of this complex morphological innovation required a substantial redesign of the microchiropteran head, literally reinventing much of the rostrum. Several of these modifications supercede the mechanical demands imposed on the skull by other cranio-dental adaptations (e.g., durophagy). The rostrum and vocal tract of *Rhinolophus* are the most extensively modified examples of this nasal emitting innovation within the Order. Sound is produced in the larynx and filter characteristics of the sub- and supraglottal vocal tract shape the source signal. Previously, source and filter were modeled as if they were linearly coupled. Those linear models of the supraglottal vocal tract in rhinolophoids suggested that the differential developmental dynamics of the mid-face directly effected fixed cavity resonances thereby imposing restrictions on what sound levels and frequency profiles are permitted by the supraglottal vocal tract in different rhinolophoids. Recently, we reopened this line of inquiry readdressing the physics of the enormous sound levels produced by some species. The airways of several *Rhinolophus* were reconstructed by micro-computer tomography in order to quantify vocal tract dimensions. We evaluate the resonant mechanics of this complicated system and test linear and nonlinear numerical models of the sub- and supraglottal vocal tract. Our goal is to simulate a signal with realistic acoustic output power and efficiency. Preliminary data indicate that linear transfer functions are insufficient to explain the functioning of this sophisticated acoustic device.

P2.131 PEREYRA, M.E.; University of Tulsa; *maria-pereyra@utulsa.edu*

Effects of climate-related variance in environmental conditions on reproductive timing and productivity in a high altitude and high latitude passerine (*Empidonax oberholseri*).

Global warming and altered frequency and duration of El Nino/Southern Oscillations may be changing precipitation patterns along the western edge of North America. One manifestation has been a decline in winter snowpack at lower elevations, but more variable snowpacks at high elevations in the western and southwestern U.S. Long-term studies of two subalpine flycatcher populations (one at high elevation, in the Sierra Nevada, and one at high latitude in northern British Columbia) indicated greater variability in time of breeding onset in the Sierran birds. This variability was largely a function of late winter and early spring snowpack, factors strongly affected by prevailing climatic influences and ENSO conditions. Winter snowpack influenced reproductive timing directly, through effects of snow water content and temperature on spring melt schedules and plant phenology, and indirectly through an array of effects on local microclimatic conditions such as ambient temperature. Effects on time of breeding onset, clutch size and fledgling production were strong in both populations, but there was little effect on time of breeding termination, even in years of late melt. In years of light to moderate snowpack, females laid earlier, fledged more chicks per nest and were more likely to renest if nest failure occurred. In years of heavy snowpack, delayed laying resulted in smaller clutches and decreased probability of renesting. Unpredictable conditions associated with more frequent El Ninos could select for shifts in habitat preference in southwestern portions of this species' range where conditions may become wetter, and could favor northward and interior continental range expansion, where the same climatic drivers may lead to more arid winters and earlier spring melt.

P3.32 PELEP, P. O.*; HADFIELD, M.G.; University of Hawaii ; *peltinolterpelep@gmail.com*

Understanding intraspecific relationships in the endangered Hawaiian tree snail, *Achatinella mustelina*

Populations of the federally listed endangered Hawaiian tree snail *Achatinella mustelina* are spread across a 20 km range in which gene flow is interrupted at 5 – 6 locations. Designation of 21 subspecific names was found not to be supported by genetic analysis of mitochondrial DNA (mtDNA) sequences. Subsequently, a principal components analysis of 11 shell characters suggested that some of sympatric subspecies might be distinguishable. To further clarify the intraspecific taxonomy of *A. mustelina*, we are now attempting to analyze DNA from preserved museum specimens of subspecies that are extinct. Because these specimens were originally preserved in formaldehyde, previous attempts to generate useful DNA sequences were unsuccessful. Using techniques developed to analyze ancient DNA from subfossil bones, we are now re-extracting DNA from the preserved specimens and getting yields of 11 – 57 ng per 30 micrograms of tissue. Goals are to employ PCR to generate useful sequences of the mtDNA-CO1 gene and a set of 8 microsatellite loci developed for *Achatinella* species and compare them to sequences from living populations and subspecies of *A. mustelina*. This should clarify both taxonomy and evolution within this species provide in the species.

P1.49 PEREZ-REYES, OMAR*; CROWL, TODD A.; UTAH STATE UNIVERSITY, LOGAN; *macrobrachium@yahoo.com*

Comparisons of the decapod community structure in urban and natural streams in Puerto Rico

Many tropical streams have been altered by water diversions, channel modification, introduced species, and water quality degradation. In Puerto Rico, watersheds range from montane, relatively pristine to highly degraded, and offer an opportunity to examine the impacts of human disturbances on native stream communities. Populations of native decapods, water temperature, pH, and DO were studied in 3 sites encompassing urban, sub-urban and pristine streams. Thirteen decapod taxa were recorded from the 3 streams. The abundance of species and community structure showed variations among the urban and sub-urban watersheds and the natural sites; ecologically relevant species (*Atya*, *Epilobocera* and some *Macrobrachium* spp.) were completely missing from the urban stream sites. The variations in decapod communities among watersheds correlated with the degradation of the physical-chemical environments, clearing of the riparian zones, and the introduction of exotic fauna to those portions of the rivers. Many nonnative aquatic species are better adapted than native species to degraded habitats (higher temperature and sedimentation); once established in these habitats, they can cause further reduction in native populations through competition, predation, and the introduction of parasites. Understanding the relationship between habitat alteration and aquatic community structure will be critical for developing enhanced conservation strategies for the impacted urban streams.

P1.5 PERINO, LAURIE L*; MUNCH, STEVEN B; PADILLA, DIANNA K; Stony Brook University; lperino@ic.sunysb.edu

Predicting the impacts of fluctuating bivalve densities on phytoplankton communities

Suspension-feeding bivalves have the potential to control phytoplankton communities both in biomass and species composition. Understanding this relationship is becoming increasingly important as eutrophication is leading to more severe phytoplankton blooms, including harmful algal blooms, which cause hypoxic and anoxic events. To assess the potential impacts of bivalves on the phytoplankton community we need a scientifically based, quantitative method to predict possible changes. To address this issue, we constructed a simple ecological model to predict the extent to which different densities of bivalves can have control over phytoplankton growth and species composition. Models such as this can be important tools for ecosystem-based management, making decisions about harvest limits and restoration goals, predicting impacts from exotic introductions, and for examining the potential for suspension feeders to control blooms of harmful algae. We parameterized our model using species from waters on Long Island, NY. We used *Mercenaria mercenaria*, a dominant species along the entire east coast of the United States and the current target for restoration efforts, as the suspension-feeding bivalve. We also used three common species of phytoplankton, *Nitzschia closterium* (20µm), *Thalassiosira pseudonanna* (5µm), and *Aureococcus anophagefferens* (2µm). We used *A. anophagefferens* because it is a harmful alga that has been blooming in Long Island waters and is believed to be hampering bivalve restoration efforts. We ran simulations of the model over a range of clam densities. The results showed a threshold response to increasing clam density. At an approximate density of 2 clams/m², the density of phytoplankton began to fall drastically until a density of 4 clams/m², when the degree of phytoplankton decrease leveled off.

P1.102 PERRIN, Gregory E.*; WANG, Fuxun; MÄLLER, Rolf; GRASSO, Frank W.; BioMimetic and Cognitive Robotics Lab, Brooklyn College, CUNY, Brooklyn, NY, School of Physics, Shandong Univ., Jinan, China, Dept. Mechanical Engineering, Virginia Tech Danville, VA; gregory.e.perrin@gmail.com
A Role for Outer Ear Features in the Ability of Bats to Localize Sound?

The ability to localize sources of acoustic signals is important in the majority of terrestrial animals and the diversity of sophisticated neural-acoustic information-processing mechanisms to support it has received intense attention. The diversity of ear shapes seen across mammals has received less attention and its functional significance is poorly understood. Echolocating bats rely on acoustic signal-processing and across species show a wide diversity of ear-shapes. We explored the impact of simple, geometric features of ear shape on the directivity of single model ears by building scaled, physical models. We recorded sounds received inside these model ears (at the ear canal) and mapped the sensitivity to broadband signals delivered to equidistant positions along a hemisphere around the ear. Geometric features included pinna shape (degree of ellipse eccentricity, conic section depth), surface features such as flaps and ridges, as well as the size and orientation of larger structures such as the tragus. The dimensions of the model ears and the wavelengths of sound used were scaled to match those of typical echolocating bat species. The results showed frequency-swept fan-beams which could encode the vertical location of a sound-source as a function of frequency. Simulation studies with geometrically similar, idealized ears produced comparable results. These findings support the hypothesis (advanced elsewhere) that such variations in ear structure may convey sound localization information to the bat's brain in a way that complements the well-studied horizontal localization mechanisms produced by computation of inter-aural delay in the bat's brainstem.

P1.74 PEROTTI, EA*; TRAN, C; HUANG, Y; CAMERON, RA; HADFIELD, MG; Univ. of Hawaii, Cal Tech; eperotti@hawaii.edu

Using cDNA libraries and in situ hybridization for analysis of receptors involved in the settlement and metamorphosis of a dominant biofouling tubeworm, *Hydroides elegans*

Larval detection of specific molecular cues on the substratum during settlement and metamorphosis is still a process we know very little about. In order to examine and identify larval receptor systems involved in settlement and metamorphosis, we developed cDNA libraries and performed *in situ* hybridization (ISH) with different larval stages of the tubeworm *Hydroides elegans*. This polychaete is a significant problem fouler in warm water ports around the world and is an excellent candidate for investigating molecular reception during larval settlement and metamorphosis. Our first goal was to develop cDNA libraries from pre-competent and metamorphically competent larvae of *H. elegans* that can be examined for specific receptor genes. Our second goal was to identify candidates for receptors for ligand detection. To this end, we performed ISH with probes developed from these genes to determine where expression occurs in larvae of different developmental stages. One candidate identified using RACE libraries was G_{αq}, a guanine nucleotide-binding protein that is a component of transduction pathways of G-protein coupled receptors (GPCRs). We expected this transcript to be present in the apical sensory organ of metamorphically competent larvae if it was involved in ligand detection. ISH did not show expression of this gene in the apical sensory organ in either competent or pre-competent larvae, indicating that perhaps GPCRs are not involved in ligand detection in these larvae. Other likely candidates for receptors during settlement that can be screened using these methods include lectin receptors and ligand-gated ion channels.

P2.133 PETERSEN, Christopher L. *; GRASSO, Frank W. ; The BioMimetic and Cognitive Robotics Lab, Brooklyn College, CUNY, Program in Ecology, Evolution, and Behavior, The Graduate Center, CUNY ; Chris.p5692@gmail.com
Seasonal Changes in Nest Maintenance Behavior of Monk Parakeets (*Myiopsitta monachus*)

Monk Parakeets (*Myiopsitta monachus*), though native to Argentina, are an invasive parrot species found throughout North America. Over the last 30 years, they successfully formed stable, localized colonies at sites from Florida to New England and from New York to California. They are rare amongst parrots and birds generally, in their construction of large, multi-chambered, stick nests and in that they communally maintain them year-round rather than just during the breeding season. In the past 10 years, our laboratory has studied the nesting activities of over 90 monk parakeet nests in Brooklyn, NY. Here we report on intensive focal studies of 2 nests located on the Brooklyn College campus for which extensive activity data were available dating back nine years. We made video recordings of nest-construction behaviors over a 6-month period that included the mating, egg incubation and fledging periods. From these videos we scored the frequency with which the parakeets added, manipulated, relocated, and removed sticks from these nests. From these measures developed a measure of nest maintenance activity. We found that nest maintenance activity declined significantly but did not cease during the fledging period $F(2,27) = 3.57$ $p < 0.05$. Specifically, stick addition $F(2,27) = 6.07$ $p < 0.01$ and on-nest stick manipulation $F(2,27) = 3.84$ $p < 0.05$, differed significantly during the fledging period compared to the incubation and mating periods. We suggest that this surge and subsequent decrease in nest construction activity, is typical of hormonally triggered nesting behavior in birds. And raise the question of whether the year-round nest maintenance activity is insensitive to the changing hormone levels that that regulate nest construction behavior during the mating and incubation periods.

P1.126 PFAU, DR*; POTTER, SY; DENARDO, DF; TAYLOR, EN; STRAND, CR; Cal Poly State Univ., Arizona State Univ.; dpfau@calpoly.edu

Effects of testosterone and captivity on medial and dorsal cortex volumes and neurogenesis in adult male Western Fence Lizards, *Sceloporus occidentalis*

In lizards, the medial cortex and dorsal cortex are thought to be homologous to the hippocampus in birds and mammals, in that these regions are functionally involved with spatial memory and learning. In birds and mammals, neurogenesis continues into adulthood in these regions and is associated with ability of spatial memory tasks. Little is known about whether adult neurogenesis contributes to memory formation or spatial memory in lizards. In some lizards, territory size is correlated with testosterone (T) levels. If T affects these brain regions to help with spatial navigation, manipulating T levels may influence the medial or dorsal cortex volumes and/or the incorporation of new neurons into these regions. We investigated the effects of castration and T replacement on neurogenesis in adult male *S. occidentalis*. These animals were in captivity for approximately two months. We also captured a group of adult males from the wild shortly before sacrifice to determine if captivity affects the sizes of these regions and/or neurogenesis. The density of new neurons in the medial and dorsal cortex was determined using immunohistochemistry for doublecortin (DCX), a marker of immature neurons. Numerous DCX-immunoreactive cells were found in the medial cortex, however, there were few to no DCX-immunoreactive cells found in the dorsal cortex. Captivity has negative effects on medial cortex volume and possibly neurogenesis within this region. The functional significance of the presence new neurons in the medial cortex of lizards remains to be determined. However if captivity does decrease neurogenesis, determining the effects of other variables on neurogenesis in captive animals may be difficult to determine.

P3.67A PILOSOV, S.; MUNOZ-GARCIA, A.*; PINSHOW, B.; HERRERA, M. L.G.; Ben Gurion University of the Negev, Universidad Nacional Autonoma de Mexico; shainova@gmail.com

Seasonal variability in urine concentration and fecal water content of free-ranging bats in a tropical deciduous forest

Small mammals inhabiting highly seasonal environments often compensate for reduced water availability by producing highly concentrated urine, by reducing fecal water content (FWC), or by both. We examined seasonal variations in urine concentration (U_{osm}) and FWC of free-ranging bats inhabiting the tropical deciduous forest of the Chamela-Cuixmala biosphere reserve, Mexico, which is characterized by marked dry and rainy seasons. We hypothesized that bats inhabiting this forest would have seasonal physiological changes to maintain water balance. To test the predictions that bats would have (1) higher U_{osm} and (2) reduced FWC during the dry season compared to the rainy, we measured U_{osm} and FWC of samples collected from free-ranging bats in both seasons. Our first prediction was supported for the insectivorous *Pteronotus parnellii* (dry season $U_{osm} = 2130 \pm 122$ mOsmol/kgH₂O, N = 24; rainy season $U_{osm} = 1731 \pm 72$ mOsmol/kgH₂O, N = 42), but not for three frugivorous (*Artibeus intermedius*, *A. hirsutus* and *A. jamaicensis*), one hematophagous (*Desmodus rotundus*) and one mixed diet (insects and nectar, *Glossophaga soricina*) bat species. Our second prediction was supported for *P. parnellii* (dry season FWC = $51.6 \pm 2.3\%$, N = 41; rainy season FWC = $71.1 \pm 0.7\%$, N = 108) and *G. soricina* (dry season FWC = $45.2 \pm 5.6\%$, N = 7; rainy season FWC = $84.9 \pm 4.3\%$ N = 11), but not for *A. jamaicensis* and *A. intermedius*. We conclude that the frugivorous and hematophagous bats are not water stressed in either season because their diets are water-rich all year round, and that *P. parnellii* copes with decreased water availability in the dry season by increasing U_{osm} and decreasing FWC. *G. soricina* also reduced FWC in the dry season, perhaps because of increased insect consumption.

P3.16 PILIKIAN, T.*; TRACY, C.R.; BAHLMAN, A.; Univ. of Nevada, Reno; pilikian@biodiversity.unr.edu

Determining patterns of behavioral hydroregulation in three families of amphibians

Amphibians lose water at high rates to the environment by cutaneous evaporative water loss, and are thus limited to habitats with water or high moisture. Not all evaporative water loss rates are created equal; the rate at which dehydration occurs depends on multiple factors such as body size, ambient temperature, physical activity levels, and cutaneous resistance to water loss. Little is known about the degree at which amphibians hydroregulate, or maintain sufficient hydration for optimum performance. We conducted a lab experiment to examine differences in hydroregulation between three families (Ranidae, Hylidae, and Bufonidae) of varying degrees of terrestriality. Individuals at Standard Mass (100% hydration with an empty bladder) were placed in arenas with access to water for voluntary rehydration. Using video surveillance, activity levels and the duration of time until voluntary rehydration were recorded. Data will be plotted against dehydration rates specific to each individual, and preferred 'set point' hydration ranges will be determined for each family. We expect the data to show that Ranidae, an obligate aquatic family, will more closely control hydration than the semi-aquatic family Hylidae. We also predict that Bufonidae, a terrestrial family, will maintain the lowest degree of hydroregulation of the three families. If our hypotheses are supported, we will lend more insight to the importance of phylogenetics in amphibian hydroregulation. If our hypotheses are not supported, this study will provide evidence that hydroregulation in amphibians is controlled by factors unrelated to family characteristics.

P2.23 PINNICK, G.L.*; COHEN, C.S.; San Francisco State University; sarahcoh@sfsu.edu

Does temperature affect Whole Body Regeneration (WBR) rate in *Botrylloides* spp?

Botryllid ascidians, colonial marine chordates, possess unique modes of propagating and regenerating that make robust models for studying the biological pathways for tissue regeneration. Here, we test the effect of temperature on regeneration ability and rate, as mediated by the retinoic acid (RA) pathway that is common in chordate embryonic development. Colonies of *Botrylloides* sp from 2 sites in San Francisco Bay with differing seasonal salinity and temperature regimes were compared. A total of 10 genotypes were used to create 33 ampullar clumps (1-6 clumps per genotype) that consisted solely of ampullar tissue with all zooids removed. Ampullar fragments were treated with retinoic acid and regeneration was observed at 3 temperatures. WBR (regeneration of an entire functional zooid) occurred rapidly, within 1-4 days. This temperature also accounted for the majority of zooids produced across the 10 day observation period. At 13 and 23 degrees, multiple zooids (1-4 zooids) were produced within a single ampullar clump. The second most productive temperature was 13 degC, which produced WBR of zooids within 5-8 days. The intermediate temperature had the highest rate of non-regeneration across all ampullar clumps, together with the highest mortality rate. WBR of botryllid zooids from ampullar fragments occurred at all 3 temperatures within 5 days with 2 out of 4 genotypes successfully regenerating in all treatments. Temperature may have an effect on WBR in this species, with the warmest temperature producing the most zooids in the shortest time in this series of experiments.

P3.92 PINSON, SE*; WILSON, J; NAVARA, KJ; The University of Georgia, Athens, GA; sbmoore@uga.edu

The effect of injecting varying doses of acute corticosterone on offspring sex in the white leghorn

Sex ratio manipulation has been documented across a wide variety of species and birds have demonstrated a remarkable ability to manipulate the sex of their offspring. Previous studies in both wild and captive birds suggest that treatment with hormones can stimulate females to manipulate the sex of their offspring before eggs are even ovulated. In particular, chronic treatments with corticosterone (CORT), the primary stress hormone produced by birds, stimulated significant skews towards female offspring in avian species and it has been suggested that CORT acts by influencing which sex chromosome is donated by the heterogametic female bird into the ovulated ovarian follicle. During previous studies designed to test this idea, CORT treatments were given via an acute injection during meiotic segregation and resulted in a significantly male-biased offspring sex ratio, the opposite of those produced during chronic CORT treatment. The purpose of the current study was to determine whether acute CORT treatments have a dose-dependent effect on offspring sex ratios. We treated laying hens with acute high or low-dose CORT injections or control injections 5h prior to ovulation and quantified the sexes of the subsequently ovulated eggs. We hypothesized that females treated with high dose CORT would produce the largest quantity of males, followed by low-dose females and finally controls. Final results will be discussed.

P3.38 POOLE, A.Z.*; WEIS, V.M.; FREITAG, M.; Oregon State University; poolea@science.oregonstate.edu

The role of DNA methylation in cnidarian-dinoflagellate symbiosis

Cnidarians such as corals and sea anemones, participate in a mutualistic symbiotic relationship with dinoflagellates of the genus *Symbiodinium*. The onset and breakdown of this symbiosis, known as bleaching, have been the subject of many investigations, though relatively few of these focus on the molecular biology of this relationship. Recent publications have revealed that there are differences in gene expression profiles of aposymbiotic, symbiotic, and bleached cnidarians, and also when the holobiont system is exposed to stressors such as temperature, disease, or heavy metals. This study investigates the potential for the role of epigenetic modifications in providing this differential expression using the tropical sea anemone *Aiptasia pallida*. Specifically, the role of the DNA methylation, which is associated with gene silencing and developmental processes is the focus of this study. While there is very little information available regarding epigenetic mechanisms in cnidarians, a full set of DNA methylation machinery has recently been characterized in the anemone *Nematostella vectensis*. In addition, there is growing evidence that DNA methylation is influenced by symbiosis in lichen and Rhizobium-legume models. In this study, the relative amounts of DNA methylation present in symbiotic and aposymbiotic *A. pallida* genomes was determined in order to elucidate the functional role of this epigenetic modification in cnidarian-dinoflagellate symbiosis.

P1.72 PIRES, A.*; LEWIS, E.L.; Dickinson College; pires@dickinson.edu

Regulation of Metamorphosis by Mechanosensory Stimulation and Catecholamines in a Gastropod

Larvae of many marine invertebrates metamorphose in response to chemical cues in the environment. However, the chemosensory induction of metamorphosis may be modulated by other sensory experience, or by the biochemical context in which metamorphic signal transduction occurs. We report that in the caenogastropod *Crepidula fornicata*, brief exposure to the catecholamine precursor L-DOPA (10^{-5} M, 30 min) resulted in 5-fold elevation of endogenous dopamine and potentiated metamorphosis in response to the natural cue, a pheromone derived from conspecific adults. Likely dopaminergic cells, localized by tyrosine-hydroxylase (TH) immunohistochemistry, were widely distributed in central ganglia and peripheral tissues. Among these cells were numerous peripheral somata with sensory morphology characterized by short apical processes leading to the epithelial surface, located around the mouth and in the tentacles and foot. Other TH-immunopositive cells with somata in the pedal ganglia innervated epithelia of the foot. Motivated by the hypothesis that mechanosensory activation of such cells may modulate metamorphosis, we stimulated larvae by gentle vortexing (10 Hz, 5 min) or repeated passage through a standardized pipet (aperture=1.5 x larval diameter, 50 cycles). Vortexing potentiated metamorphosis in response to natural cue in competent (13 d) larvae, and both treatments did so in younger (8 d) larvae that were becoming competent for metamorphosis. Mg^{++} anesthesia during vortexing abolished the potentiation of metamorphosis, suggesting that the effect of mechanical stimulation was synaptically-mediated and not a consequence of tissue damage.

P2.150 PORTER, W. R.*; WITMER, L. M.; Ohio University; wp298308@ohio.edu

Vasculature and dinosaur physiology: patterns in the extant realm

Some dinosaurs were among the largest animals known. Great size resulted in high heat loads that required efficient thermoregulation. In extant taxa, vascular systems play a key role in such thermal phenomena as evaporative and convective cooling and basking. Thus, we hypothesize that large-bodied dinosaurs had vascular mechanisms to deal with heat. To elucidate the thermoregulatory abilities of dinosaurs, a comparative study of the vasculature of extant taxa is necessary to show blood flow patterns, areas of thermal energy exchange, and vascular physiological devices. Blood vessels of birds (pheasant, turkey), alligators, and iguanas were injected with latex/barium solutions of differing concentrations to discriminate arteries and veins in CT scans and were studied with special attention to their relation to known sites of heat exchange (oral cavity, sinuses, orbital conjunctiva). The oral vascular plexus was extensive in the specimens examined. The anastomoses within the plexus increased rostrally along the maxillary palatal shelf and premaxilla. This pattern was present in birds, alligators, and lizards. The airway vasculature was extensive in birds and alligators, although more closely associated with the nasal conchae in birds, whereas in alligators it was more closely related to the entire length of the airway. In lizards, the airway vasculature was found within the nasal vestibule and along the length of the airway. Avian vasculature, which is known to function in thermoregulation, is similar to that found in alligators and iguanas, possibly suggesting comparable thermoregulatory abilities. The next phase of this project will characterize these physiological devices in a greater diversity of diapsids and identify the vascular osteological correlates that can be assessed in extinct taxa.

P2.129 PRADHAN, Devaleena S.*; GROBER, Matthew S.; Georgia State University; dpradhan1@student.gsu.edu

Inhibition of 11 β -HSD reduces 11-Ketotestosterone levels in *Lythrypnus dalli*

In many fish species, 11-Ketotestosterone (KT) is the primary androgen responsible for activating male breeding morphology and behavior. KT synthesis occurs via the sequential action of 11 β -hydroxylase (converts T to 11-hydroxyT) and 11 β -hydroxysteroid dehydrogenase (11 β -HSD, converts 11-hydroxyT to KT). Carbenoxolone (CBX), a specific 11 β -HSD inhibitor has been widely used to study glucocorticoid synthesis in the stress axis. Here, we asked whether systemic administration of CBX affects KT levels and sex typical morphology in *Lythrypnus dalli*, a bi-directionally sex changing fish in which 1) both sexes have similar levels of systemic, brain, and gonadal KT, 2) brain KT levels are several fold higher than the gonads, and 3) both systemic and brain KT increase transiently during protogynous sex change. Adult *L. dalli* were collected off the coast of California. After assessing body condition, opposite sex pairs were implanted IP with either 3:1 beeswax:CBX or beeswax only. Water-borne steroids were collected in isolated fish 1hr, 1d, and 4d after treatment. KT levels were similar in all groups 1 hr after treatment, and there was no effect of CBX in females. After 1d, there was a 48% decrease in KT in CBX implanted males. These levels were 30% lower than controls, but returned to baseline at 4d. There were no significant changes in body length, genitalia or gross gonad morphology 7d after CBX treatment. These results indicate sex differences in the effect of IP CBX implants. As CBX does not cross the blood brain barrier, the decrease we observed in males is likely due to gonad specific inhibition, suggesting low rates of ovarian KT synthesis and high rates of brain KT synthesis. The recovery at 4d suggests that KT inhibition in testis may be compensated by KT synthesis from the brain.

P2.11 PRYCE, K.*; SAMUEL, D.; MYRTHIL, M.; CATAPANE, E.J.; CARROLL, M.A.; Medgar Evers College, Brooklyn; catapane@mec.cuny.edu

Presence of Octopamine in Hemolymph and Tissues of *Crassostrea virginica* and its Possible Role as a Cardio-Regulatory Hormone

Octopamine (OA), a biogenic amine first identified in octopus, has been well studied in arthropods and a few gastropods. It is a neurotransmitter and hormone. OA has rarely been reported in bivalves and not reported in *Crassostrea virginica*. We used HPLC and Competitive ELISA to identify and measure OA in cerebral and visceral ganglia, gill, palps and hemolymph of *C. virginica*. HPLC was performed with an isocratic, ion-pairing Phenomenex Gemini 5 μ C18 column with a Beckman HPLC system and Jasco FP 2020 Spectrofluorometer. A Competitive ELISA was performed using wells coated with conjugated OA (BSA-G-OA) followed by standards and samples treated with primary anti-OA antibody. After washing, a HRP-labeled secondary antibody was applied and a colorimetric reaction quantified in a Molecular Devices SpectraMax M5 plate reader. HPLC showed OA present in ng amounts in gill, palps, cerebral and visceral ganglia, and hemolymph. OA levels increased after treatment with tyramine, an OA precursor. The OA peak was verified by injecting samples spiked with standard OA. ELISA confirmed the presence of OA in the samples. To determine a possible physiological role of OA in *C. virginica*, heart preparations were prepared *in situ* by removing right shells and connecting the ventricle to an isotonic transducer. Heart rate was monitored with a Narco Systems Physiograph. Basal rates averaged 5.6 beats/min. Superfusion of OA (10 μ M - 1 mM) increased it in a dose dependent manner. The study identifies OA in the nervous system, innervated organs and hemolymph of *C. virginica* by two methods and shows a possible physiological role as a cardio-regulatory hormone. The physiological role of OA in *C. virginica* and other bivalves should be further explored. This work was supported by grants 2R25GM06003-05 of NIGMS, 0516041071 of NYSDOE, 0622197 of NSF and P382A080040 of USDE.

P2.81 PRIESTER, C.*; MORTON, L.C.; KINSEY, S.T.; WATANABE, W.O.; DILLAMAN, R.M.; UNC Wilmington; cpl3791@uncw.edu

Distribution of nuclei in white muscle fibers of juvenile and adult black sea bass, *Centropristis striata*

Studies in our lab on white muscle fibers from blue crab and black sea bass, have demonstrated how diffusion limitations can influence organelle distribution. Here we investigated the distribution of nuclei at equivalent sites in juvenile and adult black sea bass ranging from 0.4g to 4840g. In large fish, samples were also compared at 6 sites along their length. Nuclei were counted in 1 μ m optical sections using confocal microscopy of DAPI-stained muscle fibers. As *C. striata* increased in body size, mean muscle cell diameter increased from 36 μ m in the 0.4g fish to 216 μ m in the 1885g fish. Growth beyond 2000g triggered the recruitment of new, smaller fibers (<120 μ m), creating a nearly bimodal distribution in fish from 2691g to 4840g. Mean fiber diameters in large fish (2258g-4840g) sampled frontal to caudal did not differ at any location, but, the most caudal region had a smaller range and coefficient of variation, and did not have very small or very large fibers. Nuclei in the smaller fibers were only subsarcolemmal (SS), whereas in larger fibers, nuclei were more numerous and included intermyofibrillar (IM) nuclei. The IM nuclei of large *C. striata* were not as evenly distributed nor as numerous as in the blue crab. They were either randomly distributed, or arranged in a ring pattern. This ring pattern of nuclei was only in large (>2000g) fish, and predominantly in the middle three sample regions of the fish, not in the caudal or frontal regions. Such a pattern may be the result of SS nuclei being uniformly released from the sarcolemma due to some unknown episodic event that only affected a portion of the fibers. In addition, examination of fiber diameters of age-matched versus size-matched fish indicated that mass, not age, determines fiber diameter.

P1.9 PUTNAM, Nicholas H; Rice University; nputnam@rice.edu

Testing for the action of selection on genome rearrangement dynamics deep in the metazoan tree.

Recent genome sequencing efforts have dramatically expanded the sampling of metazoan diversity represented among sequenced genomes. One unexpected result yielded by comparisons among these genomes is that large-scale organization of the genome is conserved from the eumetazoan ancestor in representatives of at least five metazoan phyla, while it appears to have been lost in other genomes. This conservation allows the reconstruction of chromosomal gene complements for very ancient animal ancestors, and reveal specific events of genome rearrangement along ancestral lineages. These reconstructions can be used to constrain the parameters of models of genome evolution. A still unresolved question is whether the observed conservation is the result of selection acting to preserve functional features of genome organization, or of slow neutral decay of the ancestral genome organization. I will present progress in testing neutral and non-neutral models against the data.

P3.81 RADE, CM*; WARD, AB; Adelphi University; cristinarade@gmail.com

Evolution of fin size and morphology in otophysan fishes

Highly elongate body forms are found in most major groups of vertebrates. Body elongation in tetrapods has often resulted in the reduction or loss of the pectoral and pelvic girdles. Few studies have focused on whether there is a correlation between body elongation and reduction or loss of the paired fins in fishes. In this study, the relationship between body shape and fin size and morphology in otophysan fishes was examined. Morphometrics of the body and fins from 33 species including members of Characiformes, Cypriniformes, Gymnotiformes, and Siluriformes were collected. Fin anatomy from two species: the deep-bodied *Carassius auratus* and the highly elongate *Apteronotus albifrons*, was described in order to determine whether fin reduction is correlated with a more simplified musculoskeletal anatomy. All of the species included had pectoral fins, with the exception of *Channallebes apus*. Nine species did not have pelvic fins and those species without pelvic fins were significantly more elongate than species with pelvic fins. With regard to reduction of paired fins, it was found that body elongation was negatively correlated with length and width of the pectoral fins, but not the pelvic fins. Surprisingly, the musculoskeletal anatomy of the pectoral fin was more complex in the elongate knifefish, which has reduced fins. It is likely that the increase in number of fin muscles is associated with fin use during locomotion. This work will provide an understanding of how fin size and anatomy differs among related species that range in body elongation.

P2.25 RAMOS, L.; OMONDI, C.; HALME, A.; FUSE, M.*; San Francisco State University, University of California, Berkeley; fuse@sfsu.edu

Ionizing irradiation produces a delay in pupation in the hornworm, *Manduca sexta*.

The imaginal discs in *Drosophila melanogaster* larvae are extremely resilient and are repaired extremely efficiently. Imaginal disc repair is facilitated by an endocrine-induced delay in pupation to accommodate repair of the damaged tissues. Damage within imaginal discs can be produced by the administration of high doses of irradiation during larval development. We have examined whether a similar delay can be induced by larval irradiation in another holometabolous insect, the hornworm *Manduca sexta*. *M. sexta* larvae are large and will be a useful model for characterizing the blood-borne factors regulating this developmental delay. We have found that irradiation of *M. sexta* larvae produces a dose-dependent delay in pupation as well as eclosion, in a manner similar to that seen in *Drosophila*. At low doses of irradiation, animals eclosed with minimal morphological abnormalities and were viable adults. At higher doses, adults showed significant abnormalities, but only occasionally were unable to eclose fully. Under these conditions tanning and hardening of the cuticle was also delayed. Blood transfer experiments from damaged to control animals appeared to induce delays in pupation, but to a lesser extent than seen in the damaged larvae, suggesting a blood-borne factor delays development.

P1.148 RAHEMI, H; NIGAM, N; WAKELING, JM*; Simon Fraser University, Burnaby, BC; hrahemi@sfu.ca
Effects of muscle pennation on its kinematics and force development

Force development, power production and mechanical efficiency of muscle fibers depend on the speed at which they shorten. In a pennate muscle, individual fibers are aligned with a pennation angle relative to the line of action of the muscle belly. Pennate muscles have typically been associated with high force production because of higher number of fibers they consist. Recent work indicates that rotations of fibers can change their gearing and mechanical effectiveness in case of controlling muscle force output and velocity simultaneously. Here we have modeled the role of pennation on the fiber length and force production of whole muscle. Muscle fibers had physiologic tension-length properties (passive and active), muscle bellies were assumed to maintain constant volume, and tendon and aponeurosis compliances was included. Muscles with greater initial pennation had lower gearing (muscle belly strain: fibre strain) and greater fiber rotations. Muscles with lower initial pennation developed greater force than would have been predicted from their resting physiological cross-sectional area and pennation alone. Whilst pennation does lead to increased muscle force, this is not its only role. When muscles contract their internal architecture changes and this may be utilized to maintain optimal gearing between the fibers and muscle belly. Muscle pennation alters the way the internal architecture changes during contractions.

P2.77 REAVES PIERCE, Holland*; RIQUELME, Cecilia A.; LEINWAND, Leslie A; SECOR, Stephen M.; University of Alabama, University of Colorado; hipierce@crimson.ua.edu
Python model of pathological cardiac hypertrophy

Cardiac hypertrophy is a physiologic/morphologic response to volume ('physiological hypertrophy') or pressure ('pathological hypertrophy') overload. Burmese pythons experience with feeding physiological cardiac hypertrophy, evident by a 20-30% increase in heart mass. Because pathological cardiac hypertrophy characterizes human heart disease and failure, mammalian models of pathological cardiac hypertrophy have been developed using transverse aortic constriction to generate chronic pressure overload. We modified this procedure for the python by completely ligating the left systemic artery, thereby forcing all cardiac output through the right systemic arch. This procedure has not resulted in any mortality and ligated pythons are active and feeding for many months. Compared to hearts of fasted, non-ligated snakes, ligation has generated a 20% increase in ventricular mass within one month, a level of increase observed for similar-size non-ligated pythons (500 - 550g) digesting rodent meals. When exposed to the combination of ligation and meal digestion, pythons responded with a 32% increase in ventricular mass. A morphological characteristic of pathological cardiac hypertrophy for mammals is an increase in interstitial connective tissue content. Using Masson's trichrome staining we observed a slight increase in the presence of fibrotic tissue for hearts from ligated snakes. In addition to exhibiting physiological cardiac hypertrophy during digestion, pythons potentially respond to pressure overload with pathological hypertrophy and hence increase their utility as a model to explore the signaling and cellular mechanisms of cardiac hypertrophy.

P2.104 RECCIA, L.*; MOOI, R.; California State Polytechnic Univ., Pomona, California Academy of Sciences, San Francisco; rmooi@calacademy.org

Cake sand dollars with combed tube feet: morphometry and phylogenetics of Indo-Pacific arachnoidid clypeasteroids

The genus *Arachnoides* (Clypeasteroidea: Arachnoididae) includes very flat, circular, sharp-edged sand dollars occurring on shallow-water sandy substrates in the Indo-Pacific. Unique among sand dollars, arachnoidid food grooves extend from the mouth to the apical system and are bordered by sometimes extensive fields of tube feet and spines arranged in highly regimented "combed" rows involved in food collection. Although some *Arachnoides* species occur in great abundance, few systematic analyses have been done on the group since its description by Leske (1778). The genus is surprisingly under-represented in collections, and its natural history and phylogenetics remain poorly known. Specimens are recorded from Australia to Papua-New Guinea in the east, and from the Philippines westward to Bangladesh. However, literature sources disagree on the actual range. This study uses basic morphometric differences in the overall shape of the known species, *A. placenta* (Linnaeus, 1858) and *A. tenuis* (H.L. Clark, 1938), to determine whether they exhibit variable morphologies throughout their ranges or if hitherto undescribed taxa exist. *A. tenuis* is restricted to Western Australia, but even within this distribution, variants exist that strongly suggest the presence of cryptic species. Upon determination of all terminal taxa, phylogenetic analyses can be performed not only on *Arachnoides*, but on the other genera in the family such as the New Zealand endemic, *Fellaster*, as well as *Ammotrophus* and *Monostychia* (the latter known only from fossils). A combination of morphometrics, phylogenetics, and biogeography can shed light on the evolution of these important sand dollars, focusing on the origins of their sharp, disk-like shape and peculiar combed arrangements of the spines and tube feet.

P1.122 REGELSON, K.W.*; COVI, J.S.; CHANG, S.A.; CHANG, E.S.; MYKLES, D.L.; Colorado State Univ, UC Davis Bodega Marine Lab, UC Davis Bodega Marine Lab; aindeamhan@gmail.com

Studies on the signaling pathways regulating facultative and constitutive ecdysteroidogenesis in the crustacean molting gland

Ecdysteroidogenesis in the molting gland, or Y-organ (YO), of decapod crustaceans is controlled by neuropeptides, molt-inhibiting hormone (MIH) and crustacean hyperglycemic hormone, produced in the X-organ/sinus gland in the eyestalks. Cyclic nucleotides mediate MIH control of YO ecdysteroidogenesis: cGMP primarily inhibits facultative synthesis, while cAMP primarily inhibits constitutive synthesis. MIH inhibition of facultative ecdysteroidogenesis may involve activation of NO-sensitive guanylyl cyclase, as NO donors can inhibit ecdysteroid synthesis. As constitutive synthesis requires translation of mRNA to protein, we hypothesized that cAMP suppresses insulin/metazoan Target of Rapamycin (mTOR) signaling. We are using *in vitro* YO culture to determine the effects of recombinant MIH and signaling antagonists on YO ecdysteroidogenesis. Eyestalk ablation (ESA) was used to activate YOs from blackback land crab, *Gecarcinus lateralis*, and green crab, *Carcinus Maenas*. Using reagents to block the activities of signaling molecules, we can identify components of the MIH signaling pathway. In addition, rapamycin will be used to examine the role of the mTOR pathway in the constitutive production of ecdysteroids. Supported by NSF (IOS-0725238).

P3.101 REES, S.R.*; BALTZLEY, M.J.; St. Mary's College of Maryland; sdrees@smcm.edu

Visualizing electrical connections between sensory neurons in two leech species, *Hirudo verbana* and *Macrobdella decora*.

The leech *Hirudo verbana* has four pressure mechanosensory neurons (P cells) in each midbody ganglion. Previous experiments indicate that there is weak electrical coupling between P cells in both *H. verbana* and the leech *Macrobdella decora*. To visualize this electrical coupling, we injected neurobiotin, a small molecule which can pass through gap junctions, into the P cells of adult *H. verbana* and *M. decora*. We visualized the neurobiotin by conjugating it with streptavidin-Cy3. The injections failed to show dye-coupling between P cells and any other neurons in adult *H. verbana*. Injections in adult *M. decora* showed P cells dye-coupled to other neurons within isolated ganglia, but not to other P cells. Because our dye-coupling results were inconsistent with those of previous experiments, we hypothesized that the neurobiotin may not pass between the cells if the gap junctions are a great distance from the soma, which may prevent neurobiotin from diffusing from the injected P cell soma to another P cell soma. Therefore, we also injected neurobiotin into P cells of juvenile *H. verbana*, which have smaller midbody ganglia. Similar to our results with adult *M. decora*, the P cells were dye-coupled to other neurons within isolated ganglia, but not to other P cells. There are several alternative hypotheses for our results. It is possible that the weak electrical coupling is due to a small number of gap junctions connecting the cells, preventing enough neurobiotin from passing to the coupled soma, or that the P cells are connected electrically through an interneuron, indicating that maybe enough neurobiotin didn't pass through to secondarily coupled-P cells.

P2.87 REISER, PJ*; BICER, S; PATEL, R; AN, Y; CHEN, Q; QUAN, N; Ohio State University; reiser.17@osu.edu

The Myosin Light Chain 1 Isoform Associated with Masticatory Myosin Heavy Chain in Mammals and Reptiles is Embryonic/atrial MLC1

We recently reported (J Exp Biol 212:2511-2519, 2009) that masticatory myosin heavy chain (MHC-M) is expressed as the exclusive or predominant MHC isoform in masseter and temporalis muscles of several rodent species, contrary to the prevailing dogma that rodents express almost exclusively MHC isoforms that are typically found in fast limb muscles and not masticatory myosin. We also reported that the same rodent species express the embryonic/atrial isoform of MLC1 (MLC1E/A) in jaw-closing muscles and not a unique masticatory MLC1 isoform that others have reported as being expressed in jaw-closing muscles of carnivores that express MHC-M. The objective of this study was to determine whether MLC1E/A is consistently expressed in jaw-closing muscles of other, non-rodent species, including members of Carnivora, which express MHC-M. Jaw-closing muscles and fast and slow limb muscles of nineteen species (six Carnivora species, one Primate species, one Chiroptera species, five marsupial species, alligator and five turtle species) were analyzed using protein gel electrophoresis, immunoblotting, mass spectrometry and RNA sequencing. Gel electrophoresis and immunoblotting indicate that MHC-M is the exclusive or predominant MHC isoform in jaw-closing muscles of each of the studied species. The results from all of the approaches collectively show that MLC1E/A is exclusively or predominantly expressed in jaw-closing muscles of the same species. We conclude that MLC1E/A is the exclusive or predominant MLC1 isoform that is expressed in jaw-closing muscles of vertebrates that express MHC-M, and that a unique masticatory isoform of MLC1 likely does not exist. Supported by the National Science Foundation.

P3.63 REYNA, K.S.*; BURGGREN, W.W.; University of North Texas; Reyna@unt.edu

Thermal stress during the pre-incubation period alters development, disrupts hatch synchrony, and reduces egg viability in developing northern bobwhites

Northern bobwhites (*Colinus virginianus*) are precocial game-birds experiencing population declines concurrent with climate warming. We sought to describe the relationship between high temperatures (T_a) and the ontogeny of northern bobwhites. We hypothesized that bobwhite embryos subjected to hyperthermic pre-incubation conditions would exhibit altered development, decreased hatch rates, and reduced hatchling metabolism. For the 12 days prior to incubation (the pre-incubation period), bobwhite eggs were exposed to 1 of 5 thermal treatments: low-fluctuating T_a (LF; 25–40°C), high-fluctuating T_a (HF; 30–45°C), or treatments of HF during pre-incubation days 1–4 (H1), 4–8 (H2), or 9–12 (H3) with LF during the remainder of pre-incubation. Normal incubation followed (23d @ 37.5°C). Morphologically, HF eggs developed more (stage 15) during the pre-incubation period than LF eggs (stage 4). Eggs from all treatment groups lost ~15% of fresh egg mass during the experiment; significantly more than control eggs (11%). Hatchlings from H1 and H2 groups had lower wet mass than control, HF and LF treated eggs ($P=0.02$). Physiologically, HF embryos had higher mean oxygen consumption ($30 \mu\text{l}\cdot\text{min}^{-1}$ stpd) than all other groups ($15\text{--}20 \mu\text{l}\cdot\text{min}^{-1}$ stpd) on day 10 of incubation; however no difference was detected during the remainder of incubation or as hatchlings. Mean hatch rates were lower for HF eggs (5%) compared to LF (52%) and Control (85%). The significantly reduced hatch rates experienced by groups receiving high, fluctuating heat suggest that the embryonic susceptibility of the bobwhite life-cycle contributes to population declines in the semi-arid regions of their range and may be a factor in population declines concurrent with climate warming.

P2.151 RICHTER, M.M.*; KOHL, F.; BUCK, C.L.; BARNES, B.M.; University of Alaska Fairbanks, University of Alaska Anchorage; mmrichter@alaska.edu

Effect of presence of post-hibernation food availability on reproductive development in male arctic ground squirrels (*Urocitellus parryii*)

The proportion of wild male arctic ground squirrels (*Urocitellus parryii*) (AGS) that become reproductively mature as yearlings is 50 to 100% in any given year. Males that do not become reproductively mature end their heterothermy 3-4 weeks before emerging above ground during which they eat cached food, recoup body mass lost over winter and develop spermatogenic testes. Males that fail to initiate reproductive development their first year end heterothermy six or more weeks later and emerge from hibernation directly after becoming euthermic at 70-50% of their pre-immigrant mass. We tested the hypothesis that the presence or absence of available food determines whether juvenile males become reproductively mature in spring. Wild-caught juvenile male AGS were placed in a cold chamber (2°C) in fall and allowed to hibernate. In February, one group was given a cache of 200g of food, while the other group had all food removed from their cages. Upon terminal arousal in spring, all animals were weighed, sampled for blood and evaluated for reproductive status every 5 days for 20 days. Animals in the group that did not receive a cache were placed on a diet to maintain weight. Our results suggest that the presence or absence of ad libitum food after heterothermy ends is not essential for an animal to undergo reproductive maturation. There was a trend for pre-hibernation body mass to influence the end date of heterothermy ($p=0.062$), but not the date of entry ($p=0.49$) or the overall duration of heterothermy ($p=0.109$). January body mass, however, did not differ between animals that became reproductively mature and those that did not ($p=0.191$).

P2.7 RICHMOND, J.P.*; REA, L.D.; ZINN, S.A.; University of Connecticut, Storrs, Alaska Department of Fish and Game, Fairbanks; julie.richmond@uconn.edu

Steller sea lion (*Eumetopias jubatus*) leptin cDNA Sequence Homology

Increased circulating concentrations of leptin are observed with increased adiposity in most mammalian species, but this relationship is not clear in pinnipeds. This suggests that either leptin may be differentially regulated in pinnipeds or that contrasting results may be due to reduced sensitivity of multi-species assays used to quantify hormone concentrations. Either hypothesis necessitates an understanding of the sequence homology of leptin for experimentation. The objective of this research was to sequence leptin cDNA in Steller sea lions and determine the homology among various mammalian species. Adipose tissue was collected from free-ranging Steller sea lions ($n=3$). Total RNA was isolated from adipose tissue (Promega SV Total RNA Isolation), and quantified by spectrophotometric (NanoDrop 1000) and electrophoretic methods (Experion RNA StdSens Analysis). RNA was reverse transcribed to cDNA (Promega RT System) and amplified with canine leptin primers using standard PCR methods. The cDNA product was sequenced using 3130XL Genetic Analyzer. The cDNA sequence of Steller sea lions is 92% homologous with dog, but shares only 84% homology with mouse. This difference in cDNA results in an inferred Steller sea lion protein sequence that shares approximately 89% and 74% homology with dog and mouse, respectively. Due to the differences in cDNA sequence between mouse and sea lions careful interpretation of results from studies that have used mouse based immunoassays must be employed. Results using mouse based immunoassays may be inaccurate due to variability in protein structure resulting in poor assay accuracy. Based on inferred protein structure, if heterologous assays must be used, antisera to canine leptin may have better potential for accurate assessment of sea lion leptin.

P3.52 RIDGWAY, R.L.*; JAMES III, J.A.; AUDET, E.K.; Seattle Pacific University; rridgway@spu.edu

Effects of High Extracellular Zinc on Hemocytes of the Pond Snail, *Lymnaea stagnalis*

Hemocytes plated onto gelatin-coated slides undergo characteristic morphological changes over time that can be divided into stages: I) initial surface attachment (2-10 min); II) cell flattening/membrane spreading (5-15 min); III) filopodial extension/motility initiation (10-30 min); IV) cell polarization/directional movement (20-60 min). Correlated with these stages are dynamic shifts in cytoskeletal organization, as visualized using fluorescent probes specific for microtubules and microfilaments. Here we examined the effects of extracellular ZnCl_2 exposure (range: 10^{-6} M to 10^{-3} M) on hemocyte morphology and cytoskeletal organization. In preparations fixed 5 min after plating, 31% of control cells had attained Stage II or greater compared to 12% of 10^{-4} M and 1% of 10^{-3} M ZnCl_2 -exposed cells. At 60 min after plating, 97% of control cells and 90% of 10^{-4} M ZnCl_2 -exposed cells had attained Stage II or greater, compared to only 30% of 10^{-3} M ZnCl_2 -exposed cells. Differences in the organization of microfilament-based structures were minimal in ZnCl_2 -exposed cells relative to control cells at the same stage. The distribution and complexity of microtubule networks was impacted in 10^{-3} M ZnCl_2 -exposed cells, but this was less evident in 10^{-4} M ZnCl_2 -exposed cells. Our results suggest that these immune system cells possess homeostatic mechanisms (e.g., zinc-binding metallothioneins, vesicular sequestration) which maintain cytosolic labile zinc at low levels. The mechanisms appear adequate provided extracellular zinc concentration is less than 10^{-4} M; higher zinc concentrations can affect cytoskeletal structure and may thus compromise hemocyte function. (Funded in part by a SPU Senior Faculty Research Grant to RLR.)

P3.100 RINEHART, Marc D.*; BELANGER, Jim H.; West Virginia University; jim.belanger@mail.wvu.edu

Biologically realistic limb coordination during walking in the absence of central connections between legs

Neuronal control of interlimb coordination during walking is not fully understood. Load and position cues are thought to influence stepping coordination between legs, but it is unclear if central connections between legs are required. To test this, we created a crayfish model in the simulation environment AnimatLab. In the model, all legs are identical, and receive sensory feedback from three sources: position sensors at each joint, a contact sensor at the dactyl, and a load sensor. All legs are driven by individual oscillators. That is, all legs function independently of each other with no direct connections between the legs. The model can produce realistic walking behavior without load feedback. The only sensory cue that is necessary is from the contact sensors. In walking simulations, legs nearest the center of mass showed a preferred coordination with ipsilateral and contralateral neighbors. Legs farther away from the center of mass displayed more variability in coordination. Contact information was also sufficient to change the characteristics of leg oscillations, i.e. cycle periods and stance durations. We also tested the effects of limb amputations. In intact models, coordination between adjacent ipsilateral legs is predominantly alternating. After amputation of a leg, the two intact neighboring legs assume an alternating coordination. These results are very similar to those observed in actual crayfish. These findings suggest that interlimb coordination in multi-legged animals does not have to be integrated into the dedicated neuronal network that produces walking. Instead, coordination can be an indirect result of the coupling of individual leg oscillators through the environment.

P1.30 ROBIN, F.B.*; SHERRARD, K.M.; MONTGOMERY, M.; SEMON, S.; MUNRO, E.M.; University of Washington and University of Chicago, University of Washington, University of Washington; rbfr@u.washington.edu

A propagating zone of localized protrusive and contractile activity drives zippering and neural tube closure in ascidians.

The ascidian neural tube forms by neurectoderm folding, followed by fusion of the neural folds at the dorsal midline by a posterior-to-anterior "zippering" process. Using time-lapse fluorescence microscopy, we found that neural closure is accompanied by the constriction of a supra-cellular purse string-like actin cable that develops at the boundaries between presumptive neurectoderm and lateral epidermis. Significantly, constriction of the purse string is strongly biased to its posterior end where it is accompanied by highly localized protrusive activity and cortical contractility. Immunostaining of fixed embryos and time-lapse microscopy of live embryos revealed that the active RhoA and active forms of Myosin are similarly localized to the highly contractile posterior zone, which propagates posterior to anterior and cell to cell as zippering proceeds. Blocking the Rho-pathway kinase ROCK with the inhibitor Y-27632 leads to loss of localized activated Myosin and specifically causes the zipper to collapse and the entire purse string to relax. Following fusion of opposed neural fold cells, midline cells are first dragged anteriorly as the zipper progresses further forward, then abruptly released as the apical domains of presumptive dermal and neural cells lose contact. The result of this process is to form two epithelia (one neural, one dermal) from a single initial epithelial layer. Our data highlight the existence of a "morphogenetic organizer" that coordinates supercellular force generation in time and space to achieve the completion of an essential step in chordate development.

P1.119 RO, J.*; WILLIAMS, J.B.; Ohio State Univ.; ro.25@buckeyemail.osu.edu

Cutaneous and Respiratory Water Loss of Temperate Passerine Birds

Amongst various functions of the vertebrate skin, its ability to impede water loss is critical for survival in terrestrial animals. The outer layer of skin, the stratum corneum is comprised of cornified cells surrounded by an intercellular lipid matrix. Lipids in the SC are thought to be responsible for forming a tight water barrier, but the generality of this idea remains untested. In this study, we measured cutaneous water loss (CWL) and respiratory water loss (RWL) of 12 species of temperate passerine birds from a variety of families. At thermoneutral temperatures, whole organism CWL of temperate birds amounted to, on average, 64.2% of total evaporative water loss. This emphasizes that CWL is a fundamental component of the water economy of birds. Normalized RWL and CWL among temperate passerines averaged 57.6 mg H₂O/g, and 27.8 mg H₂O/cm²•d, respectively. Although we found differences in RWL among species, surface specific CWL was statistically indistinguishable across the temperate passerine birds, despite their taxonomic and ecological differences. We hypothesized that water vapor diffusion across the skin was subjected to biological control and tested this idea by comparing CWL of alive and dead birds. When birds were dead, CWL was significantly reduced by 13% suggesting that CWL is under biological influence. The composition of intercellular lipid matrix is influential in determining CWL. We found that ceramides, fatty acid methyl esters, sterol esters and cembranoids were major constituents of the avian stratum corneum. Variation in CWL was positively associated with amount of ceramide 3 and cerebroside 3, but these combined represented less than 2% of the total lipids.

P2.49 ROCK, M.O.*; DAVIS-BERG, E.C.; Columbia College Chicago; octopustank@gmail.com

Embryogenesis and Development of the Sea Urchin *Arbacia Punctulata* in the Presence of the Environmental Toxin Hypochlorite

Sodium hypochlorite or bleach, found in wastewater from treatment plants and untreated runoff, can act as an environmental toxin. The sea urchin *Arbacia punctulata*, is a common subject of many embryological toxicity tests due to the sensitivity of the subject to environmental pollutants. Little published work has focused on the effects of sodium hypochlorite on sea urchin larval development, and the purpose of this research was to create a pilot study for sodium hypochlorite embryological toxicity testing in the laboratory. Sea urchin eggs and sperm were collected and fertilized then left to develop in seawater chlorination levels to mimic those found in chlorinated wastewater (0.125, 0.0625 and 0.03125 ppm Cl and a control). Effects were minimal on development and fertilization of *Arbacia punctulata*, though in many cases the embryos were smaller and took longer to develop at higher concentrations of sodium hypochlorite. While treatment of different dilutions of sodium hypochlorite did not predict the ratios of normal to abnormal embryos, treatment did seem to effect skeletal length. The average lengths for normal embryos were 27.17 µm for the control treatment, 28.38 µm for the 0.03125 treatment, and 25.77 µm for the 0.125 treatment. This study leads the way to further research on the metabolic effect of sodium hypochlorite on developing embryos in regards to retarded growth. Additional studies may include higher concentrations of sodium hypochlorite and toxicology studies with other embryological indicator organisms.

P3.5 ROJAS, M*; SCHIZAS, N.V.; University of Puerto Rico, Mayagüez; monicarojasp@gmail.com

Genetic Population Structure of Two Brittle Stars (*Ophiocoma echinata* and *Amphipholis squamata*) With Contrasting Life Histories

Knowledge of the genetic population structure of species is required for sustainable management plans, since changes in population dynamics and demographics have direct consequences on the exploitability and sustainability of species. Echinoderms display a wide array of life histories, which can have a profound effect in the dispersal potential and population structure of species. The brittle stars *Ophiocoma echinata* and *Amphipholis squamata* are commonly found in the shallow waters of the Caribbean Sea. The two species exhibit differing modes of development: *O. echinata* is a spawning species having asynchronous breeding cycles and *A. squamata* is a brooding species, viviparous and self-fertilizing hermaphrodite. Their overlapping geographic range offers the potential to compare their genetic population structure as generally, brooders are expected to exhibit higher population subdivision than spawners. Mitochondrial (16S) and ribosomal nuclear DNA sequences (ITS-1) were recovered from eight populations of *O. echinata* and *A. squamata* around the Caribbean. Preliminary results indicate that the spawning *O. echinata* harbors high levels of genetic variability in the mitochondrial gene 16S (115 specimens, 33 haplotypes). There is significant population structure ($F_{ST} = 0.10259$; $P = 0.00978$) among specimens distributed in the eastern Caribbean and Panama. Pairwise F_{ST} comparisons indicate that there is a genetic break between eastern and western Caribbean. Samples of *A. squamata* are currently processed from Caribbean localities to compare the effect of different life histories in the population structure of species.

P1.27 ROMNEY, Amie L*; REIBER, Carl L; Univ. of Nevada, Las Vegas; romneya@unlv.nevada.edu

Embryonic development and cardiac morphometrics of the Grass shrimp *Palaemonetes pugio*

Variation in developmental strategies among the Decapoda represents their successful adaptation to diverse environmental conditions. Such variation can range from patterns of direct development, where an extensive embryonic period is followed by a shortened larval stage, to patterns of regular development where a shortened embryonic period is followed by a lengthened larval stage. Having multiple larval stages allows for transitional steps throughout development whereby an animal can compensate appropriately for varying environmental parameters. The Grass shrimp, *Palaemonetes pugio*, inhabits the brackish waters off the Atlantic and Gulf coasts where salinity concentrations constantly fluctuate from daily to seasonally. Larval development of the Grass shrimp has been reported by Broad (1957), yet to fully understand the physiological and morphological ontogeny of these animals, embryonic development must be described. Here, we document the embryonic development of the Grass shrimp and establish an 8 stage sequence. Under control conditions, (25°C, 30-32 ppt sea water), average time for embryonic development took approximately 12 days. Morphological changes were observed under stereomicroscope and further characterized by photo and video imaging. Features of the Grass shrimp throughout development can be used to compare embryonic and larval developmental rates with other Decapoda under various environmental conditions. Furthermore, phenotypic differences within and between similar species can be identified and related to environmental changes and developmental plasticity.

P2.110 ROLIAN, Campbell*; LIEBERMAN, Daniel; HALLGRIMSSON, Benedikt; University of Calgary, Harvard University; campbellrolian@gmail.com

Did human fingers and toes coevolve?

Human hands and feet have similarly derived digital proportions compared to African apes, including longer, more robust first rays, and shorter lateral rays. These similarities are often assumed to be independently-evolved adaptations for manipulative activities and bipedalism, respectively. However, hands and feet are serially homologous structures that share virtually identical developmental blueprints, raising the possibility that some aspects of digital morphology coevolved in human hands and feet because of underlying genetic/developmental linkages that increase phenotypic covariation between them. Here we show that magnitudes of covariation between homologous traits in the feet and hands of *Homo*, and especially *Pan* not only exceed the average level of covariation across all traits, but also exceed covariation magnitudes within these structures. Further, when subjected to episodes of simulated directional selection, this increased covariation causes the fingers and toes to evolve along highly parallel trajectories, even when selection pressures push their means in divergent directions. Our estimates of the selection pressures required to produce human-like fingers and toes from a chimpanzee-like ancestor indicate that selection on the toes was substantially stronger, and likely led to parallel phenotypic changes in the hands. Our data not only support the hypothesis that human hands and feet coevolved, but also suggest that the evolution of long robust big toes and short lateral toes for bipedalism led to changes in hominin fingers that may have facilitated the emergence of stone tool technology.

P1.149 ROSARIO, M. V.*; TAYLOR, J. R. A.; PATEK, S. N.; Univ. of California, Berkeley, Univ. of Massachusetts, Amherst; michaelvrosario@gmail.com

Probing the evolutionary biomechanics of elastic energy storage in mantis shrimp

Structural and biomechanical variation in elastic energy storage mechanisms is fundamental to the rich evolutionary diversity of fast movements. Mantis shrimp (Crustacea: Stomatopoda) power their fast and powerful predatory appendages with an exoskeletal compressive spring. Here we compare the mineralization patterns of the spring and elastic energy storage mechanics across 10 species of mantis shrimp, including species with hammer-like, spear-like and intermediate raptorial appendage forms. Using computed tomography to visualize mineralization patterns, we found that the primary spring is conserved across all species, but its size, length and articulations vary considerably. A materials testing machine was used to measure the maximum compression force of the spring and the spring constant. We found that spring constants were nearly overlapping across species, even with a 200-fold range in body mass; however, body size scaling relationships varied across taxa. For example, three taxa exhibited no correlation between spring mechanics and body size while *Gonodactylaceus falcatus* exhibited a significant positive correlation between body size and maximum compression force and a non-significant association with spring constant, and *Gonodactylus chiragra* showed no correlation between body size and maximum force and a significant negative correlation with spring constant. This variation in spring form and mechanical behavior suggests that different prey capture strategies may indeed be associated with evolutionary variation in the underlying power-amplifying springs.

P2.128 RUIZ, ME*; MCNERNEY, CA; HORNING, KL; TAYLOR, EN; STRAND, CR; Allan Hancock College, Cal Poly State Univ.; cstrand@calpoly.edu

Orexin/hypocretin immunoreactivity in the brains of fed and fasted ball pythons (*Python regius*)

Orexin/hypocretin peptides are involved in food intake, energy balance, and regulation of sleep/wake states. The distribution of orexin-immunoreactive(ir) cells and fibers in the brains of birds, mammals, lizards, and amphibians has been documented. Various hypothalamic nuclei contain the soma of orexinergic neurons, depending on the taxa. Differences in the location of orexinergic neurons between taxa may indicate roles for this neuropeptide in regulation of homeostasis. Although in mammals there is not a difference in the expression of orexin based on food intake, central orexin administration does stimulate feeding. The goal of this experiment was to investigate the distribution of orexin-ir cells and fibers in the brains of fed and fasted ball pythons, *Python regius*. Since pythons eat infrequently and exhibit numerous physiological responses to feeding, they will make for an interesting comparison to other vertebrates in identifying the role orexins may play in regulating feeding behavior and energy homeostasis.

P2.125 SARGENT, ML*; LOVERN, MB; Oklahoma State University; michelle.sargent@okstate.edu

Short- and long-term consequences of yolk steroid exposure for green anole lizards

Maternal effects can influence progeny in myriad ways; one pathway for such effects is hormone transfer from mother to offspring. In oviparous species, steroids including testosterone (T) and corticosterone (CORT) are transferred to the yolk during egg formation, where they may have both short- and long-term consequences for offspring. Although short-term effects have been amply demonstrated, few studies have followed offspring into adulthood to determine long-term effects. We document baseline hatching success, growth, and behavior of a laboratory colony of green anole lizards, *Anolis carolinensis*, and we compare these results to those obtained for lizards raised and housed identically but exposed to experimentally elevated levels of yolk steroids. We demonstrate that we can successfully maintain lizards from egg to adulthood that exhibit high survival and sex-typical growth and behavior. Males and females hatched and raised in the laboratory in 2008 obtained reproductive competence in 2009; we currently are raising the offspring that resulted from those eggs. In 2009, we applied 5 μ l of either 95% ethanol alone or 95% ethanol containing 5 μ g of T or CORT to the surface of freshly oviposited eggs collected from wild-caught females; we also left some eggs untreated. Compared to untreated, ethanol-treated, and T-treated eggs, CORT-treated eggs took significantly longer to incubate and produced significantly smaller hatchlings; hatching success for CORT-treated eggs also was significantly lower (30% vs. 82-83% for the other groups). We additionally will provide data on sex-specific survival, growth, and behavior of these juveniles to determine the extent to which embryonic exposure to T or CORT may produce long-lasting effects on offspring phenotype.

P1.8 SANTONI, AM*; ALLEN, JD; Randolph-Macon College, College of William and Mary; amandasantoni@students.rmc.edu
Predator induced plasticity in maternal investment of the mud snail *Ilyanassa obsoleta*

Phenotypic plasticity occurs in various organisms including marine gastropods. In many instances plasticity is a defensive response to predator cues in the environment. In addition to a morphological response to predator cues (e.g. increasing shell thickness), gastropods can also respond behaviorally by changing their investment in reproduction. While plasticity in gastropods has been demonstrated in adult and larval stages, our understanding of plasticity in reproductive investment is poor. Our study tested whether the presence of predators can induce changes in the maternal investment of the mud snail *Ilyanassa obsoleta*. We exposed mud snails and their egg capsules to the marine predators *Carcinus maenas*, *Pagurus longicarpus*, and *Littorina littorea*, as well as a no predator treatment. As a positive control, *I. obsoleta* were also exposed to the urchin *Strongylocentrotus droebachiensis* which are not known to prey on mud snails or their egg capsules. In order to distinguish between responses of adults and responses of embryos, snails were exposed to predator treatments either throughout the entire experiment, only when laying, or only as encapsulated embryos. Because of the complex life cycle of *I. obsoleta* (intracapsular development, followed by a free-swimming larval stage), it was expected that egg size would decrease, hatching times would also decrease and therefore larvae would escape benthic predation by entering the water column sooner. Adult *I. obsoleta* responded to cues from *C. maenas* by increasing the number of eggs allotted per egg capsule. However, egg size was not affected by the presence of predators. We will also discuss the effects of predator exposure on egg capsule morphology, time to laying and time to hatching.

P3.60 SCHOLNICK, David A.; HAYNES, Vena N.*; NYERGES, Gyorgyi; Pacific University, Oregon, Pacific University, Oregon; david.scholnick@pacificu.edu

Influence of Hypoxia on *Psychrobacter* Levels in the Dungeness Crab, *Cancer magister*

Decreases in environmental oxygen, similar to those experienced by many coastal marine crustaceans, can limit the ability of crabs to respond to indigenous bacteria in the hemolymph and increase the rate of bacterial infection. Male Dungeness crabs, *Cancer magister*, were collected off of the central Oregon coast and maintained in UV sterilized seawater at 9°C. Innate bacteria was characterized from hemolymph isolated from crabs exposed to either 50 or 100% air-saturated water for 3 h. A partial 16S rDNA sequence (1490 nucleotide), amplified from the isolated bacteria, showed 99% identity to 16S rRNA genes from multiple *Psychrobacter* strains. In order to test the hypothesis that hypoxia impairs antibacterial defense against *Psychrobacter*, crabs were injected with buffered saline (control) or buffered saline with isolated *Psychrobacter* (2.5 X 10⁴ g⁻¹ body weight) following exposure to 3 h of hypoxia or under 100% air saturation conditions. Hemolymph was sampled before injection and at 10, 20, 40 and 80 min afterward. Saline injections produced no change in the bacterial or hemocyte counts under hypoxia or air-saturation. The total number of *Psychrobacter*, measured as colony forming units (CFU) present per mL of hemolymph, was not significantly different between animals held in hypoxic water when compared to normoxia. Injection of *Psychrobacter* decreased circulating hemocytes regardless of oxygen levels although the number of hemocytes were significantly higher in hypoxic crabs compared to normoxic (8.2 versus 3.8 million respectively) 80 min after bacterial injection. These data demonstrate that *Psychrobacter* is present in Dungeness crabs and that low oxygen may limit immune response.

P2.141 SCHOLNICK, David A.*; MANIVANH, Richard V.; NELSON, Whitney N.; Pacific University; david.scholnick@pacificu.edu

Effects of Malaria Infection on Post-Exercise Thermoregulation and Metabolism in the Western Fence Lizard, *Sceloporus occidentalis*

Western fence lizards (*Sceloporus occidentalis*) infected with the malarial parasite, *Plasmodium mexicanum* select higher recovery body temperatures and have elevated cost of recovery when compared to uninfected lizards. Malarial infections depress hemoglobin concentrations by as much as 25% and elevate post-exercise lactate levels by almost 30%. Western fence lizards collected from southern Oregon and central California were screened for *P. mexicanum*. Lizards were placed in a temperature controlled treadmill at preferred body temperature (34.5°C) and induced to walk at constant speed for 5 minutes (0.7 m min⁻¹) or sprint maximally (2 min of activity). Blood lactate and glucose levels were measured before activity, immediately after activity, and at 15, 30, 60 and 90 min during recovery. Malarial infections decreased lizard resting blood glucose levels and induced hyperglycemia post-exercise. Blood glucose was 27% higher in malaria infected lizards than uninfected lizards after 60 min of recovery. Elevated body temperatures following activity decreased lactate removal rates in malaria infected lizards by 1.5 times but had no significant effect on uninfected lizards. In a separate set of experiments hemoglobin concentrations in uninfected lizards were lowered by 25% in order to determine the impact of anemia associated with malarial infection upon recovery metabolism. Uninfected-anemic lizards had increased post-exercise oxygen consumption and blood glucose concentrations similar to malaria infected lizards. These results suggest that anemia associated with malaria infection can partially explain the elevated cost of recovery and disruptions in glucose regulation following activity.

P3.30 SCHULZE, Anja*; ODUM, Lerin; Texas A&M University at Galveston; schulzea@tamug.edu
Detection of non-indigenous species in Galveston Bay, TX by DNA barcoding of zooplankton

The Houston Ship Channel (HSC) connects the Port of Houston to the Gulf of Mexico, traversing a range of salinities in Galveston Bay. The HSC experiences some of the highest ship traffic in the US, potentially facilitating the introduction of non-indigenous species (NIS). Detection of benthic NIS can require extensive surveys, which may be disruptive to the environment. However, most benthic invertebrate species that have a tendency to become established in new habitats produce planktonic larvae. We are using a DNA barcoding approach to examine zooplankton for the presence of NIS, including both the larvae of benthic species and holoplanktonic species. We collect monthly plankton samples at six stations in Galveston Bay with different distances to the HSC and different salinities. Each sample results from the filtration of 24 l of water. Any meroplanktonic or holoplanktonic invertebrates are sorted microscopically to morphotypes and processed for sequencing of the cytochrome c oxidase subunit I gene (COI), the most commonly used barcoding sequence. The morphotypes are photographically documented. In addition, we take biweekly shore-based plankton samples which are evaluated qualitatively at one station near the entrance of the HSC to the Gulf of Mexico. Each generated sequence is submitted to a GenBank BLAST search. If a close match is found, the geographic distribution of the respective species is researched in the literature and compared to a list of 37 target species that could potentially become invasive in Galveston Bay. Our data show the presence of several species that have previously been reported from the Gulf of Mexico but not from Galveston Bay and others that have not previously been reported from the Gulf of Mexico. Whenever possible, we are aiming to confirm the species identities by sequencing samples of adults with confirmed identifications.

P2.80 SCHROEDER, J.R.*; MCCORMICK, M.M.; PREHODA-WYERS, M.M.; DEAROLF, J.L.; Hendrix College, Conway, AR; schroederjr@hendrix.edu

The effects of betamethasone on myosin expression patterns of fetal *Cavia porcellus* rectus thoracis muscle

Betamethasone, a glucocorticoid, can be administered to pregnant women likely to give birth prematurely in order to accelerate the development of their fetus' organs. While much research has focused on determining the effects of this treatment on fetal lungs, little research has been conducted on their effects on the ventilatory muscles. Glucocorticoids are known to switch the cell cycle from proliferation to differentiation. In muscles, differentiation involves changes in myosin heavy chain expression. Specifically, fetal myosin will decrease in expression and is replaced by adult isoforms: neonatal, IIA, IIX (fast) and I (slow). From these ideas, our hypothesis is that the *Cavia porcellus* fetal rectus thoracis exposed to glucocorticoids will display more adult fast (neonatal, IIA, IIX) myosin isoforms than control muscles. To test this hypothesis, pregnant guinea pigs were injected with either betamethasone (0.5 mg/kg) (treated) or with sterile water (control) at 70% gestation. An assessment of the fetal myosin profile occurred with the use of 7% acrylamide, 30% glycerol gels ran at 275V, 10° C for 24 hours. After silver staining and drying, the gels were analyzed with Scion Image in order to determine the proportions of fetal, neonatal/IIA/IIX, and slow MHC isoforms each sample expressed. If our hypothesis is supported, the treated fetal rectus thoracis will contain more adult fast myosins than our control muscles. Therefore, the treated muscle should then express the characteristics, fatigue resistance, and oxidative capabilities of adult muscle. These abilities potentially mean that the rectus thoracis muscle will have more functionality in the case of pre-mature birth and be better suited to support neonatal ventilatory demands.

P3.144 SCHUTZ, H*; ESCOBAR, R.A. III; GARLAND, T. Jr.; Univ. of California, Riverside, Loma Linda Univ.; heidisc@ucr.edu

Responses of Scapular Size and Shape to Exercise and Selective Breeding for High-Activity in Mus

Various studies on rodent long bones show that chronic exercise produces a variety of osteological responses, including increased bone diameter and mass. Studies of skeletal responses to voluntary exercise in flat bones, such as the major girdle elements (e.g. scapula), are scarce, but show that scapular shape is also responsive to different types of exercise. A previous study used hindlimb bones of house mice selected (S) for high voluntary wheel running and non-selected controls (C) to examine responses to 8 weeks of wheel access and breeding for high activity (J. Morphology, 2006, 267:360-374). With body mass as a covariate, long bones showed significantly greater diameters and masses in response to both wheel access and selection. Additionally, S mice with the mini-muscle phenotype (50% reduction in hindlimb muscle mass) had longer, thinner long bones, but no differences in bone mass. Employing the same mice, we used geometric morphometrics to generate quantitative descriptors of scapular shape, centroid size, and a series of linear measurements from which we calculated ratios previously used to quantify scapular proportions. As previously reported, S mice were smaller in body length and mass than C, and access to wheels reduced body mass in both S and C mice. ANCOVA showed no differences between the S and C lines in scapular mass, centroid size, ratio of scapular mass/centroid size (SM/CS) or relative width. However, wheel access significantly increased scapular mass and SM/CS in both groups. Finally, S mice with the mini-muscle phenotype had significantly narrower scapulae, larger centroid sizes, and a smaller SM/CS. Supported by NSF IOB-0543429.

P2.31 SCHWARZ, B.*; LANK, D.B.; IRWIN, D.E.; Simon Fraser University, Canada, University of British Columbia, Canada; bschwarz@sfu.ca

Who travels where: unraveling population structure, migratory connectivity, and song patterns in Western Sandpipers

Western Sandpipers (*Calidris mauri*) are long-distance migrants that breed in Western Alaska and Eastern Siberia. In the winter they migrate south to sites along the west coast from southern North America to northern South America. A small part of the population winters on the east coast and in the Caribbean. Data on morphological differences gathered on various wintering grounds indicate that different subpopulations may exist in this species. In addition, juveniles that winter further south seem to show a profoundly different life history than those wintering further north in that they are more likely to remain on the non-breeding grounds throughout the summer and not reproduce until their second year. We are currently investigating the genetic population structure of Western Sandpipers. We will determine the degree of genetic variation between different breeding sites and develop suitable markers for each site. We will then use these markers to determine the breeding origin of birds on the wintering grounds and at migratory stopover sites to detect possible patterns of migratory connectivity. If population differentiation exists in this species, it might be maintained through differences in mating vocalizations. During the breeding season, male Western Sandpipers perform display flights during which they emit a species-specific song. We will analyze recordings from major breeding sites to investigate whether songs differ between these sites. We will then compare acoustic and genetic data sets to investigate whether population differentiation in shorebirds might be maintained by similar mechanisms as those shown for songbirds.

P3.13 SEARS, MW; Bryn Mawr College; msears@brynmaur.edu

Spatial arrangements of thermal habitat mediate competition for space

When facing tradeoffs between thermoregulation and food acquisition, theory predicts that individuals should thermoregulate more carefully under high productivity. Often, though, individuals make thermoregulatory decisions in the presence of others. In these cases, the potential for exploitative competition exists and individuals should thermoregulate less carefully. Contrarily, if competition is through interference, theory suggests that individuals might benefit from more careful thermoregulation. Here, I explored these predictions more thoroughly in a spatial context where I distributed thermal resources in various arrangements. In a set of simulations, I allowed two differently sized lizards to thermoregulate, both alone and together, amongst several thermally structured environments. I assigned specific rules to individuals to search amongst patches for environmental temperatures that would provide maximal energy assimilation. Additionally, I assigned further rules of engagement to individuals such that larger individuals were more likely to win encounters with smaller individuals and retain their positions. All habitat was configured such that 25% of the available patches contained temperatures within the preferred range of body temperatures. I assigned temperatures which were outside of this range to the remaining habitat patches. When thermoregulating together in a configuration where all favorable patches were clumped, larger individuals thermoregulated more accurately while incurring lower energetic costs than did smaller individuals. In contrast, these individuals exhibited comparable performance when thermoregulating alone. In habitat configurations with evenly distributed favorable patches, differences in thermoregulatory performance disappeared. This result occurred because individuals partitioned space in a manner which minimized contact with one another, thereby reducing the potential for interference competition.

P2.153 SEARS, K.E.*; MESSERMAN, A.F.; KERKHOFF, A.J.; ITAGAKI, H.; Kenyon College; kerkhoffa@kenyon.edu

Modeling growth and metabolism in *Manduca sexta* larvae: variation across individuals and instars

Metabolism and material exchange with the environment are complex and intricately related processes that depend heavily on animal size. We developed a model of larval growth for the tobacco hornworm, *Manduca sexta*, an organism that grows 10,000-fold in approximately 18 days. Based on detailed daily measurements of food intake, frass production, carbon and nitrogen assimilation, animal mass, and metabolic rate, we document substantial physiological changes at or near times of molt. As a result, patterns of larval growth within each of their five instars may follow trends comparable to the ontogenetic trajectories of vertebrates. Models for growth integrating metabolic scaling and energy uptake that have been successfully applied to mammals and birds may thus be parameterized separately for each instar when applied to larval growth. Metabolic scaling exponents vary among instars and across individuals, and inter-individual variation may allow us to predict differences in growth among individual larvae. Our results suggest that relatively simple models relating metabolism and material exchange to growth in vertebrates can be extended to describe the complex ontogeny of insect larvae. At the same time, further studies of *M. sexta* will allow us to use controlled experiments to learn how variation in food quality, temperature, and living conditions influence the interactions between metabolic scaling, material exchange, and growth, while still considering a large range of magnitudes in animal size.

P1.89 SECOR, S. M.*; TAYLOR, J. R.; GROSELL, M.; University of Alabama, University of Miami; ssecor@biology.as.ua.edu

Postprandial matching of intestinal function and metabolism
Snakes vary with respect to feeding habits in the regulation of intestinal form and function. Frequently feeding species tend to maintain intestinal function with fasting and feeding, whereas infrequently feeding species significantly up and downregulate intestinal function with the start and finish of each meal. To investigate metabolic correlates of intestinal regulation, we examined postprandial changes in intestinal metabolism for the frequently feeding diamondback watersnake (*Nerodia rhombifer*) and the infrequently feeding Burmese python (*Python molurus*). We used in-vitro intestinal tissue respirometry to measure rates of oxygen consumption (VO_2) by the mucosal and serosal sides of intestinal segments from fasted and fed snakes. Intestinal mucosal VO_2 was significantly greater (by 50-100%) than serosal VO_2 , except for fasted watersnakes. For fasted snakes, intestinal VO_2 of watersnakes was twice that of pythons. Watersnakes experienced no significant postprandial increase in VO_2 for the proximal small intestine when normalized to area or mass. In contrast for the python, feeding generated significant increases in intestinal VO_2 that peaked 3 days postfeeding at 3-4 fold of fasting VO_2 . For the fed python, the mucosa and serosa exhibited similar magnitudes of increase in VO_2 . The watersnake's maintenance of intestinal function with fasting is reflected in its higher fasting intestinal VO_2 and its lack of a postprandial increase in intestinal metabolism. For the python, the upregulation of intestinal function with feeding is matched in magnitude with the increase in the intestine's metabolic rate.

P2.171 SEFATI, S.*; FORTUNE, E.S.; COWAN, N.J.; Johns Hopkins University, Baltimore, MD; *shahin@jhu.edu*

Counter-Propagating Waves in the Ribbon Fin of *Eigenmannia virescens* Enhance Maneuverability

Ribbon-finned weakly electric knifefish, *Eigenmannia virescens*, are agile and maneuverable swimmers. A long undulating fin along the ventral side of the body of *Eigenmannia* generates the majority of its propulsive force. Several parameters of the undulating fin affect thrust force, some of which are fixed (e.g. the height of the fin is a fixed morphological parameter) while others are actively controlled to modulate thrust (e.g. frequency, amplitude and wavelength of undulation). Fin length may seem to be a fixed parameter, but *Eigenmannia* employ a mechanism for changing effective fin length. The fin motion is partitioned rostrocaudally with the two ends undulating in counter-propagating waves, hence generating antagonistic thrust forces. During station-keeping (or "hovering"), the fin is partitioned equally front-to-back; in forward swimming, the partition node moves caudally, generating a forward net thrust. Here, we investigated how *Eigenmannia* produce net thrust during steady-state forward swimming using high-speed videography of individuals swimming in a flow tunnel. We recorded video captured from fish behavior during different steady state flow velocities and we observed that frequency, amplitude, and wavelength of the two counter-propagating waves remain nearly constant over a range of 0-10 cm/s, but the node position moves from near the center of the fin toward the downstream end of the fish. These experiments strongly suggest that at these low swimming speeds, node position dominates differential thrust production. This strategy might enable fish to rapidly switch the direction of motion without the need to completely reverse wave propagation along the entire fin. Future work will investigate this directly by observing fin kinematics during transient movements and by simulation using computational fluid dynamics.

P2.48 SEYFABADI, Jafar*; HEYDARI, Masoud; Tarbiat Modares University; *jseyfabadi@gmail.com*

Diel vertical distribution assessment of the invasive ctenophore, *Mnemiopsis leidyi*, off Anzali Coast, South Caspian Sea, Iran

The diel vertical distribution and abundance of the invasive comb jelly, *Mnemiopsis leidyi*, in the south Caspian Sea were studied during three diel periods in August 16-17, 27-28 and 29-30, 2007, at one station (depth ~ 50m) off Anzali coast, Iran. The determinative factor in general zooplanktonic abundance was found to be the thermocline with its base being located at around 20- 35 m depths during the sampling period. As a result, the zooplankton abundance decreased from surface to depth, being higher in waters above the thermocline, especially 0-10 m layer. Although the presence of *M. leidyi* in all depths was evident, higher abundance and distribution were always encountered in the surface waters above the thermocline (depth 20 m) both days and nights, indicating no occurrence of diel vertical migration. Therefore, temperature and food availability could be considered as the main factors in the vertical distribution of *M. leidyi*.

P1.84A SEGOVIA, Romulo*; WALKER, Pett; TREWICK, Steve; GLEASON, Dianne; LAVROV, Dennis; Iowa State University, Massey University, EcoGene New Zealand, Massey University; *rsegovia@iastate.edu*

Extensive tRNA editing in mitochondrial genomes of *Onychophora*

One of the most difficult tasks in annotating animal mitochondrial genomes is identification of transfer RNA genes. This is because these genes underwent degenerative evolution and lost most of the features characteristic of "standard" tRNAs. Furthermore, in some lineages, maturation of tRNA genes involves RNA editing. Despite the fact that "absence of evidence is not evidence of absence", the inability to identify some tRNA genes have led to repeated claims that these genes are absent from the genomes. As an example, in a recent paper Podsiadlowski et al. have claimed that onychophoran *Epiperipatus biolleyi* lacks all tRNA genes for 4-fold degenerate codons and that this absence "raises the fundamental question of whether there are any differences in the recognition mechanisms" between tRNAs for 2-fold and 4-fold degenerate codons. However, we have previously sequenced mtDNA from the same species and identified all 22 tRNAs characteristic for animal mtDNA. To check whether genes for 4-fold degenerate tRNAs are indeed absent from onychophoran mtDNA we checked for the presence of these tRNAs on RNA level by the RT-PCR approach. We found that tRNA genes for 4-fold degenerate codons are present in onychophoran mtDNA but that all tRNA genes undergo extensive tRNA editing at the 3' end. This editing not only repairs the mismatched pairs of nucleotides in the 3'-ends of the acceptor stems by forming Watson-Crick base pairs in a 5'-end template-dependent editing system, but also edits many nucleotides in the TYC arm. Further study of mt-tRNA gene in the onychophoran *Peripatoides sympatrica* from New Zealand suggests that this editing mechanism evolved early in the evolution of the group and has been retained for at least 100 MY.

P3.117 SHAHBAZI, M.*; CARRUTH, L.L.; Neuroscience Inst., Georgia State Univ.; *biomxs@langate.gsu.edu*

The role of glucocorticoid receptors and stress on the development of the avian song system

When male zebra finches (*Taeniopygia guttata*) experience early developmental stress they exhibit reduced song complexity and a decreased HVC size in adulthood. Song nucleus HVC is required for learning and production of song and song complexity is important for mate choice. This reduction in song complexity and song nucleus size suggests a direct link between the stress response, brain and behavior, however the mechanisms underlying these effects are unknown. We are investigating the role of glucocorticoid receptors and stress on the development of the avian song system. Glucocorticoid receptor-like immunoreactive-neurons (GR-like ir-neurons) were localized in the brains of male zebra finches collected on P1 (post-hatch day 1, song nuclei not yet formed), P10 (post-hatch day 10, song nuclei formed), and adult birds (post-hatch day 90 or older, sexually mature and singing crystallized songs). In adults, high density of glucocorticoid receptor-like immunoreactivity was found in the HVC, tubero-infundibular area, nucleus paraventricularis (PVN), posteromedialis and lateralis hypothalami, nucleus septi lateralis, tectum opticum, and brainstem nuclei including the locus coeruleus and raphe nucleus. The cerebellar cortex and hippocampal formation were also immunopositive. In addition, adult birds that were stressed from P5-26, via chronic corticosterone treatments, had significantly smaller HVC volumes and altered regulation of GR-like ir-neurons in several telencephalic and diencephalic brain regions when measured in adulthood. Plasma corticosterone concentrations were measured using radioimmunoassay to validate the treatments and compare treated versus control birds. The mechanism of how chronic stress influences HVC size is yet to be determined.

P3.74 SHEARMAN, Rebecca M; LEOPOLD, Jennifer L; MAGLIA, Anne M*; Wesleyan University, Missouri University of Science and Technology; magliaa@mst.edu

Utility of the Amphibian Anatomical Ontology for Interdisciplinary Research

AmphibAnat (www.amphibanat.org) and the associated Amphibian Anatomical Ontology (AAO) provide a means to assemble and formalize the vocabularies for amphibian anatomy, embryology, and taxonomy. As biology becomes increasingly more integrative, AmphibAnat is a powerful tool for addressing interdisciplinary questions. AmphibAnat is an obvious resource for studying the anatomy and phylogeny of frogs, salamanders, and caecilians, but its utility extends both beyond strict morphological studies and beyond amphibians. Typical developmental and gene expression studies use model organisms such as the mouse, chick, frog, or zebrafish. But whether using the mouse to understand humans or reconciling information about various model organisms, data must be placed in an evolutionary framework to understand their significance. As basal tetrapods, the out-group to amniotes, and the link between zebrafish and chicks/mice, amphibians are critical to establishing the evolutionary context for research involving many model organisms. For example, a large amount of developmental and genetic information is available for *Xenopus laevis*/*X. tropicalis*, as well as the emerging salamander model, the axolotl. The anatomy of these animals is included in AmphibAnat, and this represents a critical first step to linking genotype and phenotype in amphibians. Here in we provide examples demonstrating the utility of AmphibAnat for studies in comparative anatomy, evolution, development and molecular biology.

P1.29 SHERRARD, K.*; ROBIN, F; CARVAJAL, D.; DANAHER, B.; DENG, W.; JOSHI, S.; MONTGOMERY, M.; SEMON, S.; WHITE, D.; MUNRO, E.; Center for Cell Dynamics, University of Washington, Center for Cell Dynamics (U.W.) and University of Chicago, Universidad de Antioquia, Columbia, SARS Institute, Bergen, Norway, University of Pittsburgh, University of Washington, University of Alberta, Edmonton; kmsherra@alumni.uchicago.edu

CellularBasis for Ascidian Neurulation

Ascidians form a neural tube of only a few hundred cells, providing an unparalleled opportunity to study this fundamental morphogenetic process at the cellular level. Several distinct subprocesses contribute to ascidian neurulation. First, primary invagination of the neural plate is followed by axial elongation accompanied by mediolateral cell-cell intercalation and oriented cell divisions. Second and concurrently, constriction of the blastopore and medially-directed crawling bring epidermal cells together at the posterior midline to initiate neural tube closure. Finally, neural tube closure proceeds through anterior to posterior zippering of both the neural tube and the overlying epidermal cells. Experiments with explants and laser ablation reveal that neural plate invagination proceeds normally in the absence of the posterior zipper-forming cells, but zippering fails. Conversely, zipper initiation and propagation proceed normally in the absence of the primary neural plate. Furthermore, unlike in vertebrates, formation and elongation of the neural tube does not require the presence of a notochord. A propagating zone of localized rho-kinase-dependent myosin activation is required for blastopore closure and for zippering, but not for invagination of the neural plate. Thus in ascidians, the complex process of neurulation can be decomposed into, and understood in terms of, a set of fundamental cellular mechanisms that are directly amenable to experimental analysis.

P3.146 SHERIDAN, T.A.*; ANDERSON, C.V.; DEBAN, S.M.; University of South Florida; tsherida@mail.usf.edu

Scaling relationships of the tongue apparatus in the family Chamaeleonidae

The feeding mechanism of old world chameleons (Family Chamaeleonidae) is highly specialized and produces extreme performance via its spring-loaded projection mechanism. While many musculoskeletal systems of ectotherms scale with near isometry, we hypothesize that the chameleon tongue apparatus may scale differently because muscles are launched ballistically from the mouth and may be subject to additional constraints on their proportions. Spring-based systems may scale differently than muscle-based systems by virtue of their extreme performance. We determined scaling relationships of the chameleon feeding apparatus from a total of 59 individuals representing 16 species from 7 genera of the family Chamaeleonidae. Specimens ranged in snout-vent length (SVL) from 37 - 223 mm. We find based on the log-transformed measurements that entoglossus (ENT) length is negatively allometric to both SVL (0.83 ± 0.09 ; mean slope $\pm 95\%$ conf. int.) and jaw length (0.89 ± 0.07). The mass of the posterior, circular portion of the accelerator muscle (2.76 ± 0.28) and the retractor muscle (2.85 ± 0.37) scale geometrically to ENT length. In addition to addressing questions about the scaling relationships of this spring-based system and its potential constraints, these scaling relationships aid in calculation of mass-specific performance parameters based on external measurements when applied to feeding performance in animals of a range of body sizes.

P1.45 SHISHIDO, C. M.*; BURNAFORD, J.L.; HENDERSON, S.Y.; University of Puget Sound, CSU Fullerton; cshishido@pugetsound.edu

The effect of sediment type of the distribution of the invasive purple varnish clam and associated native kleptoparasitic pea crabs on Pacific Northwest beaches

Nuttallia obscurata (the purple varnish clam) is an invasive species that inhabits sandy and muddy beaches in the Pacific Northwest. This invasive clam is associated with at least 3 species of native kleptoparasitic pea crabs, and the distribution of clams and pea crabs varies from site to site. We investigated potential causes of variation in infection rates between sites by focusing on two locations, Jackson Beach and Argyle Beach on San Juan Island, WA. These beaches are separated by less than 150m. We used field surveys to quantify the sediment characters and distribution of clams and crabs at each site. At Jackson Beach, where the sediment was sandy, *Nuttallia* were found deep in the sediment and pea crab infection rates were high (28.7% of clams infected). At Argyle Beach, where the sediment was muddy and rocky, *Nuttallia* were shallow and pea crab infection rates were low (15.6 % of clams infected). We used laboratory manipulations to determine whether these differences in sediment characteristics affected the clam/crab association. *Nuttallia* burial depths were different in sediment from the two sites, but sediment type had only a weak effect on crab movement. Long term comparisons of clam growth rates at the two sites indicate the possibility of physiological differences in clam populations which may affect the clam/crab association. These data increase our understanding of this close association between native species and an abundant invader of Pacific Northwest beaches

P3.49 SHUPE, KE*; HARRISON, CA; COOLEY, JR; NAGY, LM; University of Arizona; lnagy@email.arizona.edu
Requirement for GSK-3 signaling in the early *Ilyanassa obsoleta* embryo.

Canonical Wnt signaling plays a key role in determining axial polarity and cell fate identity across a diverse array of organisms. Here we report our findings concerning the role of Wnt signaling in the marine mud snail *Ilyanassa obsoleta*, with particular attention to its function during the early cleavage divisions and the establishment of axial polarity. We characterized the embryonic expression profiles of *Ilyanassa* Wnt4, Wnt5b and Wnt7 orthologs. IoWnt7 is maternally provided and shows an 8 fold increase in abundance at the 16 cell stage, while IoWnt4 and Wnt5b are not expressed until 45 hours of development and show a 1000 fold increase after 65hrs, when we observe an overall burst in zygotic transcription. We also characterized the effects of treating early *Ilyanassa* embryos with alsterpaullone, a selective inhibitor of GSK-3, which mediates the proteasomal destruction of β -catenin. Embryos exposed to alsterpaullone for 24 hours lacked eyes, shell, and velum and were characterized by large, irregularly shaped patches of cilia and pigmentation. Nanos expression, which marks the early division progeny of 4d (the endomesodermal precursor cell) was normal in drug-treated embryos. Engrailed expression, which marks the developing shell field, was absent or reduced to a few irregularly positioned cells. Progressively later application of the drug resulted in a progressive recovery of cell fates. The results are consistent with a role for GSK-3 signaling during the first 5 cleavage cycles in *Ilyanassa* development.

P3.103 SIMPSON, M. C.; YAGER, D. D.*; Univ. of Maryland, College Park; ddyager@umd.edu

CNS processing of auditory signals differs in light and darkness in the praying mantis, *Parasphendale agrionina*

Most praying mantises detect ultrasound using a single ear in the ventral midline of the metathorax. This provides early warning of a bat attack and triggers an effective evasive response. The head is necessary for the behavioral response, but descending control has not previously been studied. Ascending auditory information in 3-5 axons reaches the head 13-15 ms post-stimulus. Extracellular recording from the lateral half of the descending connective typically shows an early response of several units (latency 22-35 ms) followed at >100 ms post-stimulus by activity in 3-4 very large units that can extend several hundred ms after the 200 ms stimulus train. The overall spike numbers for the descending responses when the animal was in darkness compared to when it was in light averaged 45% greater (range 18%-81%), but response duration was the same. The darkness responses immediately after lights off typically had fewer spikes than after 10 min. in the dark. Although descending responses under both conditions can be variable, habituation of responses in darkness was slower than in light in some experiments. Experiments were carried out during the animals' subjective day, which makes the greater darkness responses especially surprising. We predict that physiological experiments during dusk and the first half of the animals' night, the peak activity period for this species, will show even greater differences between the responses in light and darkness. Our data suggest integration of visual and auditory information in which input from the eyes suppresses processing of information from the ear. This fits with the circadian pattern in evasive behavior we see in the lab in which stimuli that elicit robust, low threshold responses in the evening fail to trigger evasion in the afternoon.

P1.150 SIMONS, Erin L. R.; Midwestern Univ.; esimon@midwestern.edu

Mechanical properties of the forelimb skeleton of birds utilizing different primary flight modes

Mechanical testing at the whole bone level was performed on the wing elements of several bird species to address hypotheses related to the relationship between avian skeletal structure and function. Young's modulus (stiffness) in dorsoventral bending was determined from the humerus, ulna, and carpometacarpus of three species of birds that utilize different primary flight modes: the Double-crested cormorant, a continuous flapper; the Brown pelican, a static soarer; and the Laysan albatross, a dynamic soarer. Results of this study reveal that variation exists in Young's modulus both among wing elements within a species and among species that utilize different primary flight modes. Within all three species, the CMC and ulna are significantly stiffer than the humerus, presumably to accommodate the loads transmitted through the flight feathers. In addition, the dynamic soaring albatross and continuous flapping cormorant exhibited stiffer wing elements than the static soaring pelican. Both flapping continuously and dynamic soaring in high speed winds may cause more stress on the wing, requiring the wing elements to be stiffer to adequately resist the load. In addition, static soaring birds with large broad wings, such as the pelican, may have elements optimized to resist torsional rather than dorsoventral bending loads. These results are discussed in the context of the cross-sectional geometry of the forelimb elements.

P3.102 SINGH, G; HUYNH, M; MURRAY, JA*; Cal. State. U. East Bay; james.murray@csueastbay.edu

Analysis of crawling activity of *Tritonia diomedea* in light versus dark settings

Tritonia diomedea have eyes several mm deep in heads but there is no evidence that light affects their behavior. To test the effects of photoreception on locomotion, the animals were kept in a tank where they were exposed to 12 hours of light and 12 hours of dark. We tested the animals in two 4 hours trials on alternate days, one trial consisting of IR light only and one under normal light only. The trials were done during the same time of the day on two different days where IR trial is done first day and the light trial is done the next day. The animal's movements were recorded by a digital camera and the video was analyzed for total time active and net movement for the first one hour. Preliminary results show that on average the slugs were crawling 56% of the time in light and 47% of the time in the dark. When net distance traveled of all subjects were averaged, total distance traveled in the dark was 313 cm in comparison to 699 cm traveled in the light. *Tritonia* may be more active when in lightened environments.

P1.59 SLOAN, L.M.*; ANDERSON, S.V.; PERNET, B.; California State Univ., Long Beach; lms89@humboldt.edu
Kilometer-Scale Spatial Variation in Prevalence of the Rhizocephalan *Lernaeodiscus porcellanae* on the Porcelain Crab *Petrolisthes cabrilloi*

Because parasitic castrators have strong effects on both average individual host fitness and host population-level processes, understanding the causes of variation in their prevalence is an important goal in ecological parasitology. We studied spatial variation in the prevalence of the rhizocephalan barnacle *Lernaeodiscus porcellanae*, which castrates its host porcelain crab, *Petrolisthes cabrilloi*, at four southern California intertidal sites located within a few km of each other. The prevalence of rhizocephalan externa varied significantly among sites, with the southernmost site, White Point, consistently showing higher prevalence than the others. Externa prevalence was a good proxy of true (interna) prevalence. We examined several hypotheses that might explain observed spatial variation in prevalence. Host susceptibility to infection (indicated by the proxy of damage to host limbs), did not differ among sites. Among site differences in sex ratio contributed slightly to observed variation in prevalence; however, host size appeared to be the most important factor, explaining 80.4% of the variation. At all sites the probability of infection increased with increasing host size, and White Point crabs were on average much larger than crabs at other sites. Larger *P. cabrilloi* likely have had greater opportunity to be infected by rhizocephalans, either because they are older, or because they have undergone more molts (during which they are vulnerable to infection). A deeper understanding of small-scale spatial variation in prevalence in *L. porcellanae* will require information on the causes of among-site variation in host population size structure.

P1.83 SMITH, V.L.*; GROBER, M.S.; Georgia State University; vsmith8@student.gsu.edu
Is SOX9 Expression Sexually Dimorphic in the Gonads of a Sex Changing Fish?

One approach to understanding the mechanisms that permit adult sex reversal is to determine the degree to which the highly conserved molecular cascades that generate gonadal tissues have come under the control of novel regulatory elements. One gene in particular, SRY-box 9 gene (SOX9), plays a key role in the male sexual differentiation cascade amongst all groups of extant vertebrates and throughout the animal kingdom. In most vertebrates, once sex has been determined, gonadal function is fixed for life. As a result, SOX9 is not expressed in the adult ovary, but is highly expressed in the adult testis. The bluebanded goby (*Lythrypnus dalli*) exhibits an alternative reproductive strategy called sequential hermaphroditism where fish respond to changes in social status by changing from male to female (protandry) or from female to male (protogyny) phenotype. We hypothesize that the highly conserved molecular cascades that produce vertebrate testes or ovaries have come under the control of social cues in *L. dalli*, allowing for gonadal sex change. This hypothesis assumes that sex-changing fishes utilize the conserved molecular cascades for the production of gonads. To examine this assumption, this experiment will measure SOX9 mRNA expression in the ovaries and testes of adult *L. dalli*. I have isolated and sequenced cDNA fragments of SOX9 using previously published primers for semi-quantitative PCR. Preliminary results (n=5) indicate that the gonads of adult *L. dalli* display the conserved sexual dimorphism in gonadal SOX9 expression. Confirmation of this conserved mechanism of differentiation is an initial step towards understanding the novel regulatory mechanisms that control adult sex reversal.

P1.52 SMITH, J.; PHILLIPS, N.E.*; Victoria Univ. Wellington, New Zealand; nicole.phillips@vuw.ac.nz
Vulnerability of embryos in benthic intertidal egg masses in New Zealand to summertime ultraviolet radiation and conditions at low tide

The Southern Hemisphere is exposed to high intensities of ultraviolet radiation (UVR) in summer due in large part to human-induced ozone loss. Few studies, however, have focused on risks to New Zealand's intertidal marine fauna, or how UVR may interact with other stressors in this physically challenging environment. A variety of marine species deposit benthic egg masses throughout the intertidal zone, exposing developing embryos to a host of physical stresses, including UVR. Using field surveys and outdoor experiments conducted over summer, we examined the potential interactions between UVR, desiccation and tidal pool conditions on the embryonic mortality of three common molluscan species: two rocky shore pulmonate limpets (*Benhamina obliquata* and *Siphonaria australis*) and the mudflat-dwelling bubble-shell *Haminoea zelandiae*. For egg masses from the field, embryonic mortality was significantly higher in egg masses that had been in full sun compared to shade for all three species. For *S. australis*, there was also greater mortality in egg masses in tidal pools or desiccated at low tide compared to those that remained submerged in flowing seawater. For *H. zelandiae* desiccation increased embryonic mortality compared to those in shallow tidal pools. These results were supported by outdoor experiments, where we manipulated exposure to UVR and low tide conditions in a factorial design. Results from this study suggest that the egg masses of these three species are vulnerable to UVR, but with species-specific vulnerability to other intertidal stressors and possible interactions with UVR. Embryos of these species may be at risk of high mortality particularly during mid-summer when extreme conditions of UV intensity and high temperature coincide with low tide cycles.

P1.90 SMITH, M.E.*; DUREAU, J.; DUKE, J.T.; SECOR, S.M.; University of Alabama; mesmith10@crimson.ua.edu
Meal type effects on lizard specific dynamic action

We examined the effects of meal type on the specific dynamic action (SDA) of the following four lizards; curly-tailed lizard (*Leiocephalus carinatus*; Leiocephalidae), bearded dragon (*Pogona vitticeps*, Agamidae), golden gecko (*Gekko auratus*; Gekkonidae), and ocellated skink (*Chalcides ocellatus*, Scincidae). We hypothesized that hard-bodied prey would generate a greater SDA than soft-bodied food, and that SDA would increase with meal energy content. Lizards were fed hard-bodied crickets, mealworm beetles, and either mealworms or superworms, and soft-bodied waxworms, butterworms, and silkworms. Meals equaled in mass to 5% of lizard mass and SDA measurements were conducted using closed-system respirometry at 30C. All meals generated for each lizard significant increases in oxygen consumption (VO₂) that remained elevated for 2 (silkworm meal) to 8 (superworm meal) days. The factorial scope of peak postprandial VO₂ (peak VO₂/SMR) was significantly greater (by an average of 38%) for hard-bodied prey compared to soft-bodied prey for each species. SDA, calculated from the extra oxygen consumed above SMR, averaged 88% greater for hard-bodied meals than soft-bodied meals for the four lizards. Silkworms required the least amount of energy to digestion, whereas superworms and beetles required the most. SDA coefficient, SDA as a percentage of meal energy, varied among meals (9.9% for butterworms to 28.6% for crickets) and was greater for hard-bodied (25.7%) than soft-bodied (13.4%) meals for each lizard. SDA increases with meal energy for *Leiocephalus*, *Pogona*, and *Chalcides*. The lack of an increase for *Gekko* was due to their modest SDA for the high-energy butterworm meals.

P2.124 SMITH, N.S.; ADAMS, S.A.*; HO, J.M.; DEMAS, G.E.; Xavier University of Louisiana, Indiana University; nsmith8@xula.edu

Functional effects of endocannabinoid signaling on ingestive behavior in Siberian Hamsters

Siberian hamsters are a seasonally breeding species that undergo seasonal changes in energy balance, losing ~30-40% of their body mass in short "winter-like" days. These changes are driven primarily by changes in food intake, but the underlying neuroendocrine mechanisms are still unknown. Hypothalamic peptides traditionally attributed to regulation of energy balance give little explanation for this seasonal change. Endocannabinoids (EC), specifically those acting at CB₁ receptors, have been linked to the regulation of ingestive behavior in other rodent species but their functional effects in Siberian hamsters have yet to be tested. To determine the functional effects of EC signaling we housed animals in long days or short days and injected them with either a CB₁ agonist (ACEA) or antagonist (SR141716) for five days and measured food intake and hoarding. We found that blockade of CB₁ receptors decreased food intake, but only in long-day animals. While drug treatment had no effect on hoarding, photoperiod differentially affected hoarding within each sex: long-day males hoarded more than short-day males whereas short-day females hoarded more than long-day females. Together these findings indicate patterns of hoarding across photoperiod differ between sexes, and that functional effects of EC signaling in Siberian hamsters leaves the possibility for a role in mediating seasonal changes in energy balance.

P3.55 SOKOLOVA, I.M.*; IVANINA, A.; EILERS, S.; KUROCHKIN, I.; SOKOLOV, E.P.; University of North Carolina at Charlotte, Charlotte, NC, Carolinas Medical Center, Charlotte, NC; isokolov@uncc.edu

Cadmium affects nitric oxide metabolism during normoxia and intermittent anoxia in eastern oysters *Crassostrea virginica*

Nitric oxide (NO) is an intracellular signaling molecule involved in regulation of many cellular functions including mitochondrial metabolism and bioenergetics; however, its role in invertebrates is not well understood. We determined sensitivity of mitochondrial and cellular respiration to NO and the effects of Cd and intermittent anoxia on NO metabolism in oysters, *Crassostrea virginica*. NOS activity was strongly suppressed by exposure to 50 µg L⁻¹ Cd for 30 days, and further decreased during anoxic exposure in Cd-exposed oysters but not in their control counterparts. Nitrate/nitrite content (indicative of NO levels) decreased during anoxic exposure to less than 10% of the normoxic values, and recovered within 1 h of re-oxygenation in control oysters. In Cd-exposed oysters the recovery of steady-state NO levels lagged behind reflecting their lower NOS activity. Oyster mitochondrial respiration was inhibited by exogenous NO, with sensitivity on a par with mammalian mitochondria, and ADP-stimulated mitochondrial respiration was significantly more sensitive to NO than resting respiration. In isolated gill cells, manipulations of endogenous NOS activity had no effect on respiration, likely due to the fact that mitochondria in the resting state are relatively NO-insensitive. Likewise, Cd-induced stimulation of cellular respiration did not correlate with decreased NOS activity in isolated gill cells. These data suggest that regulation of bioenergetics is an evolutionarily conserved function of NO. Supported by NSF.

P2.44 SNYDER, S.J.*; TRACY, C.R.; University of Nevada, Reno; ssnyder@biodiversity.unr.edu

Impacts of fire on thermoregulatory opportunities for desert tortoise: Use of operative temperature models

Recently, fires in the Mojave Desert have burned extensive portions of habitat used by the threatened desert tortoise (*Gopherus agassizii*). Burned landscapes may challenge the thermoregulatory capabilities of tortoises, since they rely on underground burrows and vegetative cover as buffers from extremes in desert thermal environments. By reducing the availability or altering the physical properties of above ground vegetative cover, fires may indirectly result in behavioral and/or physiological changes to tortoises living in burned-unburned habitat interfaces. To assess the differences in temperatures available to tortoises, operative temperature models were placed in various microhabitats available to desert tortoises in burned and unburned areas. Operative temperature models were constructed from copper mixing bowls similar in dimension to a desert tortoise and painted to match the integrated spectral absorbance of a tortoise's shell for daytime solar radiation. These models were relatively easy to build and replicate allowing operative temperatures in many microhabitats to be simultaneously recorded for comparison. Measurement of model temperature was achieved using an internally mounted iButton. Thus, models could be distributed throughout the landscape, untethered to a data logger, and could be moved easily among locations. Temperatures gathered from the physical operative temperature models closely matched mathematically calculated operative temperatures, validating their use for evaluating the thermal quality of burned and unburned habitat with respect to tortoises.

P3.71 SOU, E*; HERNANDEZ, LP; George Washington University; emilys525@gmail.com

Origin and development of the hypertrophied cypriniform pharyngeal jaws

Significant hypertrophy of the pharyngeal jaws characterizes most cypriniforms. Here we use both a phylogenetic approach, as well as an ontogenetic analysis of growth to examine the origin and evolution of the hypertrophied ceratobranchials. A phylogenetic survey of basal teleosts and Ostariophysans to determine the relative size of ceratobranchials early in teleostean evolution has never been undertaken. Our findings suggest that it is only at the base of Cypriniformes that we see a greatly hypertrophied ceratobranchial 5. Indeed in several more basal clades, including Gonorhynchiforms (sister to Cypriniformes) and Clupeomorpha, the fifth ceratobranchial is markedly smaller than more anterior ceratobranchials. Interestingly other ostophysan groups are also characterized by a smaller ceratobranchial 5. We also measured ceratobranchials of other teleostean groups to assess the number of times such hypertrophied pharyngeal jaws have evolved from a basal condition characterized by smaller 5th ceratobranchials. To better understand the developmental mechanisms via which such changes in ultimate size may have occurred we used zebrafish to examine increase in length and surface area of ceratobranchials from their first origin as cartilaginous elements at early larval stages until adulthood when all elements had undergone ossification. Growth rate of all ceratobranchials changed significantly during larval development, with a marked increase in growth rate corresponding to the onset of mineralization. Timing of initial differentiation as cartilaginous elements, earlier mineralization, and increased growth rate (especially of surface area) all appear to be involved in the generation of zebrafish hypertrophied jaws.

P1.111 SOUTHWOOD, Amanda*; SNODDY, Jessica; PARGA, MariLuz; SWIMMER, Yonat; University of North Carolina Wilmington, SUBMON Conservacion Estudio, NOAA Pacific Islands Fisheries Science Center; southwooda@uncw.edu
Blood biochemistry of sea turtles incidentally entangled in fishing gear

Mortality due to incidental entanglement in fishing gear has been implicated as a contributor to population decline for several species of sea turtle. Documenting the number of in-net mortalities that occur is straight-forward, but post-release mortality due to stress of entanglement or injuries incurred while in the net has not been thoroughly investigated. Previous studies have shown that forcibly submerged sea turtles display significant alterations in blood biochemistry indicative of hypoxia and restraint stress which could have negative consequences for sea turtles post-release. We investigated the blood biochemistry of sea turtles entangled in shallow set gillnets and pelagic longlines to evaluate the metabolic and physiological impacts of entanglement in these gear types. We measured concentrations of lactate, corticosterone, ions, enzymes, protein and glucose in the blood. Entanglement in fishing gear resulted in elevated levels of blood lactate, LDH, CPK, corticosterone, and glucose compared with baseline levels reported in the literature and control blood samples. Intense struggling and forced submergence during entanglement likely result in a shift from aerobic to anaerobic metabolic pathways due to an imbalance between oxygen supply and demand. Elevated blood enzymes are indicative of internal tissue damage, and elevated levels of corticosterone and glucose indicate induction of a systemic stress response during entanglement. Alterations in blood chemistry were associated with poor health status as reflected by physical exam. The time required for recovery from enforced submergence requires further investigation.

P2.58 SPAIN, D.D.*; RAMIREZ III, D.R.; ANIAG, J.P.; Dominican University of California; dspain@dominican.edu
Developing Effective Communication Skills in Undergraduate Science Classes

The ability to communicate effectively through the written and spoken word is highly valued in our society. Although these skills are useful to everyone, in our scientific and technologically driven society it is even more important. Therefore it is essential that college graduates have solid communication skills. This has an additional implication for college graduates with a degree in science because they need to master these skills and develop a high level of scientific literacy. Unfortunately, it is rare to see the scientific writing process emphasized in a science curriculum. In our department we have a series of four research methodology courses for undergraduates primarily focused on conducting research with a faculty mentor. We modified the format to include both oral and written presentations. The goal set for the students is to progress from presentations in these classes to presentations at national/international conferences. We developed a survey focusing on writing/oral communication experiences (previous and current), and exposure/comprehension of scientific literature to monitor student progress. The survey was administered to students at the beginning and end of the semester for the first class in the series. Also, we created grading rubrics for written and oral assignments for the second and third class in the series. Preliminary results show positive increases in student communications skills in several areas. Our approach seemed relevant to the students because they were actively using these skills and were able to observe their progress in both an academic and real-world environment.

P1.14 SOWER, STACIA A.*; BALZ, EILEEN; MACDONALD, CARYN; KAVANAUGH, SCOTT I.; University of New Hampshire, Durham, University of New Hampshire Durham; sasower@cisunix.unh.edu
Changes in Brain Concentrations of GnRH-I, -II, and -III During the Final Reproductive Period in Adult Male and Female Sea Lamprey

Sea lampreys are anadromous and semelparous, i.e., they spawn only once in their lifetime, after which they die. Sexual maturation is thus a synchronized process coordinated with the life stages of the lamprey. Recently, a novel gonadotropin-releasing hormone, lamprey GnRH-II, was identified in lampreys and suggested to have a hypothalamic role in reproduction (Kavanaugh et al., 2008). To further understand the role of lGnRH-II, changes in ovarian morphology, brain gonadotropin-releasing hormone (GnRH-I, -II, and -III), and plasma estradiol were examined during the final two months of the reproductive season of adult male and female sea lamprey. The results show significant correlations between water temperature, fluctuation of brain GnRHs and plasma estradiol during this time. In males, lGnRH-I concentration increased early in the season, peaked, then declined with a subsequent increase with the final maturational stages. In comparison, lGnRH-II and -III concentrations were also elevated early in the season in males, dropped and then peaked in mid-season with a subsequent decline of lGnRH-II or increase of lGnRH-III at spermiation. In females, lGnRH-III concentration peaked in mid-season with a drop at ovulation while lGnRH-I remained unchanged during the season. In contrast, lGnRH-II concentrations in females were elevated at the beginning of the season and then dropped and remained low during the rest of the season. In summary, these data provide evidence that lampreys have three hypothalamic GnRHs and that these GnRHs change in a differential manner during this final reproductive period. Supported by NSF Grants 0421923, 0849569, NSF REU supplement and NH AES Hatch 332 to SAS.

P2.45 SPARROW, J.D.*; ROSTAL, D.C.; Georgia Southern Univ., Statesboro; jsparro1@georgiasouthern.edu
Temperature variations within and among Loggerhead Sea Turtle (*Carretta carretta*) nests across

SPARROW, J.D., ROSTAL, D. C. Georgia Southern Univ., Statesboro Georgia Southern Univ., Statesboro jsparro1@georgiasouthern.edu Temperature variations within and among Loggerhead Sea Turtle (*Carretta carretta*) nests across the season Loggerhead sea turtles have temperature dependent sex determination meaning that depending on temperature during the middle third of incubation only males, females or a mixture of males and females will be produced. For *C. caretta* males are produced mainly at the beginning of the season, a mixture of males and females during the mid season, and females during late season. However, not much is known about how much the temperature varies within a nest. To assess the variation in temperature between top, middle, and bottom of *C. caretta* nests during early, middle, and late season at Blackbeard Island, temperature dataloggers were utilized. Ten nests were selected from each division of the season and 3 dataloggers were placed in the nest; one in the top, middle, and bottom of each nest. In addition, three nests from each period were chosen to have a sister datalogger placed in the beach a meter north of the nest in alignment with the middle datalogger. Preliminary results show little temperature difference between top and middle dataloggers. For the entire incubation period, the bottom and sister dataloggers show cooler temperatures compared to the top and middle. Temperature during the critical period did not vary significantly across the nest from bottom to top or from the sister datalogger. Eggs at the top of the nest experienced much greater daily fluctuations in temperature than eggs at the bottom of the nest. These initial findings suggest that since the edges of the nest are hovering around pivotal temperature for sex determination (29°C) the sex ratio is normal and in temperature studies utilizing just one datalogger, the central location is sufficient to understand the nest temperature.

P2.109 SPERLING, Erik A.*; VINTHER, Jakob; MOY, Vanessa M.; WHEELER, Benjamin M.; SEMON, Marie; BRIGGS, Derek E.G.; PETERSON, Kevin J.; Yale University, Dartmouth College, North Carolina State University, Universite de Lyon, Dartmouth College; erik.sperling@yale.edu

MicroRNAs Resolve an Apparent Conflict Between Annelid Systematics and Their Fossil Record

Both the monophyly and interrelationships of the major annelid groups have remained uncertain, despite intensive research on both morphology and molecular sequences. Morphological cladistic analyses indicate that Annelida is monophyletic and consists of two monophyletic groups, the clitellates and polychaetes, whereas molecular phylogenetic analyses suggest that polychaetes are paraphyletic and that sipunculans are crown-group annelids. Both the monophyly of polychaetes and the placement of sipunculans within annelids are in conflict with the annelid fossil record – the former because Cambrian stem taxa are similar to modern polychaetes in possessing biramous parapodia, suggesting that clitellates are derived from polychaetes; the latter because although fossil sipunculans are known from the Early Cambrian, crown-group annelids do not appear until the latest Cambrian. Here we apply a different data source, the presence vs. absence of specific microRNAs – genes that encode ~ 22 nucleotide non-coding regulatory RNAs – to the problem of annelid phylogenetics. We show that annelids are monophyletic with respect to sipunculans, and polychaetes are paraphyletic with respect to the clitellate Lumbricus, conclusions that are consistent with the fossil record. Further, sipunculans resolve as the sister group of the annelids, rooting the annelid tree, and revealing the polarity of morphological change within this diverse lineage of animals.

P2.30 STAPPUT, KATRIN*; LOHMANN, KENNETH J.; University of North Carolina, Chapel Hill; stapput@email.unc.edu

Magnetic orientation in birds and sea turtles: a comparative approach

Although diverse animals use the Earth's magnetic field for long distance orientation and navigation, relatively little is known about how animals perceive magnetic fields or how magnetic information is used to guide migrations. Studies on birds and sea turtles have revealed the most detailed picture of how animals use magnetic parameters. In birds, extensive lab and field studies of migratory species, as well as homing pigeons, have allowed the development of standardized methods to record orientation behavior; they have also enabled researchers to test for underlying mechanisms and investigate possible magnetoreceptors. Similarly, extensive behavioral experiments with migratory sea turtles have revealed characteristics of the turtle magnetic compass and the way that migrating turtles exploit positional information in the Earth's magnetic field. Taken together, these lines of research suggest many similarities in the magnetoreception systems of the two groups, but also suggest that magnetic information may be exploited in fundamentally different ways during the long-distance migrations that birds and sea turtles undertake. We are developing a laboratory assay of magnetoreception in turtles to facilitate further comparisons between the two taxa. A comparative approach to studying magnetoreception appears likely to provide insights into underlying commonalities, as well as the environmental and evolutionary pressures that may have shaped divergent magnetic navigational strategies.

P1.118 STAHLSCHMIDT, Z.R.*; HEULIN, B.; DENARDO, D.F.; Arizona State Univ., Tempe, Centre National de la Recherche Scientifique, Paimpont; zs@asu.edu

Plasticity of python eggshell permeability and its role in a dynamic respiration-hydration tradeoff

Parental care is a widespread reproductive adaptation, and python egg-brooding behavior exemplifies parental care because it mediates a tradeoff between embryonic respiration and hydration. However, because egg brooding does not adjust to the increasing metabolic requirements of developing offspring, it imposes hypoxic costs to embryos later in incubation as it increases gas exchange resistance between the embryonic and nest environment. Thus, we tested the hypotheses that python eggshells (1) have increased permeability over time to compensate for increasing embryonic respiration, and (2) exhibit permeability plasticity in response to chronic hypoxia. Over incubation, we serially measured the atomic and structural components of Children's python (*Antaresia childreni*) eggshells, as well as in vivo and in vitro gas exchange across eggshells. In support of our first hypothesis, *A. childreni* eggshells exhibited a reduced fibrous layer, became more permeable, and facilitated greater gas exchange as incubation progressed. Our second hypothesis was not supported, as incubation O₂ concentration did not affect the shells' permeabilities to O₂ and H₂O vapor. Our results suggest that python eggshell permeability changes during incubation, but the alterations over time are fixed and independent of environmental conditions. These findings are of broad evolutionary interest since they demonstrate that, even in relatively simple parental care models, successful parent-offspring relationships depend on adjustments made by both the parent (i.e., egg-brooding behavioral shifts) and the offspring (i.e., changes in eggshell permeability).

P1.11 STAROBINSKA, Ella/I*.; SWEENEY, Sarah; DAVIDSON, Brad; Univ. of Arizona; elstar@email.arizona.edu

Identification of Novel Genes Involved in Heart Formation

Fibroblast Growth Factor (FGF) signaling plays a crucial role in heart development. We study the role of FGF in the process of heart formation using the cellularly and genetically simple model organism *Ciona intestinalis*. In *Ciona* embryos, FGF/Map Kinase signaling activates an Ets family transcription factor, Ets 1/2. In turn, Ets 1/2 regulates the expression of various genes that impact heart development. To determine possible Ets target genes, we first performed microarray analysis experiment specifically designed for selection of these candidate targets. Moreover, we conducted in situ hybridization assays to confirm predicted expression patterns of candidate target genes. Specific roles of these genes in heart formation will be determined using antisense morpholino knockdown and misexpression. Identification of genes involved in *Ciona* heart formation as well as in-depth understanding of FGF signaling will contribute valuable insights into heart formation in vertebrate embryos.

P3.147 STOVER, KK*; WILLIAMS, SH; College of Charleston, Ohio University; kkstover@edisto.cofc.edu

Intraspecific scaling of chewing cycle length and jaw-muscle activity in goats, alpacas and horses.

Chewing cycle length (CCL) and frequency influence the rate of food processing and an animal's ability to meet its metabolic requirements. Interspecific studies on the scaling of CCL in mammals have demonstrated an inverse relationship with body size. However, scaling exponents relating CCL to body mass (BM) or jaw length (JL) differ depending on the phylogeny, morphology and diet of the sample. Intraspecific studies controlling many of these variables are rare given the limited size range within a species. Here, we conduct an intraspecific study on the scaling of CCL and jaw-muscle activity in goats, alpacas and horses. Goats and alpacas comprised independent ontogenetic samples of pre-weaned infants to adults, while horses include only adults ranging from 140 to 794kg. CCL and jaw-muscle activity durations were determined from kinematic data or electromyographic recordings from the jaw adductors during rhythmic chewing. Reduced major axis regressions of log-transformed data revealed significant correlations between CCL and both BM and JL in goats and alpacas but not in horses. Slope estimates for the scaling of CCL with BM in goats and alpacas and horses are 0.35, 0.37, and 0.23, respectively. Slope estimates for the scaling of CCL with JL are higher, ranging from 0.79 (horses) to 1.61 (alpacas). In goats, but not alpacas or horses, jaw-muscle activity duration was also significantly and positively correlated with both BM (0.41) and JL (1.06). Within species, CCLs and jaw-muscle activity durations are influenced by changes in the biomechanics, function or neuromuscular control of the masticatory system. However, the lack of a correlation between CCL and size in the adult horses suggests that selective breeding may not result in concomitant changes in feeding mechanics.

P1.151 STURM, J.J.*; LONG, J.H.; PORTER, M.E.; Vassar College; josturm@vassar.edu

Bending Strain at Intervertebral Joints and Centra in the Cartilaginous Vertebral Columns of *Squalus acanthias*

Vertebral columns are usually modeled with infinitely rigid skeletal elements and flexible, spring-like joints. By treating the vertebrae as elements with infinite stiffness, however, their possible contribution to the overall elastic behavior of the vertebral column is ignored. With this in mind, we model the joints and vertebrae together as a series of Kelvin-Voigt viscoelastic elements. To determine the relative mechanical contributions of each element to the behavior of the column, we measured axial strain of the joints and vertebrae during dynamic bending of an in vitro column segment preparation. We tested vertebral column from six sharks using segments of ten centra. Dynamic testing frequencies ranged from 0.25 to 3.0 Hz at various curvatures on an MTS Tytron 250. Displacement of the joint and centra were measured using sonomicrometry crystals placed bilaterally on the vertebral column at the cranial and caudal surfaces of the central joint and on the centra. Each test was conducted in an environmental chamber in which the vertebral column was submerged in room temperature elasmobranch Ringers solution. We found differences in joint strain with varying curvature. Strain of the vertebrae was less than that of the joints. This work was supported by NSF DBI-0442269 and IOS-0922605.

P2.115 STREICHER, J.W.*; HARVEY, M.B.; SMITH, E.N.; Univ. of Texas, Arlington, Broward College; streicher@uta.edu
Biogeographic Patterns in Morphologically Conserved and Genetically Diverse Anuran Lineages from the Sunda Shelf

The Sunda Shelf includes peninsular Malaysia and much of western Indonesia. Climate induced land bridge formation and geologic uplift have shaped the complex biogeography of this region. While biogeographic patterns are known for many vertebrates from the Sunda Shelf, they remain poorly studied in anurans, especially among species from the islands of Sumatra and Java. Using combined evidence from molecules (mitochondrial DNA [mtDNA]) and morphology (multivariate morphometrics), we examined levels of diversity in fanged (Anura: Dicroglossidae), true (Anura: Ranidae), and parachuting (Anura: Rhacophoridae) frogs from Sumatra and Java. For comparative purposes, we also included data for select species from Borneo. We investigated phylogeographic, genetic, and morphological patterns in these anuran groups and report several instances of syntopic yet highly divergent mtDNA haplogroups in morphologically similar taxa.

P1.112 SUCRE, E.; BOSSUS, M.; CHARMANTIER-DAURES, M.*; CHARMANTIER, G.; CUCCHI-MOUILLOT, P.; Equipe AEO, Univ. Montpellier 2, France, Equipe AEO, Univ. Montpellier 2, France ; mireille.charmantier@univ-montp2.fr
Gill ionocytes ontogeny in the sea bass: from embryos to juveniles, developmental and functional aspects.

The ontogeny of the gill ion transporting cells has been studied in the sea bass (*Dicentrarchus labrax*) embryos, prelarvae, larvae and juveniles. *In toto* immunolocalization of the NKA in embryos revealed the presence of numerous tegumentary ionocytes clustered around the gill slits. Histological investigations suggest that these ionocytes, close to the future gill chambers, are at the origin of the ionocytes observed on gill arches and gill filaments after hatching. Triple immunocytochemical staining, including NKA, various NKCCs and CFTR, were used to evaluate the functionality and diversity of the ionocytes, in embryos and juveniles exposed to different salinities. In embryos, the early ionocytes of the gill slits were immature with the presence of NKA and CFTR and the lack of NKCC1. However, in these cells, the CFTR expression disappeared when the salinity decreases from 38 to 5 ppt. In juvenile gills, either ion excretory or ion absorptive ionocytes were detected according to the external medium salinity. At 38 ppt NKCC1 has been immunostained basolaterally and the CFTR is located in the apical crypts of the excretory ionocytes. At 5 ppt, the CFTR and NKCC1 are absent but the T4 antibody (knew to recognize both NKCCs and NCC) reveals an immunostaining in the apical crypts of the ionocytes. The results are discussed in regard to the recent findings in other teleosts.

P2.79 SWART, Justin C.*; TATE, Kevin B.; REED, Wendy L.; CROSSLEY II, Dane A.; University of North Dakota, North Dakota State University; justin.swart@und.edu
Cardiovascular function in embryonic Canada geese (*Branta canadensis*)

The current understanding of embryonic cardiovascular development in avian species is primarily based on domestic chickens. While these studies have provided valuable information in formulating a general comprehension of this process, to build an understanding of how this developmental process has evolved in birds, non-domesticated species must be investigated. In this study, cardiovascular physiology in Canada geese (*Branta canadensis*) was assessed at 70% and 90% of development in control embryos as well as in embryos incubated under the chronic challenges of dehydration and elevated corticosterone levels. Resting arterial pressure and heart rate increased from $1.3 \pm .07$ kPa to $2.6 \pm .14$ kPa and 234 ± 4.52 beats \cdot min⁻¹ to 249 ± 6.49 beats \cdot min⁻¹, respectively, between 70% and 90% of incubation. During this period, vagal tone was present at 90% development while both α -adrenergic and β -adrenergic blockade significantly impacted cardiovascular function at both points of development. It was also evident that hematocrit levels were lower in animals raised under the experimental conditions. Results demonstrate embryonic cardiovascular function varies from that of the domestic chicken and emu. These differences provide additional avenues of investigating how developmental patterns of cardiovascular maturation vary between taxa. Project was supported by a NSF career award to D.A.C IBN# IOS-0845741

P1.66 SYLVESTER, JB*; RICH, CA; STREELMAN, JT; Georgia Institute of Technology; gth644s@mail.gatech.edu
Boundary Integration Generates Brain Diversity

The brain is the best-studied vertebrate organ and it has played an important role in the evolution of our own species. The rapid expansion of the cerebral cortex, or telencephalon, is a defining aspect of hominid evolution. The processes that control growth in the telencephalon have been well described in the 'late equals large' model, but little is known about the evolution of functional domains within the telencephalon. We investigate comparative telencephalon development in ecologically distinct cichlid fishes lineages from Lake Malawi (East Africa) to study diversity. The two dorso-ventral domains of the telencephalon, the pallium and subpallium, are patterned by *wnt* and *shh* signaling, respectively. Evolutionary variation in the deployment of these pathways and their downstream members changes the position of the pallial-subpallial boundary (PSB), which in turns modifies the size of each domain. Notably, rock vs. sand-dwelling Malawi species differ in the initial position of the PSB and early allocation of cells to the pallium and subpallium. We observe that this shift in the PSB is correlated with the relative position of an adjacent signaling boundary, also established in part by *wnt* and *shh* signaling, called the zona limitans intrathalamica (ZLI). The evolutionary correlation of PSB and ZLI suggests that diversity within the telencephalon results from the integrated patterning of boundaries across the developing forebrain.

P1.71 SWIDERSKI, D.L.; Univ of Michigan, Ann Arbor; dlswid@umich.edu

Coordination of branchial arch development in neonatal mice

Changes in branchial arch function and development are among the most revolutionary in vertebrate evolution. During development of the branchial arch skeleton, as in its evolution, elements from different arches become anatomically linked and integrated and elements from the same arch become differentiated and independent; some reintegrating at a later stage. These changing patterns of independence and integration should be reflected in the coordination of growth and remodeling, as well as in the expression of cell signaling pathways. To identify critical intervals for control of differential growth and shape transformation through developmental signaling interactions, I am assessing the rate and localization of skeletal growth during early postnatal ontogeny of mice. During the first postnatal week, the dentary and tympanic (1st arch membrane bones) exhibit tremendous changes in size and shape whereas the malleus and incus (1st arch endochondral bones), undergo much smaller and subtler changes in both size and shape. The stapes (2nd arch endochondral bone) undergoes little change in size, but an intermediate amount of shape change. These bones also differ substantially in degree of ossification. Whereas the dentary changes from a lacy mesh to a much denser, but still very porous framework, the malleus and incus go from cartilages devoid of bone, to bony frameworks at least as dense as the dentary, lacking cartilage except at articulations. The stapes undergoes a similar transformation in ossification. Thus there are profound differences in this week between elements that contribute to feeding (dentary and hyoid) and elements that contribute to hearing (malleus, incus and stapes), as well as between the arches and between endochondral and membrane bones of the same arch. These results predict there also will be gene expression differences both within and between arches.

P3.40 TABIMA, J.F.*; GRANADOS, C.; MANRIQUE, N.; ARDILA, N.; SAÍNCHEZ, J.A.; Universidad de los Andes; j-tabima@uniandes.edu.co

Adaptive radiation in Eastern Pacific sea fans?

New environments and niches provide ecological opportunities facilitating adaptive radiations. Compelling evidence for a burst-like rapid adaptive radiation is found in the Eastern Pacific sea fans (*Pacificorgia*: Gorgonidae: Octocorallia). With only one species in the Atlantic, it is suggestive that since the closure of the Isthmus of Panama a few ancestral species turned into about 30 morphological species. Up to one order of magnitude difference can be observed among the mesh sizes of these suspension-feeding corals. Mitochondrial trees using several coding genes (*msh1*, *ND2* and *ND6*) indicated lack of phylogenetic resolution among species. Non-monophyletic relationships were also detected within the ITS2 intragenomic variation in the same species. *Pacificorgia firma*, *P. rubicunda* and *P. media* had consistent signal for sharing ITS2 ancestors from disparate places in the phylogeny. Low phylogenetic resolution and divergence were observed with both nuclear and mitochondrial sequences. Mito-nuclear discordance was evident in contrast to very similar diversification times. Molecular clocks for ITS2 and *msh1* genes showed that most radiations occurred after the rise of the Isthmus. The information gathered suggests a rapid adaptive radiation scenario for this group, which could involve reticulate evolution. The rise of the isthmus induced dramatic oceanographic changes at both sides, the Caribbean turned oligotrophic whereas the Eastern Pacific turned in a productive environment with a luxuriant diversity and biomass of plankton. The offer of new resources allowing new niches for suspension feeding organisms, such as sea fans, could drive an adaptive radiation for these corals.

P1.100 TALLEY, Jennifer L.*; CHIEL, Hillel J.; WHITE, Edward B.; WILLIS, Mark A.; Case Western Reserve University, Texas A & M University; jlt17@case.edu

Male insect pheromone tracking behavior is affected by physical structures in the air flow.

It is known that male American cockroaches and tobacco hornworm moths both locate mates by tracking species specific female sex pheromones. Differences in the species typical tracking behavior is due to a combination of 1) body mechanics, 2) nervous system processing, and 3) the environments imposed by the different modes of locomotion. In our laboratory experiments, cockroaches walk on a horizontal surface while the moths fly freely. Our measurements show that putting physical structures, like the cockroach floor, in the insect's environment alters the pattern of air flow. In this experiment we introduced physical structures like a cylinder (tree) and grid (leaves or branches) into the wind tunnel to disrupt the air flow. We used hot wire anemometry to make detailed measurements and compare how the floor, cylinder, and grid structures change air flow characteristics. We have also recorded from the antenna of the insects to determine how the variations in air flow introduced by physical structures then affect how pheromones are distributed. We then challenged males of both species to track odor in the wind tunnel with the 1) grid, 2) cylinder, 3) both grid and cylinder, and 4) without either structure, all at a slow and fast wind speed. Cockroaches are slower while tracking odor and have wider track angles when a cylinder is present in the air flow and these effects are heightened at the faster wind speed. Moths fly faster while tracking odor when a cylinder is present and the difference is intensified by a faster wind speed. Not only are the tracking behaviors of these two species different, but they differ in their response to a change in odor environment.

P3.115 TARASKA, N.A.*; BOETTGER, S.A.; LOCK, N.C.; WALKER, C.W.; West Chester University, The University of New Hampshire; nt648886@wcupa.edu

Initiation of hemic neoplasia in the soft-shell clam *Mya arenaria* - Treatment with Bromodeoxyuridine.

Hemic neoplasia is one of the six most destructive diseases among bivalve mollusks populations and specifically in populations of *Mya arenaria*. The disease is characterized by the development of abnormal, round blood cells that proliferate and immortalize. The specific cause of hemic neoplasia in *M. arenaria* remains undetermined, however, the involvement of viral pathogens and/or environmental pollutants has been considered. In this study we are using 5-bromodeoxyuridine (BrdU) known to induce a murine leukemia virus in order to initiate hemic neoplasia a leukemia-like disease. Three treatment methods were run to test the probability of a viral induction to develop hemic neoplasia in *M. arenaria*. Prior to the initial injection of BrdU in the experiments, all of the clams were biopsied to ensure that they were non-neoplastic. Each clam from the three treatments were screened weekly for the development of hemic neoplasia. The three treatments consisted of 1. injection of 100µg/ml BrdU into the individual *M. arenaria*, 2. inoculation seawater with BrdU and 3. no contact with BrdU as a control. Animals were biopsied weekly for 8 weeks and neoplasia development recorded on a scale of 1-4 (4 = terminal stage of the disease). Based on our results, hemic neoplasia in *M. arenaria* may be virally induced rather than develop due to environmental contaminants. (OSRFDC through WCUPA to SAB)

P3.99 TAN, D*; PATTON, P; COOMBS, S; Bowling Green State University; dstan@bgsu.edu

Are the swimming kinematics of blind cavefish (*Astyanax mexicanus*) adapted for active flow-sensing?

When visual cues are poor or unavailable, animals often use a form of active sensing in which they produce their own signal energy to probe various features of the environment (e.g. echolocation by bats). Blind cavefish exhibit a less-understood form of active sensing in which they use a kick and glide swimming style to generate a relatively stable, dipole-like flow signal during the glide phase of the swimming cycle. Nearby obstacles create distortions in the self-generated flow field, which can then be detected by the lateral line. In this study, we test the hypotheses that (a) blind cavefish have evolved behavioral specializations for active flow-sensing compared to their nearest sighted relatives (a morph of the same species) and (b) flow signal production is regulated by lateral line sensory feedback. We compared the swimming kinematics of blind and sighted morphs in response to a novel, dark environment - both (a) before and after a 24-hr familiarization period and (b) with and without a functional lateral line. After initial introduction, blind morphs with a functional lateral line (N=4) had shorter glide durations and higher glide velocities and frequencies than (a) blind morphs with inactivated lateral lines (N=3) and (b) sighted morphs with (N=4) or without (N=3) a functional lateral line. Inactivation of the lateral line had little effect on the glide parameters of sighted morphs. Glide parameters in both morphs were also unaffected by an additional period of familiarization. Our preliminary results suggest that blind cavefish have evolved active flow-sensing adaptations that include swimming kinematics to produce higher flow signal amplitudes and rates, as well as feedback control by the lateral line.

P2.17 TARRANT, AM*; BEHRENDT, L; STEGEMAN, JJ; VERSLYCKE, T; Woods Hole Oceanographic Inst., WHOI, WHOI, Gradient Corp; atarrant@whoi.edu

Characterization of the ecdysteroid receptor in the American lobster (*Homarus americanus*) and development of an *in vitro* screening assay

The ecdysteroid receptor (EcR) and retinoid X receptor (RXR) together mediate ecdysteroid regulation of molting, development and reproduction in ecdysozoans. Insect growth regulators are chemicals designed to disrupt ecdysteroid signaling in insect pests, but effects of such chemicals on ecdysteroid signaling in non-target species, especially crustaceans, have not been determined. Coastal crustaceans are increasingly exposed to potential ecdysteroid-disrupting chemicals due to growing use of insect growth regulators in many applications over the last decade, as coastal human populations continue to expand. There is an urgent need to better understand the potential for exposure and effects of these chemicals in coastal crustacean populations. To this end, we have cloned the full length EcR and RXR from an ecologically and economically important crustacean, the American lobster (*Homarus americanus*). We identified two forms of the EcR that differ in 15 of 542 amino acid residues. qPCR showed that EcR expression was elevated in the muscle of lobsters exhibiting symptoms of epizootic shell disease. We also identified two splice variants of the RXR, which differed by a 15 base pair insert. We expressed these proteins *in vitro* and characterized their binding to tritiated ponasterone. Both forms of EcR bound ponasterone with high affinity, and binding was enhanced in the presence of RXR. Competitive binding assays were used to measure the relative affinity of a suite of chemicals for the EcR/RXR including steroids, pesticides, phthalates and alkylphenols. This assay is being further developed to screen environmental extracts for their capacity to disrupt ecdysteroid signaling in crustaceans. (Supported by MIT Sea Grant and Rhode Island Sea Grant).

P2.16 TAVES, MD*; SCHMIDT, KL; RUHR, IM; KAPUSTA, K; SOMA, KK; Univ of British Columbia; *taves@zoology.ubc.ca*
Local steroid levels in brain: effect of saline perfusion and comparison with plasma versus whole blood levels

The brain and other organs locally synthesize steroids, and such local synthesis is suggested when steroid levels are higher in tissue than blood. Plasma steroid levels are considered to be representative of blood levels, but plasma and blood concentrations may not be the same. Additionally, blood contamination in tissues may affect measurement of tissue steroid levels. To avoid this problem, saline perfusion may be used to remove blood. Here, in Study 1, we measured corticosterone in zebra finch (*Taeniopygia guttata*) plasma, whole blood, and red blood cells (RBC) at baseline and after 60 min restraint stress. In Study 2, we quantified corticosterone, dehydroepiandrosterone (DHEA), testosterone (T), and 17 β -estradiol (E₂) in the brain of saline- or sham-perfused animals. In Study 1, corticosterone concentrations were highest in plasma, intermediate in whole blood, and lowest in RBC. Corticosterone levels in all 3 sample types were higher at 60 min than at baseline, with a greater increase in plasma than whole blood or RBC. In Study 2, saline perfusion unexpectedly increased corticosterone levels in rostral telencephalon but had no effect on corticosterone levels in caudal telencephalon, diencephalon, or cerebellum. In contrast, saline perfusion decreased DHEA levels in caudal telencephalon and diencephalon but not in rostral telencephalon or cerebellum. Saline perfusion did not affect T levels in caudal telencephalon but increased E₂ levels in caudal telencephalon. Thus, using plasma samples can overestimate circulating steroid levels in blood, and this can impair detection of high local steroid levels in tissue. In addition, blood contamination has little effect on measurement of brain steroid levels, and saline perfusion to remove blood might have its own effects on neural steroid synthesis.

P1.4 TEMKIN, M.H.*; BELL, P.; DIXON, E; St. Lawrence University; *mtemkin@stlawu.edu*

Homeobox gene expression in developing zooids of the marine bryozoan *Membranipora membranacea*

Bryozoans are a phylum of colonial invertebrates that live in marine and freshwater habitats. Gymnolaemates represent the largest and most diverse group of extant bryozoans. Organization of body axes are established at three points during the life cycle of gymnolaemate bryozoans: as the fertilized egg develops into a larva, as the larva undergoes metamorphosis to form the ancestrula (the first member of each new colony), and as each asexually budded zooid develops within the colony. In animals, morphological structures along the body axes are specified according to the expression of the homeobox genes. A subclass of homeobox genes, called Hox genes, have been demonstrated to be responsible for organizing structures along the anteroposterior axis of the body. To begin to understand the role of homeobox gene expression in organizing the body axes of gymnolaemates, we characterized the mRNA and amino acid sequences of four homeobox genes from the marine gymnolaemate bryozoan *Membranipora membranacea*. These genes are the anterior Hox gene Deformed (Dfd), the central Hox gene Lox5, the posterior Hox gene Post-2, and the EHGBox gene Gbx2. Based on these mRNA sequences, we synthesized probes for visualizing gene expression in developing zooids using an in situ hybridization protocol. Here we present data on the expression of these four homeobox genes during the development of zooids in *M. membranacea* colonies.

P2.123 TEARE, A. R.*; ROSTAL, D. C.; Georgia Southern University, Statesboro; *ateare1@georgiasouthern.edu*
Reproductive Biology of the Alligator Snapping Turtle (*Macrochelys temminckii*)

The physiological, morphological and behavioral changes associated with reproduction are well-studied in marine, freshwater and terrestrial turtles. These studies have revealed that most species follow a generalized seasonality in reproduction that is often based around environmental conditions. Changes in temperature and other environmental factors are known to stimulate hormonal axes, triggering mating behavior and gonadal recrudescence. Most temperature turtle species exhibit postnuptial gametogenesis, in which spring/summer mating uses gametes produced the previous summer and/or fall, and separate hormonal cues initiate mating behavior and gonadal activity. The alligator snapping turtle, despite overwhelming trapping during the 1960s-1980s, is understudied, and little information exists on *Macrochelys temminckii* reproductive physiology, especially with respect to hormonal seasonality. In this study, the Flint River, Georgia population of *M. temminckii* will be investigated to delineate their reproductive hormone cycles, gonadal development, and egg production. Seasonal estradiol, testosterone, and corticosterone cycles will be analyzed by ELISA. Captured males and females will be examined by ultrasound to determine reproductive status and to validate hormone analyses. Preliminary results indicate that mating occurs in spring and nesting occurs in late spring/early summer. Hormone analyses show that male alligator snapping turtles exhibit a postnuptial peak in testosterone during the fall, while females exhibit a biphasic cycle, with testosterone peaking in spring and fall. These initial findings indicate that *M. temminckii* display hormonal cycles and reproductive seasonality similar to other temperature turtles.

P2.106 THACKER, R.W.*; BANGALORE, P.; DIAZ, M.C.; HILL, A.; LAVROV, D.; LOPEZ, J.; PETERSON, K.; POMPONI, S.; REDMOND, N.; COLLINS, A.G.; U. Alabama Birmingham, Museo Margarita, U. Richmond, Iowa State U., Nova Southeastern U., Dartmouth U., Florida Atlantic U., Smithsonian Institution; *thacker@uab.edu*

Integrative approaches for reconstructing the Porifera Tree of Life (PorToL)

Sponges (phylum Porifera) are among the earliest diverging metazoans, with over 8,000 valid species. Despite their importance in benthic habitats worldwide, phylogenetic relationships within Porifera are not well resolved. In particular, the monophyly of its largest class, Demospongiae, is questioned, as well as the relationships among its major lineages. Our team seeks to establish a robust phylogeny of sponges by integrating traditional morphological systematics with multi-tiered analyses of gene sequences. Tier 1, representing each family of sponges, will assess the monophyly and branching order of major lineages (orders and suborders) by sequencing 11 nuclear genes and complete mitochondrial genomes. Tier 2, representing at least 90% of sponge genera, will examine interfamilial relationships and morphological character evolution by sequencing 8 nuclear and mitochondrial genes. Tier 3, including at least 4,000 species, will assess relationships among species and genera, using traditional morphology and sequences from 2 barcoding genes. At the scale of major lineages, we will present 3 alternative views of sponge evolution based on phylogenies constructed from sequences of (1) nuclear ribosomal 18S subunits, (2) 7 nuclear genes, and (3) whole mitochondrial genomes. To illustrate typical species-level questions, we will present evidence supporting the reclassification of *Hyrtios violaceus* from family Thorectidae to family Dysideidae. The phylogenies generated by PorToL provide an evolutionary context that will improve the understanding of all aspects of sponge biology.

P3.2 THARP II, J. M.*; JERNBERG, I.; COOPER, B. S.; ANGILLETTO JR., M. J.; Indiana State Univ, Indiana Univ; jtharp5@indstate.edu

Turning Up the Heat: Using Thermal Extremes to Test an Optimality Model of Developmental Acclimation

Although much evidence for developmental acclimation exists, researchers still know little about why organisms acclimate the way that they do. Recent theoretical models suggest that populations should evolve genotypes with the capacity to acclimate only when the environment varies among generations. In this study, we compared the developmental acclimation of fruit flies (*Drosophila melanogaster*) from two populations, one from a subtropical environment (Miami, FL) and the other from a temperate environment (Marlton, NJ). We allowed flies from each population to develop in one of three environments: 1) a stochastically varying environment with a mean of 18°C, 2) a stochastically varying environment with a mean of 25°C, and 3) a constant environment with a mean of 25°C. After flies reached adulthood, we quantified heat and cold tolerances of flies from each developmental environment and each population. Heat tolerance was quantified as the time for a fly to lose mobility when exposed to 41°C (knockdown time). Cold tolerance was quantified as the time required for a fly to recover from a cold-induced coma (chill-coma recovery time). We predicted that flies from NJ would have greater developmental plasticity and thus display greater heat tolerance and cold tolerance than FL flies. Knockdown time acclimated in a manner that was consistent with our prediction (e.g. flies from NJ could withstand heat longer than those from FL when both were raised at 25°C). However, chill-coma recovery did not acclimate differently between the two populations; flies from both populations recovered more quickly when raised at 18°C than when raised at 25°C, and recovery times did not differ between populations. Our results suggest that new models are needed to better understand the acclimation of thermal tolerance.

P3.25 TILLMAN, Jennifer L.*; ZANI, Peter A.; Lafayette College, Gonzaga University; zani@gonzaga.edu
Effects of predator diversity and density on prey behavior: inter-population differences of side-blotched lizards (*Uta stansburiana*) exposed to snakes, lizards and birds

Animals in high-predation environments tend to react more quickly and effectively in the presence of predators when compared to populations experiencing low predation pressure. Yet, habitat differences among populations confound many previous studies. We studied a common prey species, side-blotched lizards (*Uta stansburiana*), in Oregon and Nevada to test for behavioral differences among populations that varied in types and numbers of predators, but that occupied similar habitat. We measured several traits associated with predator exposure: time spent moving and displaying, distance moved, and perch height. We also quantified potential predators (snakes, lizards, birds) at each site. Four study populations varied in predator diversity from eight potential predators (three snakes, three lizards, two birds) to as few as one (a snake). Predator density among populations ranged from as many as 20 per ha to as few as one. The two populations exposed to the highest predation potential spent less time displaying, moved less often, and moved shorter distances. Comparison among populations suggests that predator density is as important as predator diversity. A high-predation population exposed to a high density of one major predator (leopard lizards, *Gambelia wislizenii*), but lacking collared (*Crotaphytus bicinctores*) and whiptail (*Aspidoscelis tigris*) lizards, exhibited more visibility-reducing behavior (fewer movements and displays) than a high-predation population exposed to similar predator density, but consisting of all three predator species. We suggest that the higher lizard diversity gives potential predators more prey to choose from and reduces the risk to common prey species, such as *Uta*.

P1.125 TILDEN, Andrea*; KUSEMA, Escar; LANGTON, Ruth; MYERS, Jennifer; Colby College; artilden@colby.edu
Influence of melatonin, glutamate, and melatonin receptor antagonists on neurite growth in crustacean X-organ cells

Melatonin is a neuromodulatory hormone with well-studied roles in the regulation of vertebrate circadian physiology. Few studies have been conducted in invertebrates, though it has been determined that they do produce melatonin. Previous studies in our lab have shown that melatonin enhances neurite growth in cultured crustacean X-organ cells, and that luzindole, an inhibitor of both MT1 and MT2 melatonin receptors, also influenced neurite growth. In the current studies, we explored the cellular role of melatonin in crustacean neurite growth. To further determine the melatonin receptor type located in X-organ cells, we treated the cells with pertussis toxin, an inhibitor of MT1 receptor-coupled Gi (inhibitory G protein) activity. Pertussis toxin did not influence neurite growth. Prazosin, an MT3 receptor antagonist, inhibited melatonin-induced neurite outgrowth. Glutamate at high (10 mM) concentrations has neurite growth-inhibiting effects on X-organ cells, and at higher (50 mM) concentrations is excitotoxic. In prior studies, we showed that melatonin has neuroprotective effects against oxidative stress. Treatment with melatonin and non-lethal levels of glutamate had cytotoxic effects, causing necrosis in all cells within 24 hr of treatment, suggesting an interactive effect of the two modulators.

P1.40 TOLEDO-HERNANDEZ, Carlos; TORRES-VAZQUEZ, Irma; SERRANO-VELEZ, Jose; ROSA-MOLINAR, Eduardo*; University of Puerto Rico, RA—o Piedras; c.toledo_hernandez@yahoo.com

Microwave-Assisted Processing Of Coral Tissue

Although histological procedures using traditional equipment have not changed much in fifty years, the introduction of microwave technology has revolutionized histological processing by reducing processing time while improving tissue integrity. We provide the first description of a histological procedure developed for coral histology. Fourteen healthy and diseased tissue fragments of the Caribbean sea fan *Gorgonia ventalina* were processed. Using a new method we improved the quality of the histological material and significantly decreased processing time, reducing to 1 hr fixation time in contrast to the 24hrs required for conventional methods, decreasing to 40 minutes the decalcification time as opposed to an average of 24hrs, and reducing tissue processing to 1.2hrs and to 4 simple steps.

P2.155 TRACY, C. R.*; CHRISTIAN, K. A.; MCARTHUR, L. J.; Charles Darwin University; chris.tracy@cdu.edu.au
Peeing out transmitters: Anuran amphibians appear to possess a unique method of removing foreign objects from their body cavities

While conducting a study involving radio-telemetry of three species of Australian hylid frogs (*Litoria caerulea*, *L. dahlii*, *Cyclorana australis*), we observed what could be a unique mechanism by which frogs can remove foreign objects from their body cavity. Transmitters that we had surgically implanted into the abdominal cavity of frogs were subsequently found frequently in the bladder when the frogs were retrieved after several months of tracking in the field and the transmitters removed. To bring data to bear on the hypothesis that this observation revealed a potential mechanism for removing foreign objects from the body cavity (a mechanism that would not work for transmitters because they would be too large to be voided through the pelvic girdle), we implanted small (7.8 mm long, 4 mm diameter) plastic beads into the body cavities of *L. caerulea* and cane toads (*Rhinella marinus*), and monitored the animals in cages for reappearance of the beads. In *L. caerulea*, all beads were found in the frog cages within approximately 2-3 weeks; in cane toads, some beads reappeared. This result suggests two things: (1) caution should be employed during telemetry studies when assuming that transmitters found separate from live anurans in the field indicate that predation (or other forms of mortality) separated the animals from their transmitters, and (2) these data document what appears to be a unique mechanism by which foreign objects (e.g., spines or thorns) can be removed from the body cavities of some (or potentially all) anurans.

P2.122 TRAN, Michael C.*; TSUKIMURA, Brian; California State University, Fresno; tranmc@csufresno.edu
Effects of methyl farnesoate on cyst production and growth in *Triops longicaudatus*

Since the discovery of the putative hormone methyl farnesoate (MF), it has been identified in 30 crustacean species, in which it regulates reproduction and morphogenesis (Laufer and Biggers, 2001). In the tadpole shrimp, *Triops longicaudatus*, MF appears to suppress and delay ovary development in 5-day old juveniles (Tsukimura et al., 2006). This study aims to investigate the effects of MF on ovarian output by looking at total and daily cyst production, while also examining the somatic effects, upon MF ingestion. Two groups of animals were cultured and fed 120 mg of control and MF pellets (6 µg/g) every 24 hours. Average daily cyst production in individuals that survive beyond 5 days of oviposition were similar. The control and MF-treated animals had 76.4±9.9 SEM cysts/day (n=11) and 72.5±7.9 SEM cysts/day (n=13), respectively. However, there was a decline in the total number of cysts produced by MF-treated animals compared to controls, 665.3±98.5 SEM cysts (n=11) to 542.4±66.7 SEM cysts (n=13). The decrease of total cyst production appears to be the result of a decreased number of days of oviposition. MF-treated animals appears to live 1.5 days less compared to control animals, and had a mean of 7.4±0.5 SEM days of oviposition compared 9.0±1.1 SEM in control. The average daily cyst production appears to not be affected by dietary MF, but it may decrease the total cyst production by decreasing in lifespan. Daily administration of MF may also stunt the overall growth of the animal, MF-treated and control animals had growth rates of 0.67±0.1 SEM and 0.75±0.1 SEM mm/day, respectively. This coincides with a previous study, where 5-day old juveniles had a decrease body length and weight after being fed 3.8 µg/g MF-concentrated pellets (Tsukimura et al., 2006).

P2.46 TRACY, C.R.; BARBER, A.M.; WAKELING, S.R.*; Univ. Nevada, Reno; wakelin3@unr.nevada.edu
Patterns in Blood Parameters Associated with Stress Responses in Desert Tortoise (*Gopherus agassizii*)

Conservation biology aims to prevent declines in healthy animal populations and to promote recovery of declining populations. A better understanding of physiology is important to the conservation of Nevada's state reptile, the desert tortoise (*Gopherus agassizii*). Understanding stress physiology is especially important, because chronic stress suppresses the immune and reproductive systems of most vertebrates. However, short-term elevation of stress hormones can be beneficial in stressful situations by activating adaptive physiological processes, including the generation of blood glucose. Our research has focused on measuring baseline markers of the stress response in desert tortoise: blood glucose and the stress hormone corticosterone. Our research was conducted on routinely handled captive tortoises on the UNR campus. Single blood samples were collected from a group of thirteen animals to determine the correlation between blood glucose and corticosterone concentration. In a separate study, two groups of three animals were sampled at three times in a single day to determine diurnal changes in blood glucose and corticosterone. Blood glucose and corticosterone concentrations followed a similar diurnal pattern: higher levels in the morning and evening with the lowest levels in the middle of the day. These studies will provide information about average daily fluctuations in stress biomarkers within individuals, and will serve as the foundation for a larger study of handling stress in captive animals, which will be used in comparison to wild animals.

P3.148 TREYBIG, T. A.*; CARRILLO, A.; HOESE, W. J.; DICKSON, K. A.; California State University, Fullerton; tracietreybig@gmail.com

Effects of delayed hatching on muscle and skeletal development and feeding rates in the California grunion, *Leuresthes tenuis*

The California grunion, *Leuresthes tenuis*, spawns on sandy beaches during spring high tides. Fertilized eggs incubate in the sand for 9-14 days until wave action reaches them, which stimulates the embryos to hatch. If this does not happen, embryos may remain viable for up to 35 days post-fertilization (dpf) and hatch during subsequent spring high tides (= delayed hatching). We studied effects of delayed hatching on larvae from eggs collected from single females, fertilized with the sperm of a single male, incubated in the lab at 20°C, and hatched at 10 and 28 dpf. We hypothesized that, during extended incubation, additional development and differentiation would occur, and thus 28-dpf larvae would be longer, have more developed skeletal structures and locomotor muscle, and would have greater feeding rates than 10-dpf larvae. We found that the 28-dpf larvae were significantly longer, had significantly more dentary and pharyngeal teeth, and had visible hypural cartilage within the caudal fin anlage. However, the percentage cross-sectional area composed of slow and fast locomotor muscle did not differ significantly between 10- and 28-dpf larvae. In addition, we found that the 28-dpf larvae consumed more rotifers, *Brachionus* sp., during a 4-h period. Thus, delayed hatching in *L. tenuis* results in larvae with a more developed skeleton and improved feeding performance. These positive effects of delayed hatching may offset known negative effects (decreased hatching rate and energy reserves) and thus may affect larval survival and recruitment to adult populations.

P1.109 TROUTMAN, AR*; HRANITZ, JM; BRUBAKER, KD;
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A Comparison of Several Forkhead Protein DNA Binding Domains in Two Species of Leafcutting Bee

Members of the solitary, cavity nesting bee community in Central California partition their nesting niches among three principal habitats (riparian zone, marsh, grassland) and occupy nesting sites with conditions ranging from cool and moist to hot and dry. Native bee species display stenothermal nesting niches compared to two introduced species. Studies show that variation in offspring thermotolerance, HSP70 expression, and survival corresponds to adult female nesting habitat preferences and, in part, attribute the spread of these bees in the western U.S. to their tolerance of hot, dry habitats. Transcription factors possessing the forkhead domain contribute to developmental and heat shock response pathways, potentially coordinating both development and thermotolerance. The goal of this study was to survey forkhead domains of transcription factors in solitary bees that differ in HSP70 expression and thermotolerance, *Megachile rotundata* and *M. apicalis*. We used primers for a highly conserved DNA binding domain to amplify, clone, and sequence the cDNA of this domain of four forkhead proteins (DAF-16 (FOXO1), FOX A1, FOX C2, and FOX D3) in heat shocked larvae. Amplified cDNA sequences were 165 bp (*Daf-16*) and 156 bp (*Fox a1*, *Fox c2*, and *Fox d3*). Three indels differ between *Daf-16* in the heat shock pathway and transcription factors in developmental pathways. Translated protein sequences revealed DAF-16 to have 52-57% similarity with developmental transcription factor forkhead domains, which were 67-73% similar to one another. These results indicate several amino acid residues may distinguish the DNA binding function of the forkhead domain proteins that regulate heat shock response versus developmental pathways.

P1.77 TWEETEN, Kay/A.; St. Catherine University;
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Lumbriculus variegatus Populations Show Variations in Chromosome Number, Protein Expression, Response to Toxicants, and Modes of Reproduction

Analysis of several North American populations of *Lumbriculus variegatus* revealed differences in chromosome numbers. Chromosome spreads from *L. variegatus* collected from natural habitats in Iowa and Minnesota contained 34-36 chromosomes. Spreads from *L. variegatus* reference populations that have been maintained for several years in laboratory cultures or that were obtained from commercial sources contained greater than 60 chromosomes, suggesting that the genomes of these worms are polyploid. Protein profiles generated by SDS-polyacrylamide gel electrophoresis were very similar for all the populations. Analysis of proteins by two-dimensional gel electrophoresis showed some differences in levels of expression of specific proteins between the diploid and polyploid populations. Whereas the polyploid populations only reproduced asexually, the populations collected from natural habitats reproduced asexually and sexually with cocoons yielding viable offspring. Because *L. variegatus* is used extensively as an environmental quality indicator organism, the response of the diploid and polyploid populations to environmental toxicants was determined. For interpretation and comparison of experimental or toxicological results using this freshwater oligochaete, the data suggest that it is important that researchers report the diploid or polyploid nature of their test organisms.

P3.149 TUN, K.M.*; FRUTIGER, A.E.; HOLDENER, J.A.; ITAGAKI, H.; Kenyon College; itagaki@kenyon.edu

The calculation of the body surface area of Manduca sexta larvae using serial sections and computer reconstruction.

We have continued our work in estimating the body surface areas (BSA) of 2nd, 3rd and 4th instar larvae of the sphinx moth, *Manduca sexta*, of various body weights (BW). The larvae were reared from eggs on a prepared diet, then frozen and embedded in Histoprep along with four external orientation markers to serve as reference points between sections. A cryostat was used to make transverse serial sections of each larva at 50µm. Each section was digitized using a stereomicroscope equipped with a digital camera and polarization optics. The images of the sections were then imported into the NIH Image J program for analysis. The distances between each of the 4 orientation markers was measured and used to estimate the centroid of each section. A line drawn between the centroid and the upper left marker dot served as the reference axis between sections. For each section, 36 radial measurements were taken from the centroid to the surface in 10 degree increments. Each set of radii values was imported into MAPLE, in which a parametric model of the boundary curve was constructed. A second program in MAPLE was then used to create a parametric model of the body surface for each instar in addition to finding the surface area; the centroid for each section was used to determine a space curve that served as the generating curve for the body surface. Our data so far indicate that the BSA in these larvae scales to the 2/3 power with respect to the BW. This work was supported by the NSF(DMS-0827208) and the Kenyon College Summer Science Scholars Program.

P2.1 UHRIG, E.J.*; CHRISTOPHERSON, Z.; LEMASTER, M.P.; MASON, R.T.; Oregon State University, Western Oregon University; uhrige@onid.orst.edu

Interspecific Variation in the Female Sexual Attractiveness Pheromone of Garter Snakes

During the breeding season, female garter snakes produce a sexual attractiveness pheromone composed of a homologous series of saturated and monounsaturated methyl ketones. This pheromone, expressed in the skin lipids of females, elicits courtship behavior from males, who rely extensively on the pheromone for recognition of suitable mates. Utilizing four garter snake species, including two pairs of sympatric species, the current study is designed to investigate whether the chemical profile of the female sexual attractiveness pheromone exhibits interspecific variation. Pheromone samples were collected from females of each species: the red-sided garter snake (*Thamnophis sirtalis parietalis*) and the plains garter snake (*Thamnophis radix*), which are sympatric in Manitoba, Canada, as well as the red-spotted garter snake (*Thamnophis sirtalis concinnus*) and the northwestern garter snake (*Thamnophis ordinoides*), which are sympatric in Oregon. Chemical analyses revealed significant qualitative variation in the chemical profile of the pheromone between all four species. This dissimilarity was particularly evident within the sympatric groups. These results suggest that the female sexual attractiveness pheromone of garter snakes may function as a mechanism of prezygotic reproductive isolation allowing males to distinguish between conspecific and heterospecific females.

P1.26 VALLEY, Jenna R.*; MARTIN, Vicki J.; Appalachian State University; valleyjr@appstate.edu

Eye development in the box jellyfish *Carybdea marsupialis*

Cnidarians (including hydras, jellyfish, sea anemones and corals) are the most primitive invertebrates alive today to possess eyes. Referred to as ocelli, the eyes of the cubozoan *Carybdea marsupialis* are arranged in 4 groups of 6 on club-shaped structures called rophalia found suspended from each of the four sides of the bell. The ocelli consist of 2 sets of simple eyes, referred to as the slit and pit ocelli, and 1 set of complex camera-type eyes which exhibit many similarities to the camera-type eyes of higher metazoans. The development of the eyes can be followed as an adult polyp transforms to the medusa (jellyfish), the eye-bearing form. This transformation can be stimulated by an increase in water temperature in combination with a cessation of feeding. In following the transformative process, 8 morphological stages were identified using light microscopy and accompanying scanning electron microscopy. Starting with a steady-state polyp (stage 0), the main features of transformation include recession of polyp tentacles, a change of symmetry from radial to tetra-radial, eye development, emergence of medusa tentacles, and detachment (stage 7). The first eye spot can be seen by 4 days after beginning the process and by day 14, the polyp has formed a free-swimming medusa with miniature versions of adult ocelli. The first ocelli to appear are the large complex eyes, followed by the small lensed eyes and lastly, the simple ocelli. In addition, it was observed that transforming polyps with late-forming eyes were able to regress back to the original polyp state, which lacks eyes, under varying conditions.

P2.146 VAN UITREGT, V.O.*; WILSON, R.S.; FRANKLIN, C.E.; The University of Queensland, Australia; v.vanuitregt@uq.edu.au

Cooler temperatures increase sensitivity to ultraviolet B radiation in embryos and larvae of the frog *Limnodynastes peronii*

Recent studies suggest that complex interacting processes are driving global amphibian declines. Increased ultraviolet B radiation in the solar spectrum associated with ozone depletion has been implicated in declines, and evidence suggests that the effects of UVB radiation on amphibians may be greater at cooler temperatures. We tested the thermal sensitivity of UVB effects on amphibians in a controlled factorial experiment using the striped marsh frog, *Limnodynastes peronii* as a model species. We compared survival, growth and locomotor performance of embryonic and larval *L. peronii* reared under low and high UVB exposures at both 20 and 30°C. Embryonic and larval *L. peronii* proved extremely sensitive to UVB damage and exhibited greater sensitivity at 20°C compared to 30°C. Embryonic survival to Gosner stage 25 was unaffected by UVB exposure at 30°C, but at 20°C survival was reduced to 52% under high UVB. Larval survival exhibited a similar trend. At 20°C, all tadpoles survived under low UVB, whereas under high UVB there was 100% mortality after 15 days of exposure. At 30°C, 86% survived under low UVB, but only 46% survived under high UVB. Sublethal effects such as, embryonic malformation, retarded larval growth and reduced larval swimming performance were also greater at 20°C compared to 30°C. Our results strongly indicate that UVB damage in amphibians is markedly increased at cooler temperatures. Thus, populations of UVB sensitive species occurring at cold climates may be at greater risk of declines due to increased solar UVB radiation.

P3.79 VEGA, Christine M.*; STAYTON, C. Tristan; Bucknell University; cmv007@bucknell.edu

Functional Implications of Shell Shape Differences between Male and Female Painted Turtles (*Chrysemys picta*) and Wood Turtles (*Glyptemys insculpta*)

Sexual dimorphism in shell shape is observed in many species of turtle. Females need to be able to accommodate clutches of eggs, and consequently have wider and more highly domed shells, while males tend to have flatter, more streamlined shells. In addition, the males of many terrestrial species show concave plastrons to compensate for the domed shells of the females during mating. This study investigates the mechanical implications of shell shape differences between males and females of two Northeastern US species, *Chrysemys picta* and *Glyptemys insculpta*. Landmarks on the specimens' shells were collected from dorsal, lateral, and ventral views; these data were used to create digital models of the shells for finite element analysis. Eight load cases were analyzed - the resulting data set was used to compare males and females of the same species. Female shells for both turtle species developed significantly lower stresses for a given load than their male counterparts. Male *Glyptemys insculpta* experience significant stresses because of the concave shape of their plastrons.

P2.59 VENN, C.*; HRANITZ, J.; BRUNSKILL, J.; Bloomsburg University of PA; cvenn@bloomu.edu

An Interdisciplinary Project across Disciplines in Undergraduate Education: Salt Marsh Vegetation, Distribution of Salt Marsh Invertebrates, and the Application of Geographic Information Science

Students often become more engaged when they get involved in projects with a scope larger than that of a single course or lab. With that in mind, we have started a research project in the salt marshes in the Wallops Island National Wildlife Refuge, Wallops Island, VA, to relate small-scale variations in marsh habitat to sea level changes. The first step: to map vegetation changes in three 50 meter by 50 meter plots to record any differences in vegetation that might be related to small sea level differences. The primary goal of the project is to determine at what level of remote sensing those small scale differences might be detected. We have also incorporated the study area into a field project for an undergraduate course in Field Zoology, where students recorded the macroinvertebrates within 0.25m X 0.25m regularly spaced quadrats across the plots, assessing the differences in populations among the plots and among the vegetation microhabitats. Vegetation data and macroinvertebrate data collected by the students in the large scale project provide the basis for several projects for the advanced GIS course at Bloomsburg University.

P2.74 VIG, D.K.*; KERKHOFF, A.J.; Kenyon College;
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Modeling caterpillar responses to inducible plant defenses

Many herbivores have the ability to defoliate an entire plant within days. In response to herbivory, some plants generate toxic chemicals in their leaves. These inducible defenses are unique for each species of plant. For example, tobacco, *Nicotiana attenuata*, increases nicotine production when the caterpillar, *Manduca sexta*, starts to feed on it. We explored caterpillar growth and feeding behavior in the context of inducible plant defenses by creating a dynamic state variable model. At each time step the caterpillar had a "choice" to either stay on the current plant or move to a new plant. We compared the optimal life histories of caterpillars growing on plants with a low induction rates to those growing on plants with high induction rates. Caterpillars that were adapted to a lower induction rate tended to stay on a plant longer and achieve higher average fitness than caterpillars adapted to a higher induction rate. However, when caterpillars that were adapted to a low induction rate were exposed to an environment with a high induction rate, they achieved lower average fitness than caterpillars adapted to that environment, even though they displayed similar behavior. Similarly, caterpillars adapted to a high induction rate tended to remain on low induction rate plants for a longer time, but could not match the average fitness level of caterpillars adapted to the less stressful environment. Thus, variation in the inducible defenses has the potential to act as a selective force on caterpillar behavior. The generality of the model will also allow future studies to examine whether caterpillar behavior can change in response to inducible communication between plants.

P1.32 VON DASSOW, M.*; DAVIDSON, L.A.; Univ. of Pittsburgh; mvondass@yahoo.com

Force generation and viscoelastic resistance in the amphibian embryonic epithelium

The morphogenetic movements of amphibian (*Xenopus laevis*) gastrulation proceed despite great variation in tissue stiffness, including both natural and experimental variation. To explore whether coupling between force generation and embryo stiffness could explain this surprising observation, we are developing methods to measure tissue viscoelasticity and stimulate contraction in the same patch of epithelial tissue from *X. laevis* embryos. Deformation in response to suction allows measurement of tissue viscoelasticity, while electrical stimulation induces contraction of the partially aspirated tissue. Mechanical stimulation alone was not sufficient to stimulate contraction, and the viscoelastic properties were independent of the rate of stress application. Preliminary results suggest that the mechanical properties of the epithelium are well described by a linear, small strain viscoelastic model, even up to fairly large deformations under suction. Using the measured viscoelastic properties and simple models of contraction mechanics, we can calculate the time-dependent forces driving induced contractions. These methods will allow novel biomechanical approaches to investigating embryonic morphogenesis.

P2.108 VOLLRATH, K.*; MOOI, R.; San Francisco State Univ., San Francisco, California Academy of Sciences, San Francisco; kvollrath@calacademy.org

The origin and phylogeny of major sea urchin clades since the Paleozoic

Echinoids are an ecologically important clade originating in the Ordovician, and serve as models for the evolution of novel morphologies. The origin of the echinoids has been a subject of much debate. This can be attributed in part to the lack of clearly defined homologies within the Echinodermata, and among the Echinozoidea specifically. In addition, the current phylogeny of the Paleozoic urchins is incomplete both in terms of hypothesized homologies and taxon sampling. Here we provide insights into the origin of echinoids, and propose a species-level phylogeny encompassing the full diversity of Paleozoic forms. We use the Extraxial-Axial Theory (EAT) to delineate major homologies among the taxa. Even when not relying on the EAT, many of the characters have not been adequately explored for phylogenetic signal. Our approach sheds new light on when major events occurred during cladogenesis, and on phylogenetic placement of key taxa such as *Bothriocidaris*, *Bromidechinus*, *Aulechinus*, *Eothuria*, and *Ectinechinus*. The status of evolutionarily informative homologies is assessed in more than 60 genera, covering extinct and extant species of echinoids, holothuroids, and ophiocistoids by using species descriptions in the primary literature, observing fossil collections, and through dissections. A database of morphological, stratigraphic, and geographic data can then be compiled for each species using MacClade. Ensuing phylogenetic analysis will enable a deeper understanding of biodiversity in Paleozoic echinoids, and of the major events in the origins and diversification of this group. It will also help uncover the origins of major morphological characters among and subsequent divergence of Paleozoic echinoids, modern forms, and holothuroids.

P2.98 WACK, Corina L.*; WOODLEY, Sarah K.; Duquesne University; wackc@duq.edu

Effects of pheromone treatment on gonadotropin-releasing hormone and arginine vasotocin neurons in the brain of a terrestrial salamander

Gonadotropin-releasing hormone (GnRH) and arginine vasotocin (AVT) are important neuromodulators of reproductive and social behaviors. Both GnRH and AVT neurons may be modulated by pheromones to influence expression of behavior. We tested the hypothesis that pheromones would affect the number of GnRH and AVT neurons in the red-legged salamander (*Plethodon shermani*), an emerging non-mammalian model for studies in chemosensory communication. A courtship pheromone from the mental gland of the male red-legged salamander increases female receptivity, thus we predicted that this pheromone would increase the number of GnRH and AVT neurons in females compared to males. We applied male courtship pheromone or vehicle control to the nares of male (reproductive) and female (reproductive and non-reproductive) red-legged salamanders. Females that received pheromone had more GnRH neurons in the rostral telencephalon than control females that received the vehicle. Females overall had significantly more GnRH neurons in the caudal telencephalon than males. There was no effect of pheromones on the number of AVT neurons, but females had significantly more AVT neurons in the dorsal pallium than males. Additionally, reproductive males and females had more AVT neurons in the posterior preoptic area than non-reproductive females. These results suggest that male courtship pheromones influence the GnRH system but not the AVT system in red-legged salamanders.

P2.36 WAGNER, D N*; GREEN, D; COOPER, J M; BEAUCHESNE, S; WILLIAMS, T D; Simon Fraser University, Cooper, Beauchesne and Associates Ltd., Cooper, Beauchesne and Associates Ltd.; dwn1@sfu.ca

Impact of water level management on the condition of migratory songbirds

Habitat quality is thought to be important for migratory success in many neo-tropical migrants. Both the quantity and quality of riparian habitats used by migrants will vary with changes in water level and this can be an important management consideration for operation of dams and reservoirs. We have initiated a 10-year study monitoring the timing and pattern of Fall migration in four potentially dam-impacted neo-tropical migratory warbler species (Yellow Warblers, *Dendroica petechia*; Common Yellowthroat, *Geothlypis trichas*; Wilson's Warbler, *Wilsonia pusilla*; Orange-crowned Warbler, *Vermivora celata*) in a riparian zone in Revelstoke, British Columbia. We blood sampled birds over a 10-week period (July-September) and measured levels of plasma metabolites (triglyceride, glycerol, β -OH butyrate) as indicators of migratory condition and fattening rate. In addition we are using stable isotope analysis to identify residents and migrants to determine how this effects variation in habitat use and rate and timing of migratory fattening. Preliminary data analysis has confirmed few age or sex differences in plasma metabolite levels (as found in previous studies). However, we do detect significant increases in fattening rate (residual triglyceride) both over the course of a single day, with time after dawn, as well as with date over the length of the migration season. In addition, fattening rates varied significantly between the four different species of migrants, being highest in Wilson's Warbler.

P3.150 WALL, C.E.*; GAPEYEV, V.; GERMAN, R.Z.; LIU, X.; VINYARD, C.J.; WILLIAMS, S.H.; Duke Univ., NESCent, Johns Hopkins Univ., NEOUCOM, Ohio Univ.; cw19@duke.edu

The Feeding Experiments End-user Database (FEED)

Over the past 35 years, researchers have collected impressive datasets on motor patterns of muscles and associated movements and forces in the jaws and oropharyngeal apparatus during feeding across a wide range of mammals. Individually, the datasets demonstrate the physiological and behavioral complexity of mammalian feeding. Further understanding of the evolutionary basis of this complexity depends on inter-specific comparisons which are not possible without bringing individual datasets together in a comprehensive database. The utility of a database for synthetic research, in turn, depends on aligning the data recordings, behaviors, morphologies, and data acquisition protocols with respect to a common ontological language. Here we report on a database that will serve as a repository for experimental physiological data on mammalian feeding and efforts to develop an ontology for behavioral, morphological and physiological feeding data. The Feeding Experiments End-user Database (FEED), with development supported by the National Evolutionary Synthesis Center, will be a publicly available, web-based resource and the first major database of organism-level physiological data. The most common types of data are EMG, bone strain, and kinematic recordings made during chewing and swallowing. FEED will support easy upload and storage of raw data recordings and associated metadata. End-users will be able to search FEED using controlled attributes and keywords in free-text descriptions, and to download raw data recordings and associated metadata in formats suitable for post-processing and statistical analysis. We anticipate that the use of FEED will lead to new scientific findings and to studies that will generate data from novel mammalian species.

P1.48 WAITE, J N*; BURKANOV, V N; ANDREWS, R D; Univ. of Alaska, Fairbanks / Alaska SeaLife Center, NMML / Pac. Inst. of Geog., Kamchatka Branch ; jnwaite@gmail.com

Dietary resource partitioning between sympatrically breeding Steller sea lions (*Eumetopias jubatus*) and northern fur seals (*Callorhinus ursinus*) on Lovushki Island, Russia.

Steller sea lions (SSL, *Eumetopias jubatus*) and northern fur seals (NFS, *Callorhinus ursinus*) breed sympatrically on Lovushki Island, Russia. A large population of non-breeding juvenile NFS is also present during the breeding season. After experiencing a dramatic population decline over most of their range in the last 4 decades, the SSL population on Lovushki Island has begun to increase slowly in recent years. Simultaneously, the NFS population has been increasing at a rapid pace, creating the potential for intra- and inter-specific foraging competition. The dietary resource partitioning between these three groups was examined through the analysis of undigested prey remains recovered from scats and spews collected on the rookery. The prey selection of breeding SSL and breeding NFS suggests a partitioning of dietary resources based both on prey selection and spatial foraging location. There was a significant dietary overlap between breeding SSL and non-breeding NFS (Pianka's niche overlap index $O_{ij} = 0.939$) but not between breeding SSL and breeding NFS ($O_{ij} = 0.231$). SSL and juvenile NFS fed primarily on Atka mackerel (*Pleurogrammus monopterygius*) and walleye pollock (*Theragra chalcogramma*). Both of these species are low- to moderate-energy prey items that inhabit shallow, near-shore waters. Adult female NFS fed primarily on higher-energy northern smoothtongue (*Leuroglossus schmidti*) and cephalopods, both of which occur offshore in pelagic waters. While the dietary overlap between breeding SSL and non-breeding NFS is high, without knowledge of foraging locations and times, a high level of competition for prey resources cannot be inferred.

P2.172 WANG, J.*; HAYASHI, M.; GERRY, S.P.; ELLERBY, D.J.; Wellesley College; jwang2@wellesley.edu

Intraspecific Morphological Differences in Bluegill Sunfish

Bluegill sunfish, *Lepomis macrochirus*, show intraspecific morphological and behavioral differences dependent on environment. We hypothesized that Lake Waban bluegill would show morphological differences between open water (OW) and densely vegetated (DV) regions that correlate to differences in swimming performance: DV bluegill would show a truncated, maneuverable body form, while OW bluegill would have a streamlined body suitable for cruising. Bluegill were caught by hook and line and photographed for morphometric analysis. Using Image-J, fin size, area, and location relative to center of mass were measured and expressed relative to body length. OW bluegill had higher aspect ratio pectoral fins, larger dorsal fin area, and more elongated bodies than DV bluegill ($p < 0.05$). The pectoral fins of OW bluegill were farther from the center of mass than DV bluegill ($p < 0.05$). Elongated pectoral fins farther from the center of mass are likely to be effective in exerting power and torque during labriform swimming. Body elongation indicates a streamlined form that may experience lower drag forces. DV bluegill had longer soft dorsal fins, wider caudal fins, and larger eyes ($p < 0.05$). The soft dorsal, anal, and caudal fins of DV bluegill were farther from the center of mass than in OW bluegill ($p < 0.05$). The size and placement of these fins suggest that they will be effective in creating turning moments to facilitate maneuvering. These morphological features are shared by maneuvering fishes. Therefore, DV bluegill morphology is specialized for maneuverability, while OW bluegill are specialized for cruising. Future energetics, kinematics, and respirometry experiments will provide further insight into the biomechanics of bluegill swimming performance, and potential studies in genetics and diet may address questions in intraspecific diversification.

P3.120 WARNE, R.W.*; CRESPI, E.J.; BRUNNER, J.L.; Vassar College, NY, State University of New York, Syracuse; rw.warne@gmail.com

Escape from the pond: Stress response to ranavirus infection in wood frogs

Ranaviruses are widespread, directly transmitted viruses of ectothermic vertebrates that cause mass die-offs in amphibians. Despite these often dramatic and lethal impacts, little is known about how amphibian physiology mediates ranavirus infection. In an LD-50 experiment, in which prometamorphic wood frog tadpoles (*Rana sylvatica*) were infected with varying doses of a ranavirus isolated from a recent frog die-off in the Hudson Valley, NY, we found that the odds of dying increased with Gosner stage at the time of exposure. Because glucocorticoids (CORT) play an important role in both regulating metamorphic development, as well as the mounting of an immune response, we hypothesized that virus infected tadpoles would exhibit increased levels of CORT relative to controls. Here we test this hypothesis through examination of development and the daily CORT profile of tadpoles infected with ranavirus over 6 days relative to uninfected tadpoles. We found that development, measured as progression through Gosner stages, was significantly faster in infected tadpoles relative to controls. Infected tadpoles in advanced developmental stages also had significantly lower body condition relative to controls at the same stage. These results suggest that elevated CORT levels needed to mount an immune response may also drive increased development rates at a cost to nutritive condition. From a life history perspective, the advancement of development may also provide a mechanism by which tadpoles could escape a pond with an epidemic ranavirus outbreak. These results provide basic insight into the physiological mechanisms by which amphibians mediate the costs of immune function and survival in the face of emerging infectious diseases.

P2.68 WATTS, H.E.*; MACDOUGALL-SHACKLETON, S.A.; HAHN, T.P.; University of California, Davis, University of Western Ontario; hewatts@ucdavis.edu

Inter-individual variation in reproductive development in response to environmental cues

Traditionally studies investigating the use of environmental cues to time reproduction have focused on the mean response of individuals to a particular cue(s). However, individuals in such studies typically vary in their response to a given cue or set of cues. This variation is potentially important because it may reflect the potential for a species to adapt to environmental changes. Here, we examine inter-individual variation in response to photoperiodic cues inducing reproductive development in one family of songbirds, the Cardueline finches. The Carduelines exhibit a wide range of breeding schedules, ranging from strictly seasonal to opportunistic. Using experimental data collected on several Cardueline species, we investigate relationships between breeding schedule, cue intensity, and inter-individual variation. We also discuss inter-individual variation in response to photoperiodic cues relative to variation in response to other, non-photoc cues.

P1.36 WARSINSKE, H.C.*; GORDON, V.K.; PREHODA-WYERS, M.M.; DEAROLF, J.L.; Hendrix College, Conway, AR; warsinskeh@hendrix.edu

The effects of prenatal steroids on the rectus abdominus muscle in fetal guinea pigs

To increase the chances of a successful premature birth, an expectant mother is injected with glucocorticoid steroids in order to speed the development of her fetus's lungs. Betamethasone is one example of a glucocorticoid, and its long term effects on fetal lung tissue are relatively well understood. However, the effects of this steroid on a fetus's breathing muscles are not well known. We will be examining how exposure to betamethasone influences the number, size, and type of muscle fibers in the rectus abdominus, an expiratory muscle of fetal guinea pigs (*Cavia porcellus*). Our hypothesis is that the administration of these steroids to expectant mothers will cause a decrease in the number of type IIa fast twitch fibers and atrophy, such that the fibers in the muscles of treated fetuses will be smaller than those in untreated specimens. This hypothesis is based on findings of the effects of these steroids on fetal sheep hindlimb muscles and adult rodent breathing muscles. Pregnant guinea pigs will be injected with betamethasone (0.5 mg/kg) or sterile water 65%, 75%, and 85% gestation. Fetal rectus abdominus samples will be collected and prepared for immunohistochemistry, which will be used to identify the different fiber types present. Scion Image will be used to collect data on fiber number, diameter, and staining density. If our hypothesis is supported, babies exposed to prenatal steroids could have decreased ventilatory rates, as a result of decrease in the number of type IIa fibers. Atrophy would also mean smaller, less effective muscles.

P3.24 WEAVER, R. E. *; KARDONG, K. V.; School of Biological Sciences, Washington State University; weaverr@wsu.edu

Prey Preference of the Desert Nightsnake (*Hypsiglena chlorophaea*): Invertebrates and Prey Size

Nightsnakes (*Hypsiglena chlorophaea*) were collected during 2008 from 3 localities in Washington State, maintained in glass aquaria on a 12:12 light cycle, and fed a variety of known prey items. Water was available at all times. We collected odors from 3 possible invertebrate prey species: spider (*Tegenaria* spp.), scorpion (*Paruroctonus borealis*), and field cricket (*Gryllus* spp.). We then compared the responses of snakes to these invertebrate odors to known vertebrate prey odors. Further, to test whether *H. chlorophaea* can assess the size of potential prey, odors were collected from adult and juvenile garter snakes (*Thamnophis* spp.). We presented all odors on pre-moistened 13-cm cotton swabs held 2.5 cm in front of a snake's snout. For each trial we recorded the number of tongue flicks/60 s, and the latency to first tongue flick. There was no significant difference in tongue flicks or latency between either spider, scorpion, or cricket odors to water or a pungency control. Snakes did respond with greater tongue flicks, and a decreased latency to a vertebrate odor over each invertebrate odor and water control. Snakes responded with increased tongue flicks to small snake odors over large snake odors. Our study is the first to show that at least for the invertebrates tested, *H. chlorophaea* does not exhibit a chemosensory response to these invertebrate prey odors, a result which is supported by current field work. This study is also the first to show that a snake can assess the size of potential prey via an odor stimulus.

P3.67 WEBB, M.W.*; DEVIAN, M.; TOMANEK, L.; California Polytechnic State University, San Luis Obispo; mwwebb1@gmail.com

Proteomic Analysis of the Purple Sea Urchin, *Strongylocentrotus purpuratus*, in Response to Acute Heat Stress

The protein expression profiles were studied to investigate the tolerance of sea urchins to acute heat stress. Adult purple sea urchins, *Strongylocentrotus purpuratus*, were obtained from Santa Barbara, Ca. They were acclimated to 10°C and were divided into four groups. Three of the groups were separately heat shocked to 15°C, 20°C and 25°C and returned to the control temperature of 10°C for a recovery time period. The ambulacral tissue within each sea urchin was removed and homogenized. Proteins were precipitated out of each sample solution, where they were separated according to their isoelectric point (pH 4-7) and molecular mass with two-dimensional gel electrophoresis. Protein spots that were significantly different between groups, using Delta 2D gel image analysis software, were excised and digested with trypsin. These protein peptides were analyzed with a matrix-assisted laser desorption ionization (MALDI) tandem time-of-flight mass spectrometer. Using the expression profiles of significant proteins between each of the heat shock groups and the control, we can construct a physiological model of the purple sea urchin under acute heat stress.

P1.44 WELLS, S.L.*; MCCONAUGHA, J.R.; Old Dominion University, Old Dominion University; swells@odu.edu

Reproductive Variations in an Exploited Decapod Crustacean

Callinectes sapidus is a heavily exploited species in the Chesapeake Bay. In the past decade the spawning stock has been reduced, which has impacted the reproductive output of mature females of the population. Population fecundity has been reduced as females have gotten smaller. This has been compounded by the loss of a previously determined allometric relationship in this population. Despite the reduced fecundity, there is a trade-off between the number of eggs produced and the average size of those eggs. Generally, females produce a greater number of smaller eggs or fewer large eggs. The concentrations of lipids and proteins within the eggs are directly correlated with egg size, with larger eggs having greater quantities of bulk lipid and proteins. Changes were detected in egg energetic content both inter- and intra-annually indicative of significant differences in egg, and potentially, larval quality. Decreases in population fecundity in conjunction with the observed variation in the biochemical content of eggs can have far reaching impacts on the population including larval survivability and recruitment. Our results suggest that there were significant shifts in maternal effort, and potentially reproductive success, both inter- and intra-annually. Fluctuations in energy available to an embryo, as well as the production of fewer embryos have significantly lowered the reproductive output of this population, and led us to the conclusion that reproduction in this population is highly variable. At this time, it is unclear if the variation is natural or is a result of population exploitation.

P2.156 WESSELS, F. J.*; HAHN, D. A.; University of Florida; fwessels@ufl.edu

Not all Lipids are Created Equal: Differential Carbon 13 Discrimination During Lipid Biosynthesis

Stable isotopes are an important research tool in physiological ecology, where they are commonly used for diet recreation or as metabolic tracers. When an organism consumes stable isotopes that are naturally present in their diet, the isotopes can be enriched or depleted as the consumer assimilates dietary components. This difference in isotopic composition between the consumer's tissues and diet is known as discrimination. Quantifying the contribution of multiple dietary sources to a consumer's tissues is often accomplished by using one of a variety of mixing models, which typically requires discrimination to be estimated in the model. However, the discrimination of ¹³C has either been ignored or assumed to be relatively small in many systems. These assumptions do not hold under all circumstances, leading some authors to suggest that ¹³C discrimination is dependent on the dietary concentration of ¹³C (Caut et al. 2008). In this experiment we tested whether ¹³C discrimination depends on the dietary concentration of ¹³C in the bacterium *Bacillus subtilis*. We found that there is a large effect of dietary ¹³C concentration on discrimination, and have attributed this concentration-dependent discrimination to the *de novo* biosynthesis of lipids. We discuss our findings in the context of the potential implications for stable isotope analyses.

P2.71 WESTERMAN, E.L.*; DIJKSTRA, J.A.; HARRIS, L.G.; Yale University, Wells National Estuarine Research Reserve, University of New Hampshire; erica.westerman@yale.edu

Colony fusion common in a colonial ascidian

Many benthic colonial invertebrates have the ability to fuse and form chimeras with compatible colonies. Botryllid ascidians fusion rates have been determined for different populations and species by random sampling and fusion testing individuals. However, natural fusion rates over time nor their influence on colony size have not been documented. We deployed six settlement panels to monitor the growth of single genotypes of *Botrylloides violaceus* and *Botryllus schlosseri* from July to September 2006 in Salem Harbor, Massachusetts, USA, and nine settlement panels to monitor settlement, growth, and fusion of *Botrylloides violaceus* from July to mid-August 2007. Eighty percent of the recruits observed fused with at least one other colony, while six percent neither fused nor were over grown. Growth rates of the fused colonies did not differ from those previously reported for single colonies. However, fused colonies were considerably larger than single genotype colonies at the end of the study period, and colonies in the 2006 study were significantly smaller than fused entities from 2007, though not smaller than single genotype entities from 2007. These results suggest that larvae are settling in clumps of compatible individuals, and that large subtidal colonies may be the result of high numbers of fusions between compatible colonies.

P1.25 WEVER, JM*; HENRY, JJ; NEWMARK, PA; U Illinois - Urbana; jwever2@illinois.edu

Bringing Lophotrochozoa into Studies of Comparative Eye Development and Eye Evolution

Metazoan eyes have marveled both developmental and evolutionary biologists since Darwin wrote in *Origin of Species*, "to suppose that the eye with all its inimitable contrivances... could have been formed by natural selection, seems, I freely confess, absurd in the highest degree." Despite Darwin's misgivings, eyes did evolve through natural processes. While attempting to elucidate these processes, some researchers concluded that all metazoan eyes are homologous and have a single, monophyletic origin, while others argued for independent evolution across many lineages. Researchers have conducted extensive descriptions and comparisons of eye development between arthropods and vertebrates; however, the same processes are largely unstudied in Lophotrochozoans. Planarians, as basal members of Lophotrochozoa, offer an attractive opportunity to incorporate new data into the field of comparative eye development and eye evolution. Expression and functional analysis of transcription factors associated with eye development in *Xenopus laevis* and *Drosophila melanogaster* will be carried out in the planarian, *Schmidtea mediterranea*, to characterize the molecular mechanisms of planarian eye development and ultimately compare them to more highly-studied organisms. Additional candidate genes were identified from a *Xenopus* cDNA subtraction library saturated for transcripts upregulated during lens regeneration and are also expressed during eye development. Data from these studies will be presented and analyzed. Finally, the planarian eye cell transcriptome will be characterized using laser capture microdissection and 454 deep-sequencing technology, providing additional data for comparative functional analysis. These initial studies of eye development in a Lophotrochozoan will give valuable insight to researchers striving to compare eye development across phyla.

P1.6 WHITEHILL, E.A.G.*; MCALISTER, J.S.; MORAN, A.L.; Clemson University; whitehi@clemson.edu

Respiration rates and energetic content of larvae of a tropical ophiuroid: comparisons with a with a sympatric echinoid.

Larvae of sea urchins and brittle stars are morphologically convergent, but it is not known if this morphological similarity is paralleled by similar developmental energetics. We reared larvae of the tropical brittle star *Ophiocoma* sp. (egg diameter = 71 μm) and a sympatric echinoid *Echinometra vanbrunti* (diam. = 68 μm) without food, measured oxygen consumption, and sampled larvae for biochemical content. Embryonic and larval metabolic rates of *Ophiocoma* ranged from 1.2 $\text{pmol O}_2 \text{ larva}^{-1} \text{ h}^{-1}$ at the gastrula stage to a high of 3.9 $\text{pmol O}_2 \text{ larva}^{-1} \text{ h}^{-1}$ at the 2-arm stage. After reaching the 2-arm stage, development stalled and larval metabolic rate fell to a range of 1.3 to 1.5 $\text{pmol O}_2 \text{ larva}^{-1} \text{ h}^{-1}$ for the next 4 days. To our knowledge, this is the first study of developmental energetics of ophiuroid larvae. The metabolic rates of *Ophiocoma* we measured are substantially lower than metabolic rates of *E. vanbrunti*, although the metabolic rates of the *E. vanbrunti* larvae showed the same general trend of increasing during morphogenesis and subsequently decreasing to a steady level at the 4-arm stage. Larval respiration rates of *Ophiocoma* also appear lower than echinoid larvae in general. We are currently examining changes in protein, lipid, and carbohydrate content of these larvae to compare larval energy budgets of *Ophiocoma* and *Echinometra*.

P1.35 WHARTON, W.L.*; MARSHALL, S.L.; PREHODA-WYERS, M.M.; DEAROLF, J.L.; Hendrix College, Conway Arkansas; Lewis.wharton@gmail.com

Effects of betamethasone on the external abdominal oblique of prenatal *Cavia porcellus*

When a fetus is anticipated to be born prematurely, its mother is administered glucocorticoids, notably betamethasone, because this steroid is known to encourage differentiation of lung tissue. The study we conducted examined the effects of these steroids on auxiliary breathing muscle tissue differentiation in prenatal guinea pigs. Previous studies have shown that these steroids encourage muscle fiber type differentiation in non-ventilatory muscles. Thus, we hypothesize that the steroid-treated ventilatory muscle tissue, specifically the external abdominal oblique (EAO), will contain higher numbers of IIA fast-twitch fibers than control muscles. Pregnant guinea pigs were injected with betamethasone (0.5 mg/kg), or sterile water for control group, on days 43, 44, 50, 51, 57, and 58 of gestation, and euthanized at day 59. The fetuses were then dissected, and EAO samples were collected. Sections of the fetal EAO samples were stained using immunohistochemistry with the differential antibodies A4591 (Blau) for slow twitch muscle fibers and 2F7 (Lucas) for IIA fast twitch muscle fibers. Images of the stained tissue were taken using a digital image analyses system and analyzed for the staining density of the fibers with Scion Image to classify the fast-twitch fibers as 2F7+ or 2F7-. Percentages of the 2F7+ fibers will be compared between treatment groups. Thus, the functional consequences of steroid treatment for the ventilatory muscle is development of more IIA fibers, which creates an improved capacity for slow contractions for extended periods of time, but decreases capacity of the muscle to respond to environmental stimuli necessitating accelerated ventilation.

P2.173 WILGA, C/D*; MAIA, A/RMD; NAUWELAERTS, S; LAUDER, G/V; University of Rhode Island, University Rhode Island, Michigan State University, Harvard University; cwilga@uri.edu

Prey Capture Using Whole Body Fluid Dynamics in Batoids

Traditionally, suction feeding is described as rapid expansion of the buccal cavity. However, when feeding on the substrate, suction can be generated by lifting the body away from the substrate. This mechanism has been exploited by batoid species, in particular, due to the dorsoventrally flattened body form. Digital particle image velocimetry and high speed video was used to compare the hydrodynamics of feeding behavior in little skates, *Leucoraja erinacea* and round stingrays *Urolophus halleri*. We hypothesize that the difference in stiffness of the rostrum and extent of the pectoral fins onto the head between the species should result in behavioral differences; the more flexible rostrum and greater fin area of stingrays will allow more extensive use of body suction. When simulating attached or buried prey, stingrays approach the prey with raised rostral ends of the pectoral fins and then press the edges against the substrate to constrain prey. Stingrays make a tent by raising the rostrum and curling up the pectoral fin edges, then raising the head while rapidly projecting the fins forward and over the prey to generate suction. Skates show a similar behavior, although the smaller fin area does not allow lateral occlusion, thus resulting in weaker flow. Also, skates use a rostral strike behavior that pushes fluid towards the substrate potentially to stun or uncover prey. Thus skates and rays use the body to direct flow in different ways to accomplish similar tasks. This may be explained by the evolutionary divergence in rostral and pectoral fin morphology.

P2.107 WILLIS, R.E.*; PRESSLEY, T.A.; Texas Tech University Health Sciences Center, Lubbock; raymond.willis@ttuhsc.edu
Genetic Variation in the Alpha 1 subunit of the Na,K-pump in a Freshwater Serpent

The inability to tolerate changes in salinity restricts the ecological niche exploited by aquatic animals. Although it is clear that salinity acclimation depends primarily on specific changes in epithelial solute transport, these details have been identified in relatively few species. Recent observations of snake populations may provide an opportunity to observe the evolutionary transitions necessary to exploit a higher-salinity regime. The Florida cottonmouth (*Agkistrodon piscivorus conanti*) is a generalist feeder that typically consumes terrestrial, freshwater-aquatic, and carrion prey. A sub-population of snakes in Florida scavenges marine carrion in intertidal zones, and unavoidably ingests excess saltwater through the incidental consumption of accompanying detritus. This salinity tolerance likely has a genetic component, suggesting that there is a physiological specialization to eliminate the excess salt derived from ingestion of the incidental seawater. As the source of the driving force required for epithelial transport, the Na,K-pump is a likely target for any genetic variation accompanying salinity tolerance. To begin exploring the structure-function relationships responsible for this adaptation, we sequenced the alpha 1 isoform of the Na,K-pump in the kidney of the terrestrial western cottonmouth. We identified variations in the isoform specific region and surrounding residues that could potentially play a role in salinity acclimation. Funded in part by RR 19799 from the NIH.

P1.96 WILSON, Meghan A.*; SPRAYBERRY, Sprayberry D.H.; Muhlenberg College; mw235224@muhlenberg.edu
Effects of pollution on antennal nerve responses to plant odors in bumblebees

Olfaction is an influential sensory system across the animal kingdom, affecting physiological responses and behavioral patterns. Prior investigations have used honeybees and bumblebees as model organisms to study invertebrate olfaction. Several of these studies have demonstrated the importance of plant olfactory signals in foraging behavior of bees. While the reasons for recent bee colony collapse disorder remain largely unexplained, it has been hypothesized that pollution may be impacting bee foraging behavior and patterns. Chemical smog from cars has been shown to change the volatile composition of floral odor cues. This alone may have a significant impact on the ability of bees to navigate to novel food sources, as the change in composition reduces the distance such olfactory cues can travel. However, multiple types of pollution could impact foraging efficacy in bees. This study is investigating how neural encoding of floral odors in the antenna of *Bombus impatiens* is impacted by the presence of pollutants. Current pollutants of interest are non-lethal agricultural chemicals, such as herbicides, fungicides and fertilizers. Although both honeybee and bumblebee populations have been slowly declining since the 1970s, they have experienced an alarming decrease in colony numbers since the early 1990s. It seems that the dwindling of bee populations are due to a variety of factors including global trade of hives, reduction in native habitat, habitat fragmentation, pesticides, parasites, and pathogen spillover. This study investigates a pertinent epidemic, which is impacting the productivity of major food systems and total global food production.

P2.138 WILLIS, P.M.*; RYAN, M.J.; ROSENTHAL, G.G; Univ. of Texas at Austin, Texas A&M Univ.; pmwillis@mail.utexas.edu
Predation risk and encounter rates with conspecific males influence female mate choice in hybridizing swordtail fishes

Direct costs and benefits (i.e., those that affect the chooser's survival or fecundity) have prominent effects on mate choice within species. Where mate sampling is costly (e.g., where predation risk is high, or mate densities low), choosiness tends to decline. Although direct costs and benefits of choice within species are well-understood, little is known of their role in hybridizing taxa. We investigated the influence of variation in a) predation risk and b) encounter rates with male conspecifics on female mate choice in the naturally-hybridizing species pair *Xiphophorus birchmanni* - *X. malinche*. We presented female *X. birchmanni* with conspecific and heterospecific males, varying a) the distance to shelter (our proxy for predation risk), or b) the time elapsed since conspecific males were encountered. When shelter was equidistant from either species, females preferred to associate with conspecifics; however, this pattern was reversed when shelter was in closer proximity to heterospecifics. Similarly, females isolated from conspecific males for 24 hrs spent significantly more time associating with heterospecifics than they did when conspecific males were encountered immediately prior. These findings suggest that, despite preferences for conspecifics, females reduce their discrimination against heterospecifics in the face of increasing survival or search costs. As seasonal flooding and drought likely contribute to variation in both predation pressure and conspecific mate densities, one or both may be facilitating hybridization in the wild. More generally, these findings highlight the potential for direct costs and benefits of choice to promote or inhibit hybridization and reproductive isolation.

P2.60 WILSON, BA; Texas A & M International University; brittan.wilson@tamui.edu
Learning with and from our students

Many ecological problems are presented in a way which makes people, especially non-scientists, feel they are unable to connect them to their own lives. In my Environmental Science class (2008-2009 school year), I assigned a class project which focuses on making ecology accessible to non-majors. The students who participated were primarily business, marketing and journalism majors. The purpose of the project was to increase the students' ability to embrace their local ecology, and to connect regional issues to larger ecological problems. The students were asked to focus on personal choices they could make that would impact a local ecological issue, and to present it in a manner that would appeal to a target age group. Through this project, the students were better able to grasp both the scale and impact of local environmental concerns. In addition, they were able to translate this level of understanding into real-world solutions utilizing their personal specialties to address the issues of their choice. We are now working to have their work presented to their local communities, to inform and education through displays at the Boston Science Museum and throughout downtown Boston.

P1.63 WINSLOW, B. B.*; BURKE, A. C.; Wesleyan University; bwinslow@wesleyan.edu

Development of the chick costal joint

The development of synovial (diarthrodial) joints appears to be largely conserved between species and across anatomical locations. Synovial joints are thought to develop by segmentation of cartilaginous condensations, followed by cavitation to form a joint capsule. The site of segmentation is termed the interzone. Molecular control of interzone formation and cavitation has been described in limb and jaw joints. Interzone formation involves loss of cartilage specific gene expression and up regulation of Gdf5, Barx1, Bapx1, Chordin, Autotaxin, and other genes regulated by Wnt14/9a. Later, Cd44 is expressed in the interzone, and is involved in cavitation. We are interested in the development of the costal joint, a synovial joint found in the ribs of avians. The costal joint forms between the vertebral and sternal elements of the rib, and is morphologically similar to the widely studied interphalangeal joints. Despite this morphological similarity, we have found significant differences in the development of the chick costal joint and the metatarsophalangeal joint, specifically in interzone formation. The avian vertebral and sternal rib condensations are distinct and label with alcian blue by stage HH28, though Sox9 expression is continuous between the condensations. The alcian blue labeled condensations merge around HH30. Collagen II expression is never continuous between the elements. An interzone forms by HH34, and cavitation occurs by HH39, preceded by Cd44 expression, similar to other joints. Surprisingly, Wnt14/9a, Gdf5, Barx1, and Chordin are absent from the interzone of the avian costal joints at HH36. Autotaxin is expressed in the interzone, and Bapx1 is expressed by the surrounding cartilage. These data suggest that while cavitation appears similar to other synovial joints, an alternative molecular mechanism is involved in costal joint interzone formation.

P1.92 WOJNARWSKY, Pandora K. L.*; AHEARN, Gregory A.; University of North Florida, Jacksonville; P.Lee@UNF.edu

Net ³H-L-histidine transport across lobster intestine is stimulated by luminal zinc

The effects of luminal zinc on net transmural transport of ³H-L-histidine across perfused intestine of American lobsters (*Homarus americanus*) were measured. Unidirectional mucosal to serosal (MS) and serosal to mucosal (SM) fluxes were measured by adding 20 μM ZnCl₂ and variable concentrations of ³H-L-histidine (5 to 10000 μM) to either the perfusate or bath, respectively, and periodically sampling the appearance of radioactivity on the opposite side of the intestine. The direction and magnitude of net amino acid flux was calculated as the difference in the two unidirectional fluxes. ³H-L-histidine transport (MS flux) was a sigmoidal function of luminal [histidine] at the low substrate concentration range (5-100 μM) and was not affected by luminal zinc. ³H-L-histidine MS flux at the high substrate concentration range (1-10 mM) was also sigmoidal, but was significantly enhanced by the presence of luminal zinc. The dipeptide, glycylsarcosine, significantly inhibited MS ³H-L-histidine flux in the presence of zinc. SM amino acid transport kinetics at both low and high concentrations were linear functions of [histidine] and not stimulated by serosal zinc. Net fluxes of ³H-L-histidine toward the blood occurred at both low and high amino acid concentrations, but only the absorptive flux at amino acid concentrations from 1-10 mM was significantly stimulated by luminal zinc. Results suggest the presence of high and low affinity intestinal ³H-L-histidine transporters. The latter carrier system was zinc-dependent and apparently shared by the dipeptide, glycylsarcosine. Supported by NSF grant IBN04-21986.

P3.62 WITTES, J.S.*; DONOVAN, D.A.; Swarthmore College, Pennsylvania, Western Washington University; jwittes@gmail.com

Broad physiological tolerances of the invasive clam, *Nuttallia obscurata*

Nuttallia obscurata has spread rapidly through Puget Sound and the Strait of Georgia since it was introduced from Asia to the Eastern Pacific Ocean in the late 1980s. This species has been found living in regions of broadly varying salinity. We investigated how *N. obscurata* responds to hyposmotic, hyperosmotic, and thermal stress in order to determine whether broad physiological tolerances play a key role in its success as an invasive species, and also to make predictions about areas in the Eastern Pacific that may be at risk of being colonized. Clams were acutely exposed to salinities ranging from 1 - 60 ppt at 13°C and 20°C. Hemolymph osmolality and gill tissue hydration were monitored over two weeks. We found that *N. obscurata* tolerates an exceptionally broad range of salinities. It osmoconforms at salinities ranging from 10 - 50 ppt, and osmoregulates at 1 and 5 ppt. Patterns of osmoregulation and osmoconformity were the same at both temperatures. Gill tissue hydration ranged from 81 - 90 % water content and decreased significantly at higher salinities. Temperature did not significantly affect gill tissue hydration. Given the breadth of this species' salinity tolerance and its distribution in more temperate waters in Asia, this clam may have the potential to extend its range south along the coasts of Oregon and California.

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Phylogeny and nematocysts of the invasive species *Cordylophora caspia*

The Ponto-Caspian invasive hydrozoan *Cordylophora caspia* contains four genetic lineages. Nonetheless, the species has not been formally split, nor has there been a clear pattern of use for older names like *Cordylophora lacustris*. Complicating this situation is the physiological and morphological plasticity of *C. caspia*. It can tolerate a range of salinities, from brackish (~15 ‰) to freshwater, assuming different morphologies based on different salinities. It is unclear whether different populations represent geographical isolates, physiological races, or distinct species because of the ecological plasticity, broad range, and physiological tolerance of these animals. Nematocysts, the complex cellular secretory structures responsible for the stinging capabilities of jellyfish, are taxonomically informative in many groups, but have not been explored for the various lineages of *C. caspia*. I assay representative populations of *C. caspia* to evaluate whether the size and distribution of nematocysts varies among and between members of each genetic lineage.

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Muscle pennation and bulge varies with the mechanical demands of a movement

During locomotion we can move at a wide range of speeds. Yet such movements are powered by muscle fibres that are most effective at a more limited range of speeds. It would make mechanical sense for the architectural gearing ratio (AGR: ratio of muscle velocity to fibre velocity) to alter to ensure that the fibres contribute effectively over a broad range of movement speeds. Geometric arguments predict that for a given muscle volume and fibre length, the pennation angle covaries with the muscle bulge. As a consequence the AGR is influenced by both the pennation angle and bulge on the muscle. Recently it has been suggested that rotations of the muscle fibres contribute to altered gearing (this was demonstrated in an isolated muscle preparation where the force and velocity of the contraction were coupled). Here we use ultrasound data from the triceps surae muscles during cycling at a range of loads and cadences to investigate the contribution of pennation angle and muscle bulge to AGR in vivo. Fibre rotations appeared more sensitive to load than cadence, with greater rotations occurring at higher loads. The muscle bulge increased with both the pedal cadence and load. The AGR had little change with load but did increase with faster cadences, this was particularly the case for the soleus muscle. The higher AGR at faster cadences enable the muscles to be mechanically effective across large range of speeds.

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The expression of spindle assembly checkpoint protein Bub-1 in zebrafish (*Danio rerio*) oocytes.

Chromosome segregation is highly regulated and the spindle assembly checkpoint is a conserved cell cycle surveillance mechanism that regulates the fidelity of this process. In mitosis, a single unattached kinetochore activates the checkpoint to signal a periodic arrest of the cell cycle in metaphase. This arrest of the cell cycle is a crucial stage in oocyte development and is followed by completion of meiosis and the prevention of aneuploidic genomes or hyper-prolific daughter cells. Several checkpoint genes have been identified in budding yeast including *Bub-1*. These proteins are thought to play lead roles in a MAPK-regulated pathway for checkpoint activation as a response to microtubule defects. Previously, studies on this checkpoint have been performed in mammals and amphibians. The present study shows the involvement of Bub-1 in zebrafish (*Danio rerio*) oocyte development. Zebrafish oocytes were treated with Nocadazole, a microtubule depolymerizing drug, to activate the spindle assembly checkpoint. Protein and RNA assays revealed that Bub-1 is present in *D. rerio* and appears to be regulated in both Nocadazole- and progesterone-treated oocytes. Levels of Bub-1 were higher under microtubule destabilization by Nocadazole, suggesting that the Bub-1 protein could be activated in response to microtubule instabilities. Further studies will lend a greater understanding of the relationship of the Bub-1 gene with the spindle assembly checkpoint in *D. rerio* oocytes. This arrest of the cell cycle is a crucial stage in oocyte development and maturation prior to successful fertilization.

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Genomic Basis for Sex-Role Phenotypes

For many animals, the expression of sex-typical behavior can be plastic depending on the social environment. We use the African *Julidochromis* cichlid fish as a model to determine the underlying physiological and molecular mechanisms that account for differences and plasticity in expression of sex-typical behaviors. Sex-roles in most monogamous cichlids consist of territory defense by the larger male and parental care by the smaller female. Behavioral studies show that the species *J. transcriptus* follows these sex-role conventions. However, the sister species, *J. marlieri*, exhibits a reversal of these sex-roles. *J. marlieri* females are dominant to their mates and are clearly the aggressive sex. The reversal in sex-role behavior is size dependent. We show that experimental reversal of size ratios in both species causes a reversal from natural sex-role behavior phenotypes. In size-reversed pairs the larger mate is dominant and more aggressive towards intruders regardless of sex or species. Thus, while sex-roles in *Julidochromis* appear to be determined by species, they are also plastic and contingent on social context. To examine the molecular changes that accompany this heritable, yet plastic phenotype, we compare gene expression and hormone levels between species and between size-conventional and size-reversed pairs of both species. Microarray data defines modules of gene expression associated with sex-role independent of gonadal sex, and modules of gene expression associated with gonadal sex independent of sex-role. Furthermore, species-specific variation in gene expression patterns suggest that *Julidochromis* males and females have undergone changes in gene expression patterns on an evolutionary time-scale.

P2.65 WOODLEY, Sarah K.; Duquesne University; woodleys@duq.edu

The importance of discussing animal research in the physiology classroom

Animal research is a critical element of many scientific endeavors. Many biology majors will find careers in biomedical research that involve the use of animals or animal tissues. However, many students are unaware of the issues involved in animal research. Furthermore, the number of violent acts towards animal researchers committed by animal rights activists is increasing. Therefore, I developed and assessed assignments that addressed the issue of animal research in an upper-level university physiology course. Assessment was achieved via a written survey before and after assignments and discussions about animal research as part of an IRB approved study. Assignments included reading book sections authored by an animal researcher and exploring the website of a prominent animal rights organization. Results indicated that opinions changed dramatically after discussing animal research in the classroom. As one example, the percentage of students that believed that animal research contributed "a great deal" to advances in human health care changed from 60% to 98%. As another example, the percentage reporting that they agreed "not much at all" with the statement that "many lab animals endure painful experiments in cramped/dirty conditions" changed from 38% to 81%. This study reveals that biology students possess many misconceptions about the use and care of research animals and that discussion in a classroom setting significantly changes students' knowledge and opinions. I encourage physiology instructors to address this important issue.

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Characterization of apoptosis during the development and metamorphosis of *Capitella teleta*

Apoptosis, or programmed cell death, is vital to the development and metamorphosis of many animals. In deuterostomes, apoptosis is essential for vertebrate post-embryonic development and metamorphosis in sea urchins and ascidians; in ecdysozoans, the hormone ecdysone regulates apoptosis during insect metamorphosis. In lophotrochozoans, apoptosis is associated with the degenerating apical ganglion of the mollusc *Ilyanassa obsoleta* in metamorphosis-induced animals. Additional data are needed, however, to understand the role of apoptosis during the development and metamorphosis of other lophotrochozoans. Previous studies characterized cell division patterns in larval stages of *Capitella teleta* (formerly *Capitella* sp. 1), an indirect developing polychaete annelid. During development, we expect the opposing processes of cell division and apoptosis to play a role in sculpting the larva. Apoptosis has not yet been characterized in *C. teleta*, which undergoes a gradual metamorphosis during which the body elongates and the trochal bands are lost. During metamorphosis, *C. teleta* first loses its prototroch, then the neurotroch and telotroch, and apoptotic cells are expected in the trochal bands. Apoptosis may also sculpt the elongating head. We characterized the pattern of apoptosis during the development and metamorphosis of *C. teleta* using the terminal deoxynucleotidyl transferase dUTP nicked end labeling (TUNEL) method. Preliminary data show apoptotic cells in the head ectoderm and scattered cells in the ectoderm of the anterior 2/3 of the mid- to late-larval stages. In addition, labeled cells are observed in a ventral stripe of cells corresponding to the neurotroch in animals undergoing metamorphosis. These results provide a basis for further study on the role of signaling pathways involved in cell division and apoptosis in *C. teleta*.

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Pouch morphology and function in brown pelicans, *Pelecanus occidentalis*

The pouch of brown pelicans (*Pelecanus occidentalis*) is a highly derived and specialized structure, which expands to hold a volume of about 11 liters during diving. Previous work has shown that the mandibular rami bow due to a rostral bending zone that is only about 20% mineralized, and a lateral syndesmosis that is about 50% mineralized. Our current work examines the musculature of the pouch in order to determine (1) its homologies with the lingual and sublingual muscles of other birds (e.g., chicken, pigeon, egret), and (2) the function of these muscles in pouch opening and closing (water removal). We document the presence of large amounts of loose connective tissue in the pouch and tongue area, along with pleating/folding of the intraoral epithelium and external pouch skin, facilitating pouch expansion during feeding. Although the pouch is thin, and the tongue highly reduced, we found muscles throughout that we were able to homologize with those of other birds. Further, we found an elaborate network of elastin fibers within the floor of the mouth that we believe is important in passive pouch emptying. However, the *Mm. serpihyoideus*, *mylohyoideus*, and *constrictor colli intermandibularis* were all candidates for raising the floor of the mouth and evacuating water. We believe that rorqual whales are an appropriate model and may use analogous feeding and emptying mechanisms. In addition to feeding, the pouch is well-vascularized, and plays an important role in thermoregulation via gular fluttering; the pouch musculature must also be able to function in that role.

P3.64 YAMASHITA, R.*; SAITO-REIS, C.; TAKAI, J.; DOHM, M.R.; Chaminade University, Honolulu; mdohm@chaminade.edu

Ozone-induced gene dysregulation in rat and Tokay gecko lung cells: A comparative approach

Ground-level ozone (O₃), a significant oxidant component of urban air pollution, is linked to excess lung disease and morbidity in humans. Effects on wildlife are not known. O₃ is insoluble in water and penetrates into the lung. O₃ oxidizes carbohydrates, proteins, and lipids. These ozonolysis products induce dysregulation of 100s of genes in lung cells, including immune and proliferative functions. Recent studies by us on amphibians and reptiles indicate that many physiological responses are evolutionary conserved. The purpose of our study was to investigate gene expression patterns in cultured lung epithelial cells (ATCC CCL-111) from the lizard (*Gekko gecko*) in response to short (30 min) and repeated (30 min/day for one week) exposure to an ecologically relevant dose (0.2 parts per million O₃). We used a cross species approach. qRT-PCR arrays of 84 oxidative stress, antioxidant defense, and JAK/STAT pathway genes for rats were used (SA Biosciences). First, gecko cells were exposed to O₃ or clean air, then hours or days later, total RNA was extracted for cDNA, applied to arrays (cross species hybridization). Second, gecko cells were exposed to O₃ or clean air, then the conditioned media was harvested and applied to cultured rat cells (CCL-149). Total RNA was extracted from the rat cells, then cDNA was made and applied to the PCR arrays. Threshold cycles were evaluated and compared to house keeping genes. Preliminary results suggest short-term O₃ exposure caused transient dysregulation of 100s of genes in the vertebrate lung cells. Within hours following exposure, a subset of transcription factors and apoptosis-related genes were dysregulated; later, a distinct set of genes were dysregulated, with an emphasis on restoring redox balance. INBRE NIH Grant Number P20 RR016467-08 from the National Center for Research Resources.

P1.93 YEOH, A.J.*; LONG, R.A.; GILLEN, C.M.; HARTLAUB, B.A.; Kenyon College; gillenc@kenyon.edu

Gene expression in fourth and fifth instar *Manduca sexta*

The scaling exponent for metabolic rate in *Manduca sexta* is greater than expected based on isometric surface area scaling. We examined whether midgut genes involved in absorption and digestion are expressed differently in fifth versus fourth instar larvae. RNA was isolated from middle and posterior midgut and reverse transcribed to cDNA. Real-time PCR was used to quantify expression of two genes, aminopeptidase N (msAPN3) and potassium amino acid cotransporter (KAAT), by the relative quantification method using 18s ribosomal RNA as an internal control. A general linear model for APN and KAAT Δ Ct values identified significant instar and tissue effects. The best model provided a good fit, with an R-squared value of 0.9335. In posterior midgut, KAAT expression was 2.5-3.5 fold higher while APN was 1.3-1.4 fold lower in fifth compared to fourth instar larvae. Expression of KAAT was 3.5 fold higher in middle compared to posterior midgut. To evaluate the sensitivity of standard statistical methods to real time PCR data, a Monte Carlo simulation of the coverage probabilities for Ct, Δ Ct and $\Delta\Delta$ Ct was conducted for the normal, uniform, exponential, t and chi-square distributions using parameter estimates derived from our data. Coverage probabilities for Ct and Δ Ct were close to the 95% confidence level, indicating that the interval estimates are relatively insensitive to distributional assumptions. A notable exception was the exponential distribution of Ct, where the coverage probability dropped to 0.88. Coverage probabilities for $\Delta\Delta$ Ct were reasonable when using the mean of a comparison group, but not when arbitrarily selecting an individual measurement for comparison. (Supported by NSF-DMS #0827208 and Kenyon College)

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Ecology, Evolution, and Conservation Biology: Tales from a feather as told by the White Tern

Feathers are currently being used to examine ecological and evolutionary patterns of bird populations and a single feather can provide a source of stable isotopes and DNA for feeding ecology and genetic studies. Stable isotopes can inform a broad range of ecological studies by elucidating patterns in trophic food webs (e.g. feeding, migration and element cycling). Molecular markers can be used to understand evolutionary processes by examining dispersal patterns and population connectivity of a wide variety of species. These non-traditional methods have been particularly useful for studies where they can supplement or replace more intrusive methods such as banding, collection of regurgitates and blood samples, stomach flushing, and collection of birds. Tissue samples from molted feathers, freshly dead and museum specimens were used to assess the genetic and ecological variation of the Pacific White Tern (*Gygis alba*). Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios were examined and findings show no difference between the tip and base of feathers and among feather types. This suggests that any type of feather could be used as an indicator of the status of the individual and that diet is constant during individual feather growth. Additionally, carbon and nitrogen values were similar to those of juvenile yellowfin tuna (*Thunnus albacares*) within the Hawaiian Archipelago. Mitochondrial DNA results suggest that there are no phylogenetically distinct species or subspecies within the Pacific Ocean. Furthermore, the recently established population of White Terns on Oahu shares haplotypes with all examined subspecies, suggesting multiple source populations across the Pacific.

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Relationship between gonadosomatic index and shell condition of male snow crab *Chionoecetes opilio* from the Bering Sea

Research concerning the reproductive biology of snow crabs *Chionoecetes opilio* from the Bering Sea is predominantly focused on females, with little known about male physiology. While male crabs may reach reproductive maturity prior to the terminal molt, it is unclear whether reproduction is compromised by molting physiology. Male snow crabs can be distinguished in two groups by a change in chela allometry: terminally molted males are classified as "large-claw" (LC) whereas non-terminally molted males are classified as "small-claw" (SC). Shell condition is a relative measure that differentiates crabs having recently molted (new-shell) from those that have not molted for months to years (old-shell). Crustacean molting, mating, and behavior are regulated by hormones, among those ecdysteroids (molting), and methyl farnesoate (MF, reproduction). Literature supports a relationship of significantly higher MF in reproductively active male crabs; we propose that MF levels will be lower in post molt crabs. We sampled hemolymph from snow crabs to quantify ecdysteroids and MF. Circulating ecdysteroids differ between the two morphotypes; a SC male still has the potential to molt while a LC male stops molting. We measured gonadosomatic index (GSI) as a proxy for reproductive capacity. We measured male gonad weight versus total wet weight of 185 snow crabs. GSI was significantly lower in new-shell males compared to old-shell males (ANOVA, $p < 0.05$). New-shell males are targeted for their visual commercial appeal over old-shell males. With lower GSI, recently molted crabs may be harvested before contributing reproductively and thus genetically to the population.

P1.94 YOUNG, K.E.*; QUINN, S.M; WAITE, J.N.; USENKO, S.; ANDREWS, R.D.; TRUMBLE, S.J.; Baylor University, University of Alaska Fairbanks, University of Alaska Fairbanks; stephen_trumble@baylor.edu

Using GC-FID in Conjunction with GC-MS to Identify Fatty acid Methyl Esters in Sympatric Marine Mammal Species

Northern fur seal (NFS, *Callorhinus ursinus*, $n = 22$) and Steller sea lion (SSL, *Eumetopias jubatus*, $n = 12$) blubber samples were collected from adults occupying the same rookery near the Lovushki Island complex, Russia. The objective of this study was to compare similarity of identified fatty acids (FA) using gas chromatography-flame ionization detector (GC-FID) and gas chromatography-mass spectrometry (GC-MS) within and between species. GC-FID identified a minimum of 25 fatty acid methyl esters (FAME) from each blubber sample against a standard set of 40 FAME. Using the Sørensen similarity index (SI) on GC-FID data we determined an 85 percent similarity on FAME between species inhabiting the same rookery. However, GC-MS identified an additional 21 FAME for NFS and 23 FAME for SSL, as well as an additional 10 FAME common to both species. Combining methods resulted in a decreased SI of 60 percent between SSL and NFS inhabiting the same rookery. Relying solely on GC-FID, which is routinely used as a method in fatty acid analysis in marine mammal predator-prey studies, would result in a significant artificial increase in shared FAME recovered from depot lipids. Because FA composition of depot lipids has long been known to reflect diet, this may lead to spurious conclusions relating to predator-prey interactions or resource partitioning between species occupying similar rookeries. While analysis of FAME by GC-FID analysis has proven to be a most reliable and accessible method for routine quantification of FA composition, we propose incorporating GC-MS for as an additional method to identify unknown FA peaks.

P3.104 ZAZAY, R*; MURRAY, JA; George Washington U., Cal. State. U. East Bay, Friday Harbor Labs; james.murray@csueastbay.edu

Correlation of the activity of novel pedal neurons and body flexion in the sea slug *Tritonia diomedea*

There have been 16 pairs of identified cells in the pedal ganglion of *Tritonia diomedea*. The pedal neurons cause flexion of the ipsilateral body wall and foot when activated, but they probably do not innervate muscle directly. We recorded the activity two new cells and their motor effects. We first made the cells stop firing by injecting them with negative current. Once the cell stopped firing, we injected it with positive current via an amplifier. In one ~100 micron wide cell, the animal lifted one side of its foot and when the current stopped it relaxed it. The cell had one axon exiting Pedal Nerve 1 and about nine dendrites coming off of it. When the cell was stimulated the front half of the foot would move dorsally and posteriorly ~ 1 cm. As the muscle relaxed, the front of the foot moved ventrally and the back of the foot had moved more posteriorly. The stimulated spikes lasted for 13 seconds and there was an approximate 3 second delay between the initial spike and the foot movement of the slug. The muscle took about 4 seconds to start relaxing and then it fully relaxed after 10 seconds. In a second cell (150 μ m soma) in a different animal, the dorsal body wall flexed medially when current was injected. It had one axon in Pedal Nerve 4 and few dendrites coming off the axon. When the cell was stimulated, the animal would flex its dorsal body wall medially, then relax. The stimulated spikes lasted for 10 seconds and there was a 3 second delay before body movement. It took about 6 seconds to start relaxation after spikes ended, and then after 15 seconds it fully relaxed. Even though the cell relaxed it did not return to its original point. These pedal neurons may be involved in turning during crawling and we will follow these experiments with fine wire recordings from crawling slugs to determine behavioral function.

P2.121 ZENEL, A.M.*; GILMAN, S.E.; CARRINGTON, E.; Scripps College; alison.zenel@gmail.com

The effect of aerial temperature on behavior and respiration in two rocky intertidal snails.

The rocky intertidal community has become a model system to study the effects of temperature on ecological processes, a topic of increasing importance in this time of climate change. Intertidal organisms are unique in facing two distinct thermal environments, at high and low tide. We studied the effects of aerial temperature on two species of rocky intertidal sea snails, *Nucella ostrina* and *Nucella lamellosa*, on San Juan Island, Washington. We first categorized six distinct behaviors of the snails, and determined the baseline respiration rate for each behavior of *N. ostrina*. We discovered that there is a significant difference in respiration rate among different behaviors. We then exposed both species to six different air temperatures for one hour, and measured the time needed to resume to normal behavior when reimmersed in seawater. There was no significant difference between recovery time after exposure to 15, 20, and 30°C, but recovery was significantly delayed after exposure to 33°C in both species. Temperatures above 33°C resulted in 100% mortality of both species. Finally, *N. ostrina* were exposed to five sublethal air temperatures for one hour, and their time to return to normal respiration rates in seawater were recorded. Exposure to 15, 20, and 25°C had no significant effect on respiration, whereas exposures to 30 and 33°C air significantly increased the time for *N. ostrina* to return to normal respiration. Our data demonstrates that the air temperatures that a snail experiences during low tide can influence its behavior when it is reimmersed in water at high tide.

P3.98 ZIMMERMAN, L.M.*; VOGEL, L.A.; EDWARDS, K.A.; BOWDEN, R.M.; Illinois St. Univ.; lmzimme@ilstu.edu

Phagocytic B cells in a reptile

Evidence for a developmental relationship between B cells and macrophages has led to the hypothesis that B cells evolved from a phagocytic predecessor. The recent identification of phagocytic IgM+ cells in fish and amphibians supports this hypothesis, but raises the question of when, evolutionarily, was phagocytic capacity lost in B cells? To address this, leukocytes were isolated from red-eared sliders, *Trachemys scripta*, incubated with fluorescent beads, and analyzed using flow cytometry and confocal microscopy. Results indicate that red-eared slider B cells are able to ingest foreign particles, and suggest that ectothermic vertebrates may use phagocytic B cells as part of a robust innate immune response.

P3.12 ZHANG, Z.Q.; ARCE, M.E.; CIUFFO, G.M.; KARASOV, W.H.*; CAVIEDES-VIDAL, E.; IMIBIO-SL - Univ. Nac. of San Luis, Argentina, Univ. of Wisconsin, Madison; wkarasov@wisc.edu

Intestinal morphometrics in flying and non-flying mammals

Studies on birds have led to the hypothesis that increased intestinal absorption between enterocytes (paracellular) evolved as a compensation for smaller intestinal size in fliers, which was perhaps selected for to minimize the mass of digesta carried. This hypothesis predicts that bats will also exhibit relatively reduced intestinal size and high paracellular absorption, compared with nonflying mammals. Published studies on two bat species do indicate relatively high paracellular absorption. One mechanism for increasing paracellular absorption per cm small intestine (SI) is increased number of tight junctions across which paracellular absorption occurs. We provide the first comparative analysis of enterocyte size and number in flying and nonflying mammals. Intestines of insectivorous bats *Tadarida brasiliensis* (mass 14.0 ± 0.5 [S.E.] g, $n = 8$) were compared with *Mus musculus* (37.3 ± 2.0 , $n = 6$) using hematoxylin and eosin staining method. After correction for body size difference, the bats had 50% shorter SI length and 40% less nominal surface area than the mouse, as predicted. Villous enhancement of surface area was 89% greater in the bat than mouse, mainly because of a greater density of villi in bat SI. Bat and mouse were similar in enterocyte diameter (respectively, 4.69 ± 0.20 microns vs. 4.60 ± 0.13). Bats exceeded mice by 52% in villous area per cm length SI and by 46% in number of enterocytes per length. An increased number of tight junctions per cm length SI could be a mechanism for increasing paracellular absorption. Supported by PICT 2004 25561 and CyT-UNSL 9502 to ECV and NSF IOS 0615678 to WHK.

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Studies of ocean acidification: the physiological response of marine larval snails to elevated CO₂

Over the last 200 years, the ocean has been a sink for atmospheric carbon dioxide (CO₂) and has absorbed approximately 50% of emitted, anthropogenic CO₂. As atmospheric CO₂ continues to rise in the future, oceanic pH is predicted to decrease by an additional 0.2-0.3 unit (from pH 8.1 to an average of 7.9-7.8); this condition is known as ocean acidification (OA). A growing body of research on calcifying marine invertebrates suggests that OA can have a deleterious effect on development and various physiological processes in these organisms. In laboratory experiments designed to mimic seawater chemistry in future oceans, we examined the effects of elevated CO₂ on larvae of two marine snails, (*Nucella ostrina* and *Haliotis rufescens*). Larva were raised in culture under control conditions and two experimental CO₂ levels. These levels span the range of current atmospheric CO₂ levels (385 ppm) to a "worst case" scenario (~900 ppm) predicted for the year 2100. Following development under conditions of ocean acidification, we measured larval thermal tolerance, shell integrity and shell formation. Our results showed elevated CO₂ did not influence veliger thermal tolerance for either species. In addition, shell strength in *Nucella ostrina* veligers and gene expression patterns for genes involved in shell formation in abalone larvae were not changed. These results suggest that larval forms of these species may have the capacity to withstand environmental change. Supported by a Coastal Environmental Quality Initiative Graduate Fellowship (UC Marine Council) to MLZ.

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Responses of Mud Snails (*Ilyanassa obsoleta*) to Synthetic Trails

All gastropods produce mucus trails during locomotion. Other snails contacting the trails follow them in the direction they were laid. The mechanism of directionality is unknown. To determine if directionality is a physical feature of the trail, we created synthetic gastropod trails using a large sugar polymer, sodium alginate. Alginate cross-links when exposed to divalent cations in seawater. Trails were generated with a circular stamp and by dragging alginate-soaked cotton swabs in clockwise or counter clockwise directions in glass bowls. Mud snails (*Ilyanassa obsoleta*) responses to the stamped trails were not directional. Snails followed the swabbed alginate trails in the direction they were laid. Snails were tested with swabbed alginate trails embedded with predator odor, crushed conspecific extract and, conspecific odors and food extract. Snails that followed trails embedded with predator odor or crushed conspecific extract away from the direction of dragging. Trails embedded with conspecific odor or prey extract were followed towards the direction of dragging. During the breeding season, trails were imbedded with male and female sex pheromones. Sexually active males and females disregarded trails embedded with same-sex pheromones. Females followed male pheromone trails in either the clockwise or counterclockwise direction. Males followed clockwise female pheromone trails and did not follow counterclockwise trails. Snails integrate textural and chemical information.