P1.109 AAMIDOR, Sarah E*; BAUCHINGER, Ulf; PINSHOW, Berry; Ben-Gurion University of the Negev; amidors@bgu.ac.il
Does dietary protein limit mass gain in migrating blackcaps refueling at stopovers?
Both fat and protein are used by birds as fuel during migratory flight, and need to be restored at stopovers. Mass gain is initially slow but increases after 2-3 days into the stopover. One explanation for this is the catabolism of digestive tract tissue (GIT), which causes reduced digestive function and hence slow body mass gain. We tested the prediction that dietary protein limits a bird’s readiness to leave a stopover because it affects the rate at which the GIT is rebuilt, and, thereby, the rate of tissue accumulation. We measured body mass, pectoral muscle size, and body composition (by dual energy x-ray absorptiometry). Thirty migrating blackcaps (Sylvia atricapilla) were mist-netted and divided into three equal groups. The birds were deprived of food for 24 hours to assure stopover behavior. The groups were then provided semisynthetic diets, that differed only in protein content (i.e. 3%, 5.3% and 10%), and water ad libitum during the 6 day experiment. Mean daily food intake differed significantly among groups (Holm-Sidak multiple comparison F₁,₁₂,₅₇ = 4.103, p = 0.018). Body mass changed differently over time among the groups (-0.13±0.08 g/d, -0.10±0.16 g/d, 0.01±0.26 g/d; RM ANOVA, time×group: F₁,₁₂,₁₆₈ = 3.08, p = 0.0006; for 3, 5.3, and 10%, respectively) as did pectoral muscle size (RM ANOVA time×group: F₁,₁₂,₁₆₈ = 2.11, p<0.05). There were no significant differences in the change of fat fraction from day 1 to day 7 between the groups (ANOVA F₁,₁₂,₅₇ =0.38, NS). Thus, the data suggest protein may be a limiting dietary factor, and that blackcaps require more protein than that we provided to replace fat used as fuel during migratory flight.

P1.187 ABATE, M.E.*; GRACEY, A.Y.; MALAVASI, S.; TORRICELLI, P.; Boston University, Massachusetts, Univ. of Southern California, Los Angeles, University Ca’ Foscari of Venice, Italy, University Ca’ Foscari of Venice, Italy; mabate@bu.edu
A comparison of brain gene expression from black goby (Gobius niger) females and males with alternate mating phenotypes
The black goby (Gobius niger) is a demersal spawning fish with females that deposit their eggs in a sheltered burrow in shallow marine waters. Territorial males provide parental care. Males have accessory sperm duct glands that release sperm trail mucins to enhance sperm longevity. These glands are less developed in small males that invest energy instead into producing relatively large testes for their body size. The difference in male reproductive structure correlates with a difference in male reproductive tactics as small males utilize a sneaker strategy to enter the nest and steal spawns from the territorial male. Hence, the black goby provides a good model for investigating the neurogenic basis for different mating phenotypes. Mature females and males were collected from the Venetian Lagoon (Northern Adriatic Sea, Italy) during the reproductive season. Brain RNA was extracted from individual fish and hybridized against a cDNA microarray prepared for the goby Gliclithrys mirabilis. A machine learning algorithm was used to identify sets of genes whose expression was associated with the fish. Although gene expression profiles were generally similar between mating phenotypes the algorithm identified a number of genes whose expression was elevated in sneaker males. The top marker gene for sneaker status was Mannose-P-dolichol utilization defect 1 (MPDU1), a gene of unknown function but which may be involved in protein N-glycosylation. These data reveal that changes in mating behavior are linked to transcriptional differences in the brain and the resulting candidate genes may have utility in studies of the regulation and evolution of this trait.

P3.61 ABBOTT, Emily/M*; ROBERTS, Thomas/J; Brown University; Emily.Abott@brown.edu
Elastic mechanisms as a determinant of anuran jumping performance: do toads bounce?
Anuran jumping performance varies widely among species. Biomechanical studies have proposed that some of the best jumpers use an elastic mechanism to produce power outputs that exceed available muscle capacity. Most studies of jump power have focused on good jumpers, and it is unclear whether species with less spectacular jumping performance also utilize an elastic mechanism. To better understand the underlying determinants of jumping performance, we used a force plate to quantify power output and takeoff time in Osteopilus septentrionalis (Cane toads), Rana pipiens (Cuban tree frogs), and Bufo marinus (Cane toads). Maximal jumps elicited from a large number of trials were analyzed. O. septentrionalis jumps were both the fastest and most powerful (takeoff time 0.0880.005 s, peak power 308.755.8 W kg⁻¹ body mass), followed by R. pipiens (0.1120.008 s, 66.619.2 W kg⁻¹), while B. marinus performed the slowest and least powerful jumps (0.1750.03 s, 14.74.3 W kg⁻¹). The power output measured for B. marinus corresponds to less than 100 W kg⁻¹ hindlimb muscle mass (16% body mass), well below the power generating capacity of typical Bufo muscle (>200 W kg⁻¹). Evidence for an elastic mechanism in B. marinus is also absent in the shape of power profiles during jumping. The asymmetric power profile of O. septentrionalis is indicative of elastic energy storage early in the jump, while B. marinus isometrically and relatively shallow power curve may indicate a jump powered directly by muscle contraction. R. pipiens power profile is intermediate and may reflect an elastic mechanism less effective than that of O. septentrionalis. These results suggest that variation in anuran jumping ability may be explained in part by variation in the effective use of elastic mechanisms. Supported by NSF grant 642428 to TJR.

P3.129 ABDU, R.W.*; ABATE, M.E.; KAUFMAN, L.; Boston University, Massachusetts; abduw@bu.edu
A test for the influence of offspring behavior on parental care in the convict cichlid (Archocentrus nigrofasciatus)
Heterospecific predators and kidnapping by conspecific alloparents threaten the survival of the fry of the convict cichlid (Archocentrus nigrofasciatus). Parents defend their young by attacking intruders and muffling their fry to move them to the nest site. Both adults and fledglings get advance warning of the risk of predation when they are exposed to olfactory alarm cue released from the broken skin of conspecifics, and they respond by seeking refuge and with enhanced group cohesion. It is unknown to what extent the fry can influence the level of parental care behavior. We periodically removed fry from their home aquaria and exposed them briefly to either conspecific skin extract or distilled water, and after placing them in rinse containers, returned them to their parents. We measured parental care by recording the parents aggression toward threatening juvenile convicts in a glass container placed near the nest. We tested for fry homing behavior using a mini-flume that exposed the fry to separate plumes of home aquarium water and foreign tank water and recorded how much time the fry spent in each plume for three minutes. We compare the behavior of the parents in the two treatments and examine the relationship of parental aggression and homing behavior to evaluate the influence of offspring behavior on parental care.
P2.27 ADDIS, E.A.*; CLARK, A.D.; VASQUEZ, R.; WINGFIELD, J.C.; University of Washington, Seattle, Universidad de Santiago, Chile, University of California, Davis; addise@u.washington.edu

Breeding variation of testosterone in the high latitude Rufous-collared sparrow, Zonotrichia capensis australis

In vertebrates, testosterone regulates many aspects of reproductive function. In birds, testosterone is important for sperm production and the development of some secondary sex characteristics, including activation of sexual behavior and territorial aggression. The challenge hypothesis addresses trade-offs between circulating levels of testosterone and male breeding behavior in birds. Two important postulates of the challenge hypothesis are: (1) testosteron levels are high during periods of social instability and territory establishment when male-male interactions are common and (2) testosterone levels decrease during the parental phase of breeding if males exhibit substantial parental care. Most tests of the challenge hypothesis have been conducted in northern temperate and arctic birds. Investigations of the Rufous-collared sparrow (Zonotrichia capensis) in Ecuador and Costa Rica show no correlation between testosterone and aggressive behavior, suggesting a decoupling of testosterone and aggression. To further explore this seeming discrepancy, we tested the challenge hypothesis in a subspecies of the Rufous-collared sparrow, Z.c. australis, breeding at high latitude in the southern hemisphere. These results were additionally compared with our previous exploration of testosterone and aggression in the Rufous-collared sparrow at mid-latitudes of the southern hemisphere.

P1.155 ALAM, J. L.*; LIEBL, A.L.; MARTIN, L.B.; FOKIDIS, H.B.; University of South Florida, Arizona State University; jalam@mail.usf.edu

Are the immune systems of tropical birds glucocorticoid resistant? Corticosterone alters immune function, but its effects vary depending on magnitude and duration, immune response characterized, species studied, and environmental context. In a previous study, we found that a cutaneous inflammatory response was not affected by chronically elevated corticosterone in house sparrows (Passer domesticus) from Panama but similar corticosterone elevation in birds from New Jersey (USA) reduced the same immune response. This differential sensitivity to corticosterone, coupled with a more persistent threat of infection in the Panamanian population, led to the hypothesis that tropical birds generally may decouple stress hormones from immune responses to maximize immune defense at all times. To test this hypothesis, we conducted an experiment on different tropical (Kenya) and temperate (Arizona) populations of house sparrows. This time, however, we compared the effects of 30 minutes in a cloth bag on the capacity of plasma to kill gram-negative bacteria (Es. coli) to determine whether: (i) other tropical house sparrows are immunologically resistant to corticosterone; (ii) acute (versus chronic) stress differentially affects immune function depending on latitude; and iii) stress affects other components of house sparrow immunity. Corticosterone release in response to the stressor was lower in Kenyan than Arizona birds, but much less so than in the prior study. Further, bactericidal capacity of blood was not affected by acute stress in either population, and Arizonaan sparrows killed almost all bacteria while Kenyan sparrows killed almost none. Collectively these results indicate population differences in immune and endocrine physiology, but not in the manner predicted. Ongoing studies of these and other sparrow populations are testing whether patterns are better explained by invasion history than latitude.
Assessing the Fight-or-Flight Response in the Brazilian Free-tailed Bat (Tadarida brasiliensis) Using Heart Rate Telemetry

As human populations expand, increased encroachment on natural landscapes and wildlife habitats is likely. We can expect that organisms able to adapt or acclimate to human-altered habitats will have a selective advantage over those unable to do so. One example of a human-altered landscape condition is the increasing availability and use of highway bridges by bats. Evidence from previous research, based on measured levels of the hormone cortisol, suggests that bridge-roosting Brazilian free-tailed bats (Tadarida brasiliensis) experience lower levels of stress and are in better overall health than their cave-roosting counterparts. This unexpected result suggests the ability of this species to rapidly acclimate to the potential stressors we observed at highway bridges. Heart rate telemetry allows direct and continuous monitoring of an acute response to a stressor and, thus, is ideal for assessing acclimation to repeated stimuli. Heart rate telemetry has been used on several avian and mammalian species; however, its use on small, free-ranging bats has not been tested. In July 2008 we assessed the suitability of heart rate telemetry in the Brazilian free-tailed bat and evaluated the ability of these bats to rapidly acclimate to environmental stressors in a large highway bridge roost. To measure heart rate, a small (0.06 g) custom-made heart rate transmitter was affixed to each bat (~12 g) and the signal was recorded on an MP3 recorder, while the bat was in the roost and at the onset of nightly emergence. We subjected lactating females (N=4) to several novel disturbance events (simulated predator) over the course of the experiment (12-36 hours), as well as noted other potentially disturbing stimuli (noise and vibration from passing freight trains) that the roosting bats may experience while roosting in bridge crevices.

P1.117 ALVINE, T*; CROSSLEY II, DA; University of North Dakota;
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Chorioallantoic Membrane Vascular Function of the Embryonic Domestic Chicken (Gallus gallus)

Vascular function and regulation is poorly understood in most fetal/embryonic vertebrates. Given the complexity of the vascular tree in developing animals, specifically the presence of the chorioallantoic membrane (CAM) vascular bed, a thorough investigation of vascular function must be completed. The CAM vasculature is critical as a gas exchange surface, and thus changes in vascular resistance will have direct effects on convective gas transport. To characterize CAM vasculature function, an isolated embryonic chicken CAM perfusion preparation was used. This model is particularly useful because it eliminates potential fetal-maternal physiological interactions. Eggs of the domestic chicken (Gallus gallus) incubated at 38°C were selected for study at days 15 and 19 of the developmental period, days corresponding to maximal CAM development and the period just prior to lung ventilation, respectively. On the day of study, the CAM vascular tree was isolated from euthanized embryos, and the major CAM artery was occlusively catherized. The preparation was perfused with saline (0.9% NaCl) at rates that mimicked previously published blood flow rates on these days of development. Responses of CAM vascular function were studied via pharmacological manipulation with selective receptor agonists, phenylephrine (alpha-adrenergic), isoproterenol (beta-adrenergic), and Angiotensin II. Preliminary data indicate that the embryonic chicken CAM responds to both beta and alpha-adrenergic receptor stimulation at day 15 and 19. These data, in combination with molecular in situ hybridization used to localize receptor mRNA, imply regulation of CAM vascular resistance may be an important mechanism of altering cardiovascular function in embryonic birds.
**P3.157 AN, Y.*; KRIENGWATANA, B.P.; NEWMAN, A.E.M.; MACDOUGALL-SHACKLETON, E.A.; MACDOUGALL-SHACKLETON, S.A.; Univ. Western Ontario, Univ. British Columbia; yan4@uwo.ca

The relationship between social rank, neophobia and observational learning in black-capped chickadees (Poecile atricapillus)

Analogous to human personality differences, behavioural syndromes are consistent patterns in behavioural tendencies across varying situations in individual animals. Although studies of behavioural syndromes are becoming more common, few studies connect individual differences in behaviour with social dominance. Black-capped chickadees flock in the winter, and dominance hierarchies are critical to their survival and reproduction. We tested the relation between social rank, neophobia and observational learning in black-capped chickadees and investigated whether social dominance is part of a wider behavioural syndrome. We captured twenty-one chickadees from five different sites in London, Ontario, and measured individual reactions to novelty and individual differences in ability to learn a novel foraging task from a conspecific tutor. The latency to approach novel objects and foods was correlated within individuals which indicates consistent individual variation in neophobia. Social rank was related to latency to approach novel objects and food. Lower ranking individuals were less neophobic, consistent with the characteristic of their dominance hierarchy in which the dominants control preferential access to resources and limit the subordinates to forage in riskier environment. Future work will address whether reduced neophobia and riskier foraging predisposes birds to becoming subordinate, or vice versa.

**P3.179 ANSON, J.Y.*; RICHMOND, R.H.; MARTINEZ, J.A.; Kewalo Marine Laboratory, Honolulu, Hi; jorg@hawaii.edu

Effects of Anthropogenic Stressors on Larval Recruitment in the Reef Coral Porites hawaiiensis

Anthropogenic stressors affecting nearshore ecosystems are an important problem throughout the Pacific Islands. Due to the rapid rate of coastal development in island nations, activities conducted within watersheds have immediate impacts on adjacent coastal zones. In Hawaii, the coral Porites hawaiiensis is primarily distributed in shallow water (0-3m) coastal ecosystems. P. hawaiiensis broods its larvae which are released daily, year-round. The availability of P. hawaiiensis larvae makes this a good model organism for analyzing the effects of anthropogenic stressors on coral recruitment and survival. Recruitment bioassays were performed using larvae exposed to environmentally relevant concentrations of freshwater, terrigenous sediments and the anti-microbial soap additive Triclosan, in the larva makes this a good model. Recruitment bioassays were performed using larvae exposed to environmentally relevant concentrations of freshwater, terrigenous sediments and the anti-microbial soap additive Triclosan, in the larva makes this a good model. Recruitment bioassays were performed using larvae exposed to environmentally relevant concentrations of freshwater, terrigenous sediments and the anti-microbial soap additive Triclosan, in the larva makes this a good model. Recruitment bioassays were performed using larvae exposed to environmentally relevant concentrations of freshwater, terrigenous sediments and the anti-microbial soap additive Triclosan, in the larva makes this a good model. Recruitment bioassays were performed using larvae exposed to environmentally relevant concentrations of freshwater, terrigenous sediments and the anti-microbial soap additive Triclosan.

**P3.112 ANDERSON, K.E.; BLACKBURN, D.G.;*; DUNLAP, K.D.; Trinity College, Hartford CT; daniel.blackburn@trincoll.edu

Scanning EM of the Placental Membranes in the Viviparous Lizard Sceloporus jarrovi

In viviparous lizards, placentas sustain the developing embryos inside the pregnant female through gas exchange and provision of nutrients. We used scanning EM to reveal the fetal - maternal interface in the spiny lizard Scoloporus jarrovi (Phrynosomatidae) during the last trimester of gestation. Two distinct placentas are formed and persist until parturition. The allantoplacenta consists of the choioallantois in direct apposition to the uterine epithelium. SEM reveals that fetal and maternal epithelia at the placental interface are highly attenuated, but not eroded, and lack surface specializations. The yollic sac placenta consists of an avascular omphalopleure (with its isolated yolk mass) in conjunction with the uterus. The omphalopleure forms elaborate folds, consisting of epithelium and yolk droplets. These folds protrude into a thick mass of material in the uterine lumen, formed from degenerating shell membrane, cellular debris, and yolk. Scanning EM indicates that this material is sequestered into a restricted, elongated region at the ventral pole, possibly to free up adjacent regions for placental exchange. The presence of elaborate placental specializations in a generalized viviparous lizard is unexpected, and underscores the need for continued explorations of placental diversity in the numerous clades of viviparous squamates.

**P3.113 ARMFIELD, Brooke A.*; THEWISSEN, J. G. M.; VINYARD, Christopher J.; NEOUCOM; Rootstown, OH.; bganner@neo.com.edu

Diversity in gene expression patterns during mammalian early tooth development

Tooth morphology is one of the distinguishing features of mammalian species, however, little is known about how differences in form along a tooth row are genetically determined in mammals other than mice. To further explore the genetic patterning underlying the diversity of tooth morphologies seen in mammals we looked at early dental development of pigs and dolphins. These mammals are good models to address this question because they represent two variations in dental patterns. The domestic pig (Sus scrofa) dentition maintains several features representative of many mammals. They have two generations of bunodont teeth and a primitive-heterodont dental formula (3-1-4-3). In contrast the pan-tropical spotted dolphin (Stenella attenuata) has a highly derived homodont dentition, only one generation of teeth and an increased tooth number. It is known that in mouse tooth type is determined early in development by signaling pathways establishing distinct boundaries for incisors and molars. We looked for expression patterns of these genes and proteins to establish associations between molecular events and dental classes across the three different dentitions. We used immunohistochemistry on dolphin embryos and in situ hybridization on pig embryos to determine the timing and location of proteins and genes (BMP4, FGF8, SHH) that influence early tooth type determination in mice. We found a range of expression patterns among these three mammal species. For example in dolphins, BMP4 expression was found to extend much more distally, perhaps contributing to the teeth incisor-like form. The variability in expression patterns suggest future developmental studies hold great promise in helping to explain the diversity in dental patterns across mammals. Supported by NSF.
Effect of chronic psychological stress on blood chemistry in European starlings

Chronic psychological stress in European starlings, Sturnus vulgaris, has been shown to cause a decrease in body weight during the period of stress. However, after the stress is alleviated body weight not only recovers but increases beyond the initial value for at least several weeks. We studied the effect of chronic psychological stress on body weight and ten blood chemistry parameters in starlings to examine the mechanism controlling the weight drop and gain. The blood chemistry parameters included albumin (ALB), aspartate aminotransferase (AST), calcium (CA), creatinine kinase (CK), glucose (GLU), globulin (GLOB), phosphorus (PHOS), potassium (K+), sodium (NA+), total protein (TP), and uric acid (UA). To induce chronic stress we rotated six different stressors (cage tapping, cage rolling, crowding, bag restriction, human voice, and radio) in a random order for 30 minutes for 4 times per day over 21 days. Mass was measured at least once every three days during chronic stress. Blood samples were collected three times every two weeks. As expected the average weight decreased by approximately 5% during chronic stress. The only parameters that varied over chronic stress were a decrease in AST and CK. The starlings were then monitored during a recovery phase of 60 days. In which mass was measured every week and blood samples were taken three times in the first 21 days. During this period the average weight remained at a constant 5% above the initial weight prior to the onset of chronic stress. All blood chemistry parameters remained constant over this period. Our study suggests that there may be a liver or muscle protein breakdown during chronic stress; however the sustained increase in weight following chronic stress cannot be explained using the blood chemistry parameters we measured.

Cloning of a cDNA encoding a myostatin-like factor from lobster skeletal muscle

Claw muscles of decapod crustaceans undergo a premolt atrophy, controlled by molting hormones (ecdysteroids), to enable withdrawal of the claws at ecdysis. Myostatin-like factors (Mstn), a negative regulator of muscle growth in mammals, is expressed in scallop, insect, and crustacean muscles, which suggests it also plays a role in controlling muscle size in invertebrates. The American lobster, Homarus americanus, is being used to study the effects of claw size and fiber composition on Mstn-mediated signaling. The larger crusher claw contains only slow-twitch (S1) fibers, while the smaller cutter claw contains fast, S1, and slow-tonic (S2) fibers. We have sequenced a cDNA that encodes Mstn using RT-PCR and RACE-PCR. The conserved RXRR cleavage site was present, indicating the presence of a mature peptide and its N-terminal inhibitory propeptide domain. The nucleotide percent identity for lobster Mstn versus land crab Mstn was approximately 79%, while the amino acid percent identity was approximately 90%. We are quantifying the tissue- and fiber-type-specific expression of Mstn using end-point and quantitative RT-PCR. The results will be related to the control of muscle size by steroid hormones. Supported by NSF (IBN-0618203).
Molting Down-Regulates Myostatin Expression in the Land Crab, 
Gecarcinus lateralis: Implications for the Regulation of Claw Muscle 
Atrophy
Molting is the periodic shedding of the exoskeleton required for organic growth in arthropods. Ecdysteroid hormones initiate cellular processes necessary for successful exuviation. One process is a programmed atrophy of the claw muscle, in which the mass is reduced 2-3-fold. This allows the claws to be pulled through the small joints of the appendage at molt. How ecdysteroids induce claw muscle atrophy is poorly understood. Myostatin (Mstn), a member of the TGF beta family of growth factors, is a negative regulator of muscle growth in mammals and birds. Our hypothesis is that ecdysteroids increase the expression and/or activation of Mstn signaling, leading to the expression of genes required for the degradation of myofilibril proteins. Real-time RT-PCR was used to quantify the expression of Mstn in claw and thoracic muscles during the molting cycle. Molting was induced by multiple limb autotomy. Mstn mRNA levels decreased during premolt and remained low at 2 and 10 days postmolt in both muscles. The reduced Mstn expression was associated with an accelerated protein turnover, which may facilitate changes in myofilament packing as fibers atrophy. Supported by NSF (IBN-0618203) and scholarships to B.D.B from the Arnold and Mabel Beckman Foundation and the College of Natural Sciences Undergraduate Research Institute.

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Effect of cadmium exposure on critical temperatures and energy metabolism of the eastern oysters Crassostrea virginica
Marine intertidal molluscs are exposed to multiple stressors (including temperature and pollution) in estuaries, which can strongly affect their physiology. According to the concept of critical temperatures (Poertner, 2002), temperature tolerance in aquatic ectotherms is limited by the reduction of aerobic scope at sub- and supra-optimal temperatures until it completely disappears at the critical temperatures (Tc) and transition to partial anaerobiosis occurs. We determined the onset of anaerobic metabolism and changes in cellular energy budget in eastern oysters Crassostrea virginica during acute temperature rise (20C-36C) in order to determine the Tc and reveal whether exposure to cadmium (50 ug L-1 for 30 days) affects Tc. Our data show that as temperature increases, oysters switch to an anaerobic mode of metabolism as indicated by accumulation of anaerobic end products and insufficiency of cellular energy. In control oysters, L-alanine, acetate and succinate significantly rose above the control levels and ATP concentrations declined at 24h indicating that this is close to Tc for this population. At higher temperatures, anaerobic end products continued to accumulate but ATP levels returned to the control indicating that oysters were capable of at least short-term regulation of cellular energy balance in the studied temperature range. Cd-exposed oysters demonstrated significantly lower accumulation of anaerobic end products compared to their control counterparts at all temperatures. Given that elevated temperatures lead to hypoxemia in Cd-exposed oysters (Lannig et al., 2008), these data suggest that cadmium exposure inhibits anaerobic pathways in oysters and indicates that accumulation of anaerobic end products is not a good index of Tc in Cd-exposed oysters.

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Recent and Ongoing Collections Facility Renovations at the Museum of Comparative Zoology (Harvard University)
Harvards Museum of Comparative Zoology (MCZ) houses some of the most historically significant and biologically diverse natural-history collections in the world. Extensive renovations that facilitate collections storage, collections-based research and teaching have been underway for the last several years and continue today. Major collection-room renovations have taken place in many MCZ departments including herpetology, ichthyology, malacology, mammalogy and ornithology. Funded by both the MCZ and the U.S. National Science Foundation, these renovations include the installation of new storage-efficient collections cabinetry and shelving, which provide much-needed collections-room expansion space, easier specimen retrievability and enhanced security for the specimens. Separate electronic databasing and digital-imaging initiatives complement renovations of the physical space and enhance collections access and utility.

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Startle behaviors are important models for understanding simple circuits and how they generate movement. The major startle of fishes is the C-start, characterized by a C-shaped body bend during the initial rapid turn (stage 1). Recently, in esocid fishes, S-start startles, which have a caudal body bend to the opposite side of the body from the major rostral bend, have been shown to involve a different pattern of motor control from the C-start. We examine whether there is variation in the use of caudal bending in zebrafish, a species believed to perform only C-start behaviors. We recorded video (1000 Hz) of the startle behavior in five-day-old larval zebrafish. In other species studied, head stimulation tended to elicit C-starts whereas tail stimulation resulted in S-starts, so we used both stimuli to generate a range of behaviors. As in previous study, head stimuli produced greater head angles and durations than tail stimuli. At both two and four ms after initiation, peak rostral curvature did not differ between stimulus types, but peak curvature was more rostral when generated with tail stimuli. Caudal bending was generally to the opposite side of the body from the rostral bend but was significantly greater and more rostral in response to tail stimulation. The ranges of caudal bending to head and tail stimuli overlapped significantly, suggesting either there is a continuum of responses rather than discrete S-start and C-start bending patterns or that fish use both bending patterns in response to each stimulus type. These explanations will need to be tested with neurophysiological recordings. This investigation indicates more variability than previously believed in startles typically thought of as C-starts. Supported by NSF grant IBN0238464 to MEH.

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Linking reproduction, swimming performance, and habitat use in the Trinidadian Guppy, Poecilia reticulata

Lab studies have shown that pregnancy reduces locomotor ability, increases predation risk, and may translate into a reduction in fitness. Understanding costs of pregnancy on locomotion is thus important in understanding the evolution of reproductive mode and associated life history traits. We investigate the link between reproduction, locomotion, and habitat use using Trinidadian Guppy (Poecilia reticulata) populations that exist in either high or low predation regimes. Female guppies were collected from two high and two low predation streams. Presence of predators and small-scale variation in water flow velocity in the capture localities were recorded. We predicted that pregnant females, particularly those at the more costly later stages of pregnancy, preferentially use regions of the habitat with the lowest water velocity and least number of predators. We also predicted that females with a higher reproductive allocation would have an inhibited escape response and a higher tailbeat frequency and amplitude when swimming a fixed speed. To verify that females collected in different sections of the drainages do exhibit differences in locomotory performance, fish were transported to a nearby lab where escape response and tailbeat frequency and amplitude were measured. Immediately following performance trials, females were sacrificed and preserved for dissection to garner reproductive data. This study connects previous studies that have examined either performance or behavior by linking an individual’s behavior in a natural setting to swimming performance. Results will be discussed.

P3.87 BASTON, J.L*; CHEDIACK, J.G.; CID, F.D.; KARASOV, W.H.; CAVIEDES-Vidal, E.; Univ. Nat. San Luis, San Luis, Argentina; Univ. Nat. San Luis, IMBIO-SL; San Luis, Argentina; Univ. of Wisconsin, Madison; libaston@gmail.com

Daily expression modulation of SGLT1 in rat jejunum during ontogeny.

SGLT1, the small intestine apical membrane protein responsible for active glucose absorption, exhibits a daily pattern of activity and protein and mRNA expression in adult rats. The activity and expression of SGLT1 is higher during dark periods when the rats are active and feeding than during light periods when they rest. However, rats during postnatal growth feed throughout the day and they have increasing nutrient requirements. Thus, we characterized the daily expression modulation of SGLT1 protein in rat jejunum at different ages. Using western blots (WB) we semi-quantified SGLT1 relative to alpha-actin in jejunal homogenates collected at 3:00h, 9:00h, 15:00h and 21:00h from 14d, 21d, 28d and 90d old Sprague-Dawley rats (ad-libium water and food; light on schedule: 6h-18h). Immuno-reactive bands (with MW compatible with different degrees of glycosylation of the SGLT1 monomer, and the tetramer) for each jejunal sample were summed and normalized to alpha-actin for analyses. SGLT1 expression pattern between ages was 14d >21d >28d, and tended to decrease at 90d. Within ages, only 90d rats exhibited a clear daily expression rhythm. SGLT1 was lowest at 9:00h and then rose to reach a peak at 21:00h (statistical differences p <0.05): 9:00h < 15:00h = 21:00h = 3:00h). In summary, SGLT1 protein expression increases with age reaching maxima during weaning and post-weaning periods. A daily pattern of expression was apparent only in young adult rats (90d old). This pattern matches previous observation of a continuous feeding during the day to supply nutrients to cope with the high energy requirements of growth. Supported by PICT2004 25561, GyT-UNSL 22Q751 to ECV, NSF IOS0615678 to WHK.

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Collisional mechanics during sifaka bipedalism

Minimization of the energetic cost of locomotion may be an influential selective factor for mammalian gait choice and kinematics. One significant cost during terrestrial locomotion is the work limb muscles must do to redirect the center of mass (COM) from generally downward to generally upward. Ruina et al (2005) have detailed a model in which redirection of the COM is described as a collision whose energetic costs during locomotion can be reduced by minimizing the number of collisions, sequencing multiple limb contacts during a collision, or simulating an elastic collision in which the incoming and outgoing velocity vectors create the same angle relative to the substrate reaction resultant. In order to test the hypothesis that animals will choose gait patterns that minimize collisional energy loss, we examined the unusual bipedal galloping gait used by sifakas. Two adult sifaka were videotaped at 250 Hz during bipedal locomotion across a long force platform. Collisions per stride, limb contacts per collision, and pseudo-elasticity of collisions were examined. The latter was calculated as the angle of the COM velocity to the substrate reaction resultant before and after the redirection of the COM. Our results support the hypothesis that the bipedal galloping gait of sifaka minimize collisional energy loss by: 1) reducing the number of collisions that occur during each stride to one (walking and running humans have two), 2)sequencing two limb impacts per collision, theoretically reducing energy loss by half; and 3)exhibiting pseudo-elastic collisions that minimize the energy loss of redirecting the COM. These results support the suggestion that the reduction of collisional energy loss is an important consideration in gait selection during terrestrial locomotion.

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Sensitivity and morphology of the cownose ray electrosensory system

The electrorceptors of elasmobranch fishes demonstrate the greatest sensitivity of any known vertebrate electrosensory system. The electrorceptors are spatially distributed to a greater or lesser extent according to the variety of head morphologies in this diverse group. Among the elasmobranchs, the cownose ray, Rhinoptera bonasus, is unique in its possession of a bilobed head morphology with paired extensible cephalic lobes on the ventral surface of the head. These cephalic lobes are extended to closely contact the substratum as the ray searches for benthic prey. This may facilitate prey detection by placing the electrorceptors closer to the source of the prey electric fields during foraging. We tested this hypothesis by quantifying the electrosensory pore distribution of R. bonasus in conjunction with its sensitivity to prey-simulating electric stimuli. Results were compared to a more conventionally shaped ray, the Atlantic stingray, Dasyatis sabina. Rhinoptera bonasus has an average of 786 electrosensory pores on the combined dorsal and ventral surfaces, with a high proportion of these pores (40.5%) occurring on the anterior ventral surface; a distribution much like that of D. sabina. Rhinoptera bonasus demonstrated a detection sensitivity of 10.4 nV/cm +/- 2.85E to simulated bioelectric fields, also similar to reported values for D. sabina. The similarity in pore distribution and sensitivity, despite the differences in head morphology, reflect the phylogenetic stability of the electrosensory system, an important sensory modality. Unlike the benthically associated D. sabina, R. bonasus is more benthopelagic and may have evolved its unique, extensible, cephalic lobes to enhance benthic prey detection even while the body remains higher in the water column.
remain successful predators across a habitat and prey shift through changes item. These data provide a functional morphological context for a scaled to predator body length, begin their strikes relatively closer to the prey faster in completing feeding movements and, when initial strike distance is RSI = 0.693) feeding events. However, larger lingcod are proportionately employed feeding mode, as quantified by the Ram-Suction index: at all sizes, depression scaled with strong isometry and cranial length decreased relative toward relatively larger feeding structures, maximum gape and hyoid predicted older lingcod would exhibit morphological and behavioral shifts as lingcod age, they feed on proportionately larger prey items; although we from soft-bottom inshore to rocky-reef habitats during the 1st year of its life. Ophiodon elongatus (BEN-ADERET, N.J.*; DEAN, M.N.; Bar-Ilan University, University of
morphology and feeding kinematics across an age-series of lingcod Habitat shifts often require alterations or flexibility in feeding behavior and/or morphology. These changes may be necessary to adjust to a different prey base and are particularly vital for habitat changes during early ontogeny, where the energy demands of rapid growth put a premium on capture performance exceeding the escape performance of prey. In this study, we used high-speed videography to examine ontogenetic changes in morphology and feeding kinematics across an age-series of lingcod (Ophiodon elongatus), a dominant, temperate Pacific predator that shifts from soft-bottom inshore to rocky-reef habitats during the 1st year of its life. As lingcod age, they feed on proportionately larger prey items; although we predicted older lingcod would exhibit morphological and behavioral shifts toward relatively larger feeding structures, maximum gape and hyoid depression scaled with strong isometry and cranial length decreased relative to body length with age. There was no clear ontogenetic pattern in the employed feeding mode, as quantified by the Ram-Suction index: at all sizes, lingcod exhibit both suction- (min. RSi = 0.05) and strongly ram-based (max. RSi = 0.693) feeding events. However, larger lingcod are proportionately faster in completing feeding movements and, when initial strike distance is scaled to predator body length, begin their strikes relatively closer to the prey item. These data provide a functional morphological context for a commercially important rocky reef predator and suggest that lingcod can remain successful predators across a habitat and prey shift through changes in behavior, not morphology or feeding mode.

Nitric Oxide Synthase Activity Correlates with Hemoglobin Content in Antarctic Notothenioid Fishes Antarctic icefishes are the only known adult vertebrates to lack the circulating oxygen-binding protein, hemoglobin (Hb). In addition to carrying oxygen, Hb is the primary reactant in degradation of the bioactive molecule, nitric oxide (NO). We thus expect NO to be degraded at a slower rate in Hb-lacking icefish than in Hb-expressing notothenioids, leading to higher steady-state levels of NO in the former group. Data from our laboratory support this prediction. Steady-state concentration of NO, however, reflects a balance between rates of synthesis and degradation. To evaluate the role of NO synthesis, we measured catalytic activity of the enzyme responsible for NO production, nitric oxide synthase (NOS). A 14C-radiochemical assay was used to determine NOS activity in different tissues of both white- and red-blooded notothenioids. In brain tissue, NOS activity (pmol min−1 g wet wt−1) is greatest in Hb-expressing Notothenia coriiceps (160 ± 11) and lowest in Hb-lacking Chaenocephalus aceratus (96 ± 10). Red-blooded Parachaenichthyes charcotii, with Hb levels lower than N. coriiceps, displays NOS activity intermediate to that of N. coriiceps and C. aceratus (116 ± 7). Total NOS activity in cardiac tissue is significantly lower than in brain tissue, but shows the same trend between white- and red-blooded species, with greatest activity seen in those species expressing Hb (C. aceratus 0.50 ± 0.17; N. coriiceps 2.93 ± 1.36). Our results suggest that NOS activity in icefishes is downregulated in response to high levels of NO. Therefore, Hb-lacking notothenioids may decrease NO production to compensate for slow degradation of this signaling molecule. We currently are examining tissue-specific distribution of NOS isoforms in these animals. Supported by NSF grants ANT 04-37887 and 07-39637.

Nitric Oxide Synthase Activity Correlates with Hemoglobin Content in Antarctic Notothenioid Fishes

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Ontogeny of morphology and feeding kinematics in Lingcod (Ophiodon elongatus)

Habitat shifts often require alterations or flexibility in feeding behavior and/or morphology. These changes may be necessary to adjust to a different prey base and are particularly vital for habitat changes during early ontogeny, where the energy demands of rapid growth put a premium on capture performance exceeding the escape performance of prey. In this study, we used high-speed videography to examine ontogenetic changes in morphology and feeding kinematics across an age-series of lingcod (Ophiodon elongatus), a dominant, temperate Pacific predator that shifts from soft-bottom inshore to rocky-reef habitats during the 1st year of its life. As lingcod age, they feed on proportionately larger prey items; although we predicted older lingcod would exhibit morphological and behavioral shifts toward relatively larger feeding structures, maximum gape and hyoid depression scaled with strong isometry and cranial length decreased relative to body length with age. There was no clear ontogenetic pattern in the employed feeding mode, as quantified by the Ram-Suction index: at all sizes, lingcod exhibit both suction- (min. RSi = 0.05) and strongly ram-based (max. RSi = 0.693) feeding events. However, larger lingcod are proportionately faster in completing feeding movements and, when initial strike distance is scaled to predator body length, begin their strikes relatively closer to the prey item. These data provide a functional morphological context for a commercially important rocky reef predator and suggest that lingcod can remain successful predators across a habitat and prey shift through changes in behavior, not morphology or feeding mode.

P.3.1 BEERS, J. M.*; SIDELL, B. D.; University of Maine, Orono; jody.beers@maine.edu

Genetic diversity and feeding preferences in the North Atlantic marine isopod, Idotea balthica

Organisms experience abiotic and biotic factors that vary in time and space as well as in presence and intensity, even over short distances. Spatio-temporal environmental heterogeneity that occurs throughout a species range can result in different selective pressures between populations, whereby alleles favored in one region of a species range may be disadvantageous in other regions. Thus, variation in natural selection can lead to local adaptation and maintenance of genetic and phenotypic diversity within a species. The marine herbivorous isopod species, Idotea balthica, is distributed throughout the North Atlantic and exhibits deep population genetic divergence among populations along the northeastern coast of North America at the mitochondrial cytochrome oxidase 1 (mtcox) gene and in AFLP markers. The diversity of intertidal marine macroalgae changes quite dramatically along this coastline in a pattern that is similar to the population genetic patterning found in I. balthica. Feeding preference and food choice assays were conducted with I. balthica using eight different algal species in order to determine if genetically distinct lineages have specialized on the macroalgal species available to the local populations. Individuals were taken from natural populations and the stomach content was analyzed using universal algal molecular markers in order to determine the accuracy of laboratory feeding assays and the algal species diversity consumed by populations.

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Helobdella stagnalis is a common glossiphoniid leech exhibiting postzygotic parental care. Hermaphroditic adults carry their broods ventrally for up to two weeks before juveniles become independent. When brooding, the parent ventilates young, and hunts for and presents food to growing juveniles. We collected adult H. stagnalis bearing cocoons from two distinct habitats; Montezuma Well (MW), AZ and the Rio de Flag (RDF), Flagstaff, AZ. In Montezuma Well, arsenic and dissolved CO2 levels are unusually high, whereas the Rio de Flag contains grey water from the outflow of the Rio de Flag Waste Water Facility. We compared brood size, the time required for all juveniles to detach from parents, and juvenile survivorship among leeches collected from each site. We also investigated whether detached juveniles will reattach to parents, and whether such juveniles discriminate between parents and non-parents when reattaching. We found significant differences in the average brood size (mean±95%CI; MW: 2.80±1.19; RDF: 15.10±7.32) and juvenile survivorship (mean±95%CI; MW: 13.61±18.19; RDF: 57.41±19.94) between the two populations; there was no difference in the time required for all juveniles to detach from the parent. The average brood size of the leeches at Rio de Flag was similar to other populations around the world whereas average brood size of the Montezuma Well leeches was well below this average. To date, the results of the parent/offspring experiment has shown that the juveniles both populations fail to recognize their parents; they reattach to any passing adult. Our results indicate that H. stagnalis is highly tractable in the laboratory, and suggest that distinct trade-offs between fecundity and care may exist within these populations.

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**P2.30 BERGEOHN BURNS, C.M.**; CAIN, K.E.; KETTERSON, E.D.; Center for the Integrative Study of Animal Behavior, Indiana University, Bloomington; cbergeois@indiana.edu

**Phenotypic integration of testosterone-mediated characters across distinct subspecies of the Dark-eyed Junco**

Male dark-eyed juncos (*Junco hyemalis*) vary in how much they elevate testosterone (T) in response to a standardized injection of gonadotropin releasing hormone (GnRH). Responses to a GnRH challenge are repeatable across individuals and co-vary with significant phenotypic characters, including aggression and ornamentation (tail white). However, the question of whether such patterns are preserved as species diverge remains unanswered, as few studies have attempted direct comparisons of hormone-phenotype relationships across populations. If these relationships are highly integrated, we would expect similar patterns, but if hormone signal and hormone response evolve independently we might not. The white-winged junco (*J. hyemalis aiken*) is a subspecies of dark-eyed junco endemic to the Black Hills of South Dakota. It is the largest of 15 named junco subspecies and the most highly ornamented. We asked whether hormone-phenotype relationships already identified within a population of Carolina junco (*J. hyemalis carolinensis* residing in Virginia) would generalize to the white-winged junco, and whether the responses would be stronger in this more ornamented population. During 2007 and 2008, we captured, measured, and administered GnRH challenges to breeding male white-winged juncos. We found similar within-population relationships between T and phenotype, suggesting generalizability. We also found greater elevation of T in response to GnRH in the white-winged junco as we had predicted. Our findings suggest stable hormone-phenotype relationships across populations maintained at least in part by variation in hormone signal, thus supporting the hypothesis of phenotypic integration.

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**Growth Factors and Receptors in the Olfactory Epithelium**

The olfactory epithelium (OE) is a dynamic cellular environment where cell death, proliferation, and neural differentiation are continuous. These dynamics are coordinated by signaling events, some of which are known (e.g., Wu et al. 2003, Neuron 37:197). Our microarray data predicts expression of 47 growth factors and 30 growth factor receptors in the olfactory epithelium. The data also predict whether they are expressed in olfactory sensory neurons (OSNs) or in other cells in the olfactory epithelium. We have used in situ hybridization to test these predictions. OSNs express growth factor receptors Acrv1, Arvcl, Bmpr1a, Fzd3, Igf2r, Pdgrb, Pdgrf1, and Tgfb1, and growth factors Ecgf, Fgf9, Fgf12, and Pdgfa. Basal cells expressed growth factor receptors Fzd3 and Tgfb1, and growth factors Hdgf and Pdgf. These data agree with evidence of local signaling in the olfactory epithelium by PDGF and TGF-beta family signals. They also predict roles for Wnt, Ecgf, and Hdgf signaling in the olfactory epithelium, or in the case of signals expressed by OSNs, the possibility of signaling to cells outside the olfactory epithelium such as olfactory ensheathing cells or cells in the olfactory bulb.

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**P1.66 BERNAL, Diego**; SYME, Douglas; MCGILLIVRAY, David; DONLEY, Jeanine; SEPULVEDA, Chugey; Univ. Mass. Dartmouth, Univ. Calgary, MiraCosta College, Pfieger Institute of Environmental Research; dsbernal@umassd.edu

**The effect of temperature on the muscle contractile properties in the common thresher shark**

This project measured the contractile properties of the aerobic red (RM) and anaerobic white myotomal (WM) muscle in the common thresher shark (*Alopias vulpinus*) captured in the Southern California Bight. Muscle twitch kinetics were measured in situ with a portable stimulator and force transducer and showed no significant longitudinal variation in twitch response of superficial WM. Laboratory preparations of WM fibers exhibited isometric twitches at temperatures as low as 8°C, while RM twitches drastically slowed (time to peak force in excess of 1.5s) at this temperature. The in vitro work loop technique was used to quantify temperature dependent work and power output in isolated muscle preparations. In WM the cycle frequency yielding maximum power ranged from 1.0Hz at 8°C to 1.5Hz at 24°C, and positive power was maintained up to 2.5Hz at 8°C and 4.0Hz at 24°C. In the RM positive power output was restricted to relatively lower frequencies, less than 1.5Hz at 24°C, less than 1.0Hz at 16°C, and 0.5Hz at 8°C. These results show that whileresher shark WM can power fast swimming across a wide range of temperatures, the RM is more limited in its thermal tolerance. However, the overall thermal effect on RM power in the common thresher appears to not be as pronounced as that documented in other regionally endothermic sharks.

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**P2.188 BERNER, N.J.**; BULLOCK, J.R.; Sewanee:University of the South, Sewanee, TN; nberner@sewanee.edu

**Fatty acid composition of membranes and storage fat in the Eastern red spotted newt (Notophthalmus viridescens viridescens)**

Eastern red spotted newts acclimatize enzyme activity and metabolic rate seasonally, in the laboratory and in the field. Winter and cold-acclimated newts have higher skeletal muscle cytochrome c oxidase (CCO) and citrate synthase activity and higher standard metabolic rates than summer and warm-acclimated newts. Membrane fatty acid (FA) composition can affect membrane-bound proteins such as CCO, and metabolic rate. We investigated the FA composition of muscle membranes to determine if changes in CCO activity could be due to changes in membrane FA composition. We are also interested in the regulation of membrane FA composition and remodeling, so we also determined the FA composition of storage fats (triglycerides and fat bodies). Finally, as diet also impacts FA composition and remodeling, so we also determined the FA composition of muscle membranes to determine if changes in CCO activity could be due to changes in membrane FA composition. We also measured the FA contents of the newt diets. Eastern red spotted newts vary in how much they elevate testosterone (T) in response to a standardized injection of gonadotropin releasing hormone (GnRH). Responses to a GnRH challenge are repeatable across individuals and co-vary with significant phenotypic characters, including aggression and ornamentation (tail white). However, the question of whether such patterns are preserved as species diverge remains unanswered, as few studies have attempted direct comparisons of hormone-phenotype relationships across populations. If these relationships are highly integrated, we would expect similar patterns, but if hormone signal and hormone response evolve independently we might not. The white-winged junco (*J. hyemalis aiken*) is a subspecies of dark-eyed junco endemic to the Black Hills of South Dakota. It is the largest of 15 named junco subspecies and the most highly ornamented. We asked whether hormone-phenotype relationships already identified within a population of Carolina junco (*J. hyemalis carolinensis* residing in Virginia) would generalize to the white-winged junco, and whether the responses would be stronger in this more ornamented population. During 2007 and 2008, we captured, measured, and administered GnRH challenges to breeding male white-winged juncos. We found similar within-population relationships between T and phenotype, suggesting generalizability. We also found greater elevation of T in response to GnRH in the white-winged junco as we had predicted. Our findings suggest stable hormone-phenotype relationships across populations maintained at least in part by variation in hormone signal, thus supporting the hypothesis of phenotypic integration.
Doubling Egg Volume to Test for Reversible Evolution of Larval Form and Effects of Eggs Size on Heterochrony

Doubling volume of the small eggs of the purple sea urchin Strongylocentrotus purpuratus by egg fusion produced larvae more similar in form to those from normal large eggs of the green sea urchin Strongylocentrotus droebachiensis. This result mirrors experiments in which larvae from half embryos of green urchins were more similar to normal larvae of purple urchins. Thus effects of egg size on larval form are similar against either species genetic background and are evolutionarily reversible. Development of the juvenile rudiment was not accelerated relative to the larval body by experimentally doubling the volume of eggs of purple urchins. In larvae from normal-size eggs, development of both larval body and rudiment were accelerated in green urchins (with large eggs) relative to development in purple urchins (with small eggs), but with greater acceleration of the larval body, so that the rudiment of larval green urchins was initiated at a later stage, even though at an earlier age. Both species exhibited similar plasticity in timing of rudiment development in response to food supplies. Although heterochronic plasticity in development of the larval body and juvenile rudiment in response to food may be a basis for similar heterochronic changes in the evolution of non-feeding larvae, experimental and evolutionary changes in egg volume did not directly accelerate rudiment development of these feeding larvae.

 Investigating the evolutionary mechanisms in the adaptive radiation of cichlid fishes of Lake Victoria basin

The Lake Victoria cichlid superflock, comprising the related radiations of lakes Victoria, Edward, Albert and Kivu, is an example of the most explosive adaptive radiation, with more than 500 species evolved within the last 15-100,000 years, and the most recent in the East African Great Lakes. The repetitive occurrence of the same adaptively important traits in unrelated taxa within and between lakes makes the superflock, and especially the Lake Victoria flock, an ideal model for studying adaptive radiation in shape, ecology and behaviour. However its very recent origin is a challenge for phylogenetic reconstruction because of incomplete lineage sorting and potential for hybridization. In contrast with the well supported monophyly of the mtDNA lineage (d-loop & ND2), the nuclear data (AFLP) suggest that the nuclear genomic diversity of Lake Victoria superflock received contributions from several unrelated lineages that hybridized when seeding the radiations. This could explain the segregation of numerous polymorphisms within and between radiations of the superflock. Furthermore, the shallow levels of species structure at neutral loci within Lake Victoria cichlids contrasts with strong differences based on adaptive genetic and phenotypic diversity. These data raise the possibility that functional traits can be transferred between species by the interaction of hybridization and selection. This is investigated by studying a large number of genomic markers (AFLP) to i) reconstruct a species level majority-genome phylogeny for the superflock and ii) to detect loci under selection associated with adaptively important phenotypic traits.

Morphological Divergences among wild populations of zebrafish, Danio rerio

Divergences in morphology among wild populations have been studied in several species of vertebrates and gradients in environmental features are known to be a major driving force for microevolutionary changes. Body shape variations among fish species are affected primarily by differences in water flow regimes, predation pressure and feeding habits. Here we measured variations in body shape and size among wild populations of zebrafish (Danio rerio) collected from moving and still water (streams and lakes) conditions in their natural habitats in northeast India. Geometric morphometric analyses conducted on male and female individuals from these populations were used to test predictions that habitat differences, particularly, in flow regimes between these populations can produce differences in body morphology. We conducted comparative analyses (using univariate ANOVA, t-test) of centroid size across lake and stream populations as well as between sexes. Multivariate analyses (discriminant function analysis) on partial warps were used to test effects of habitats on body morphology. One-way ANOVA showed a significant effect of habitat type on centroid size (F1,213 =16.4, p<0.01). Lake populations were significantly larger in centroid size than stream populations (independent t-test: t214 =-4.05, p<0.01). While pooled data for lake and stream populations did not necessarily show significant differences in body shape, we found significant differences among some populations. These populations are subjected to fluctuations in water flow and high rainfall during some seasons can drive inter-population mixing. This could thus constrain morphological diversification. Inter-population (spatial) distances might also play an important role in determining morphological divergences.
Fiddler crab locomotion: Are tide-related rhythms the same in lab and field studies?

Some behaviors of intertidal organisms are endogenously regulated and correlate with the cycle of ebbing and flooding tides. For organisms that feed intertidally, timing their movement to and from feeding areas may be especially important if they are to take advantage of favorable feeding conditions. Fiddler crabs (Uca) feed on exposed substrates at low tide and are a model organism for biological rhythms research. The purpose of this study was to determine if drove migration by the fiddler crab Uca pugilator between feeding and burrow locations under the natural conditions of its habitat was correlated with circadian or tidal rhythms. For 15 days in July 2005, during sunlight hours, we recorded the number, direction (toward feeding area = outbound or away from feeding area = inbound), and sex of crabs at an observation point between the burrow and feeding areas on a mud flat. Additionally, we collected 20 U. pugilator from the field site and recorded their locomotory movement for 7 days under controlled conditions using an infra-red actograph system. A general linear model showed that the time of high tide corresponded with both outbound and inbound movement in the field, but that the peak time of movement in the field did not correspond with peak frequency of movement under controlled conditions. There was no significant sex difference in the timing of this movement in the field, though under controlled conditions females’ peak activity occurred 1 hour prior to males. Thus, peak inbound or outbound movement for a U. pugilator drove at the field site can be used to predict the time at which a flooding or ebbing tide may occur there. Moreover, this study highlights the importance of observing activity in the field, as the results under controlled conditions did not reveal the functional locomotor pattern.
Implications of tradeoffs between crypsis and thermoregulation for the evolution of animal coloration

Patterns of covariation between the coloration of animals and their environments are some of the most striking examples of adaptation in nature. For ectotherms, such patterns likely result from a tradeoff between thermoregulation and crypsis. That is, coloration will influence both the amount of radiation that is absorbed by an individual from the environment as well as determine how conspicuous an individual appears in its environment. An evolutionary tradeoff may occur when coloration that is optimal for thermoregulation causes an individual to be more easily detected by predators. One system that shows striking patterns of color matching between individuals and their environment is the lizard community of the Tularosa Basin in New Mexico, USA. Coloration of lizards ranges from melanistic to Carrizo lava field to blanched in the White Sands dune system. Here, using biophysical models that incorporate morphological and spectral traits of lizards along with the physical characteristics of the background environment, we examine the consequences of color matching on activity and energy budgets of lizards in this system. Further, we conduct virtual transplants to examine the consequences of patterns of animal coloration that contrast with their environment. We propose that tradeoffs between thermoregulation and predation likely have given rise to patterns of coloration for lizards in the Tularosa Basin.

Embryonic muscle development in direct and indirect developing marine flatworms (Platyhelminthes, Polycladida)

We compared embryonic myogenesis of the direct-developing acotylean polyclad Melioploana ferruginea with that of Marthigrelia crozieri, a cotelan that develops via a larval stage. Fluorescently-labeled F-actin was visualized with laser confocal microscopy at different developmental stages. Developmental stages are reported as percentages of the time from oviposition to hatching. Development was completed in 7 d for M. crozieri and 22 d for M. ferruginea. At 30% development in M. crozieri and at 15% development in M. ferruginea polygonal outlines of epithelial cells were visible on the surface of the embryo. Random myoblasts appeared in peripheral areas of the egg at 36% and 22-30% development in M. crozieri and M. ferruginea, respectively. Because large amounts of yolk accumulated in the center of developing M. ferruginea, timing of the formation of primary circular and longitudinal muscle bands was possible only for M. crozieri and occurred between 37% and 44% development. For both species, an orthogonal muscle grid was established by 45-50% development. Diagonal muscles developed in M. ferruginea at 60-71% development. Hence, juveniles hatch with the basic body-wall musculature of adults. Larvae of M. crozieri did not hatch with diagonal muscles; these muscles are acquired post-metamorphosis. Specialized musculature developed in the larval lobes of M. crozieri. Oral musculature was found to be complex and was established by 72% development for both species. Our results are comparable to the muscle differentiation reported for another indirect-developing polyclad, Imagine mcgrathi and for a direct-developing species of macrostomid flatworms. Furthermore, they provide additional support that the orthogonal muscle pattern is a sympleiomorph of Spiralia.

Calcium intake, bone metabolism and reproductive output of white-footed mice (Peromyscus leucopus)

The ossification of mammalian fetal and neonatal skeletons requires a significant amount of calcium transfer from maternal sources via the placenta during pregnancy and milk during lactation. Many mammals meet elevated calcium demand at this time by increasing bone resorptive activity, which mobilizes calcium stored in the skeleton. Consequently, maternal bone mineral content and density may be reduced to detrimental levels. When dietary calcium intake is low, females have been shown to rely more heavily on skeletal stores, resulting in relatively greater reduction of bone. To address the potential trade-off between maternal skeletal maintenance and offspring production when calcium availability is low, we provided either a low-calcium diet or a standard diet to reproducing white-footed mice and assessed 1. changes in bone mineral density and bone mineral content of the femur, tibia and lumbar vertebrae using dual-energy x-ray absorptiometry 2. changes in bone resorption activity using bone marker assays and 3. differences in offspring production relative to calcium intake. Females consuming the low-calcium diet produced more pups and experienced greater bone loss than females on the standard diet, suggesting that not only are resources preferentially allocated to offspring production, but relatively more is apportioned when calcium availability is low. Our results corroborate with life history theory regarding short-lived animals that experience fluctuating resource abundance.
P2.189 BOYLES, J.G.; DUNBAR, M.B.; SCHULER, M.S.; STORM, J.J.; Indiana State Univ., Univ. of Regina, Univ. of South Carolina Upstate; jboyles3@indstate.edu

**Determining Metabolized Fuel Source during Arousal from Hibernation using Stable Isotope Signatures in Breath.**

Fat-storing mammals rely mostly on a fixed energy source, white adipose tissue (WAT), to survive the hibernation period; however, brown adipose tissue (BAT) and food may lessen use of WAT in specific situations. BAT is used mainly for thermogenesis during arousal to raise body temperature to euthemic levels, but methods previously used to estimate the time course of BAT metabolism have poor temporal resolution and generally require subjects to be euthanized. Feeding during winter is possible in some situations, but it is unclear if fat-storing mammals metabolize food immediately to power euthermia, or if it is converted to WAT for later use. We conducted two experiments with wild little brown bats (Myotis lucifugus) to test the efficacy of a relatively new technique, stable isotope analysis of excurrent breath, in determining the metabolic fuel powering arousals from hibernation and the subsequent euthermic periods. First, we collected breath samples from 16 bats as they aroused from hibernation to determine if the change between BAT and WAT being metabolized for thermogenesis was detectable in excurrent breath. Second, we fed 48 euthermic bats mealworms with a known isotopic signature to determine if bats can quickly metabolize an exogenous energy source during euthermic bouts. The results of the first experiment suggest the isotopic signatures of WAT and BAT vary enough to be detectable in excurrent breath. The results of the second experiment suggest that despite a known atrophy of the digestive system during hibernation, bats begin metabolizing exogenous fuel sources shortly after feeding and continue to metabolize them for several hours.

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**Nitric Oxide-mediated Angiogenesis in Antarctic Icefish?**

Nitric oxide (NO), produced by nitric oxide synthase, regulates diverse processes including angiogenesis and mitochondrial biogenesis. NO rapidly degrades in most vertebrates by reaction with hemoglobin (Hb) and myoglobin (Mb). Antarctic icefish completely lack Hb. In the absence of Hb, we hypothesize that NO accumulates to higher steady-state concentration. This may trigger high cardiac mitochondrial density and dense retinal vasculature observed in these fish. We measured breakdown products of NO (NO$_2^-$ and NO$_3^-$) in plasma of Hb and +Hb Antarctic notothenioids. Aggregate [NO$_2^-$ + NO$_3^-$] is higher in plasma of Hb icefish (C. aceratus: 22.75 +/- 1.15M) than in a red-blooded notothenioid (N. coriceps: 14.66 +/- 0.67M), indicating that NO concentrations are higher in white-blooded fish than +Hb fish. To evaluate whether NO stimulates angiogenesis in white-blooded fish, we used quantitative PCR (Q-PCR) to measure expression of genes involved in angiogenesis in Hb and +Hb notothenioids. We found no significant differences in expression of hypoxia inducible factor-1 (HIF-1) or vascular endothelial growth factor (VEGF). These results suggest that, if loss of Hb stimulates angiogenesis in icefish, the process must occur early in development and is not upregulated in adults. To further test relationships among [Hb], [NO] and angiogenesis, we treated red-blooded notothenioids with phenylhydrazine (PHZ), a potent hemolytic agent. Hematocrit of fish treated with PHZ for 10 days decreased from ~37% to less than 5% while [NO$_2^-$ + NO$_3^-$] increased concomitantly (N. coriceps: 14.66 +/- 0.67M. N. coriceps + PHZ: 19.60 +/- 1.18M, p=0.01). Expression of PHD2 (prolyl hydroxylase domain protein-2), HIF-1 and VEGF, known angiogenic factors, significantly increases in PHZ-treated N. coriceps. Supported by NSF grants ANT 04-37887 and 07-39637.

P1.139 BOSWELL, L.C.*; MENZE, M.A.; HAND, S.C.; Louisiana State University, Baton Rouge; lbozewi@lsu.edu

**Multiple isoforms of Late Embryogenesis Abundant proteins in Artemia franciscana embryos.**

Late Embryogenesis Abundant (LEA) proteins are highly hydrophilic, low complexity proteins whose expression has been correlated with desiccation tolerance in anhydrobiotic organisms. Originally discovered in plants, LEA proteins have also been identified in bacteria, cyanobacteria, fungi, nematodes, brine shrimp, and a chironomid insect larva. We have currently identified and sequenced six LEA genes in embryos of the brine shrimp Artemia franciscana. The deduced amino acid sequence of one protein (AfrLEA3m) is predicted to be mitochondrially localized by subcellular targeting programs. Bioinformatic analysis of these six proteins has shown each to contain qualities indicative of a group 3 LEA protein including strong hydrophilicity, and prediction of high alpha-helix content. Two of the Afrlea genes have been successfully cloned into a bacterial expression system and one protein isoform has been overexpressed and purified. Furthermore RT-qPCR has been performed on three of the six AfrLEA mRNAs. This analysis has revealed the mRNA expression of all three to be several fold higher in the two embryonic stages of A. franciscana that possess desiccation tolerance, when compared to the desiccation-intolerant nauplius larva. Verification of the predicted mitochondrial location of AfrLEA3m has also been accomplished, which represents the first evidence of a LEA protein targeted to mitochondria of animals. A nucleotide construct encoding the first seventy N-terminal amino acids of AfrLEA3m was ligated to the nucleotide sequence for green fluorescent protein (GFP) and transiently transfected into human hepatoma cells (HepG2/C3A). As confirmed with confocal imaging, the expressed fusion protein was imported into mitochondria. [NIH grant 2 RO1 DK046270-14A1]

P1.139 BRABY, C.E.; PEARSE, V.B.*; VRJENHOEK, R.C.; BAIN, B.A.; Monterey Bay Aquarium Research Institute, Moss Landing, CA, University of California, Santa Cruz, Southern Utah University, Cedar City; vpearse@ucsc.edu

**Pycnogonid-cnidarian interactions in the deep Monterey Submarine Canyon**

Whale carcasses, sunken wood, and cold seeps provide organically enriched oases where, at Monterey Bay, California, at a depth of nearly 3,000 m, we observed pycnogonids (sea spiders) of at least two species, Colossendeis gigas and C. japonica, feeding on sea anemones commonly found there. Submersible remotely operated vehicles (ROVs) provided direct observations of feeding, as well as high definition video and photographic images. We recorded the presence and abundance of both pycnogonids and anemones over the course of 12 visits during 2002-2006. The sedentary anemone Anthosactis pearseae attached directly to whalebones whereas the pom-pom anemone, Liponema brevicornis, was found resting on soft sediment, rolling in benthic currents, or amassed where these currents were disrupted by topography, as well as on whale-falls, wood-falls, and clasm fields. Both pycnogonids and anemones were abundant during 10 of the 12 dives. The whale-fall community appears to provide especially plentiful prey for the anemones, during stages when the decaying carcass attracts enormous numbers of scavenging amphipods. Like the pom-pom anemones, large pycnogonids were dramatically more abundant at these oases than in the surrounding benthos. This predator-prey pair potentially disperses together, and pycnogonids are a plausible selective force in the evolution of tentacle autotomy by pom-pom anemones. Networks of such interactions at these deep benthic oases define them as established, though short-lived, ecological communities, not merely accidental assemblages.

SICB 2009 Annual Meeting Abstracts

January 3-7, 2009, Boston, MA
Genetic variation of resource exploitation in the freshwater crustacean Daphnia
Evolutionary divergence between two closely related populations requires genetic variation within those populations. When genetic variation is present, the different environments that populations encounter drive selection on traits that better adapt the populations to their habitats. An important trait in Daphnia, a small freshwater crustacean, is the ability to exploit different resource levels. We set out to investigate whether clones (individuals) of Daphnia genetically varied in their ability to exploit abundant versus scarce resources. In this study, we used four clones from different water bodies of each species (D. pulex, D. pulicaria). D. pulex inhabit small temporary ponds high in resources, whereas D. pulicaria inhabit deep, stratified lakes low in resources. For each clone, we fed them four different levels of the algae Ankistrodesmus falcatus. We measured the juvenile specific growth rate (μg/ug/day) for each clone at each resource level and calculated the slope between the poorest resource level and richest resource level defined for each species of Daphnia clones. This allowed us to determine resource sensitivity and minimum resource requirements. Daphnia that perform well in abundant resource conditions have more sensitive growth rates while those that perform well in scarce resource conditions have lower minimum resource requirements. We found that clones responded differently to different resource levels while some clones exhibited increasing growth rates with increasing food levels others exhibited stable growth rates across each resource level. By constructing rank order tables, we also found that more sensitive clones had higher minimum resource requirements, while the converse was true for less sensitive clones.

Metabolic rate, clutch oxygen concentration, temperature and dial patterns of contraction in brooding Burmese pythons (Python molurus bivittatus)
Multiple models have been proposed to explain the evolution of endothermy. The reproductive model proposed by Farmer (2000) specifies that the initial evolution of endothermy was driven by natural selection for the maternal ability to maintain a thermally homeostatic developmental environment, thus increasing offspring fitness. Burmese pythons are an example of a species that is facultatively endothermic while brooding. We are currently building a broader study that capitalizes on this species to study the evolution of endothermy. As part of the first stage of this study, we examined 3 brooding females at 3 temperatures (25.5°C, 28.5°C, 31.5°C) for 1) diurnal cycle of female muscle contraction rate, 2) the thermal relationship between clutch temperature, female body temperature, and nest temperature, 3) the impact of brooding on clutch oxygen concentration, and 4) the relationship between muscle twitch, heat production, and metabolic rate.

Myostatin (MSTN) negatively regulates muscle growth in mammals, with some evidence in support of a similar role in fish. MSTN levels have been shown to be down-regulated in response to growth hormone and up-regulated during fasting in both giant danio (Danio aequipinnatus) and rainbow trout (Oncorhynchus mykiss). These data support a role of MSTN in fish growth. The intent of this project was to isolate and identify a potential downstream target of MSTN in muscle tissue. By utilizing the zebrafish (Danio rerio) genome and rainbow trout EST databases, a novel target, mighty was virtually cloned from rainbow trout and zebrafish. Utilizing degenerate primers, we subsequently isolated, empirically cloned, and sequenced mighty from the giant danio. Semi-quantitative and real-time PCR demonstrate similar tissue distribution between mighty and MSTN gene expression in adult giant danio. In addition, it has been demonstrated that mighty gene expression is down-regulated during fasting, while MSTN is up-regulated, suggesting an interaction in regulation of growth and metabolism. We hypothesize a regulatory interaction between MSTN and mighty, with opposing growth functions.

Variation in the first prebasic molt among House Finches, Red Crossbills, and other Cardueline Finches that differ in reproductive schedule
The annual replacement of feathers is a vital process for all birds. A successful molt is important for insulation, flight capability and efficiency, camouflage, sexually selected ornamentations and courtship displays. In addition, growing new feathers is energetically demanding. Therefore, the timing and pattern of molt can greatly affect reproductive success. The timing and progression of molt was examined in adult and juvenile House Finches (Carpodacus mexicanus) captured in Davis, California, with comparisons being made between the sex and age classes. Furthermore, the first prebasic molt pattern of juvenile birds was compared between seasonally-breeding House Finches and opportunistic Red Crossbills (Loxia curvirostra). Typically in the first prebasic molt, juvenile passerines replace the body feathers but retain their original flight and tail feathers. However, some species deviate from this pattern. Within the 16 North American Cardueline Finch species (subfamily Carduelinae, family Fringillidae), House Finches are unique in that many juveniles replace some of the flight feathers; even the congeneric Purple and Cassins Finches do not do this. Four other Cardueline species (including Red Crossbills) have been reported to occasionally replace some of the flight feathers during the first prebasic molt. Several years of field data from Red Crossbill juveniles captured throughout the Pacific Northwest show this to be surprisingly rare, given how early Crossbills often nest (winter). Potential explanations for these species juvenile molt patterns are discussed, particularly in reference to differences in flexibility of the annual reproductive cycle.

January 3-7, 2009, Boston, MA
An improved model of vertebrate muscle force generation

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Mathematical models of the generation of force in muscles by way of crossbridges date back to work by Huxley in the 1950s. The Huxley Model is based on a two-state model for crossbridges; a crossbridge is either attached to an actin filament or detached. This approach is inadequate to describe the percentage of fast-twitch fibers in the control (92.2%) and treated (92.0%) muscles. However, the fiber diameters of the treated (fast: 12.900.25 m; slow: 14.140.21 m) rectus thoracis were found to be significantly smaller than those in the control muscles (fast: 14.380.25 m; slow: 17.800.24 m). These findings support the hypothesis that steroid treatment results in smaller muscle fibers. Smaller fibers would cause the muscles of treated babies to be unable to produce as much force as muscles in babies not exposed to steroids. Therefore, these results raise concern of possible breathing muscle weakness in babies treated with betamethasone.

Modelling cranial sutures in Finite Element Analysis: a validation study using the domestic pig

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The use of Finite Element Analysis (FEA) to investigate feeding mechanics is becoming increasingly common. However, what little work has been done to validate the technique has been conducted almost exclusively on primates. This work represents the first attempt to validate cranial FE models of a non-primate mammal, by comparing specimen-specific models of the domestic pig, Sus scrofa, with strain data collected in vitro. Cranial sutures have been largely overlooked in FE models, despite evidence suggesting their important structural role as "shock-absorbers", dissipating dangerously high strains. The pig models were loaded at the tooth row, and potentially functionally important sutures (zygomatic, coronal, maxillary-premaxillary) introduced in one of three ways: fused, open, or assigned elastic properties of collagen within sutures. Results show that sutures notably affect strain patterns throughout the skull, and more attention should be paid to their role in cranial FE modelling.

Thermal Tolerances of the Invasive Mussel Mytella charruana

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Mytella charruana is an invasive bivalve that, in the past five years, has been found fouling docks and oyster reefs on the southeastern Atlantic coast of the U.S. It originates from both coasts of South America. We have been trying to better understand this species by studying its physiological tolerances. We first tested M. charruana’s cold temperature tolerances. In 14-day trials, salinity ranged from 9-15 ppt based on the collecting site. We started out using 6, 13, and 20°C water. 20°C was the baseline because this was the temperature at which we collected mussels. There was no survival at 6°C, but significant survival at 13 and 20°C (58 and 41%, respectively). So we tested a narrower range of temperatures (6, 9, 11, and 13°C). All M. charruana died at 6°C, but survived at 9, 11, and 13°C (12, 13, and 31%, respectively). These trials were carried out using 5-day adjustments between temperature treatments. Next, we conducted a shock temperature trial. All mussels were immediately placed in 6, 9, or 11°C from 20°C water. Six hours later, the temperature was adjusted back to 20°C. At 6C, there was low recovery (12%), but at 9 and 11C (66 and 71%, respectively), M. charruana had a high recovery. Warm temperature trials are currently underway, with one trial completed. 20, 23, 28, and 31°C waters were tested using 5-day adjustments between treatments. There was little mortality at any of these temperatures, so a new trial is underway with 20, 31, and 36°C treatments. Once a maximum temperature for survival is known, shock trials will be run. We have determined the thermal minimum for M. charruana (6C), and hope to soon know its thermal maximum. This information can help us predict where this invader may spread in the future.
The Relationship Between Muscle Attachment Site Size and Function in the Avian Hind Limb

The utility of osteological correlates of muscle attachment sites (e.g., scars, crests and tubercles) in the reconstruction of function and behavior in vertebrates is controversial. Whereas not every muscle leaves a scar, it has been suggested that differences in the relative size, strength and/or function of a muscle may be reflected in the relative development of an osteological correlate. This relationship has been systematically studied thus far only in an intraspecific context. Birds exhibit a wide range of hind limb locomotor adaptations ranging from cursoriality (Paleognathiformes) and diving (Gaviiformes) to predation (Falconiformes) and scansoriality (Piciformes), but the musculature of avian hind limbs is relatively conserved across taxa. This makes birds an ideal group for examining functional correlates of muscle attachment site size. Several bony crests and projections of the femur and tibia, each representing the attachment site of a functionally relevant muscle, or group of muscles, were photographed and measured in multiple avian taxa, representing eight distinct locomotor categories. The area of each osteological correlate was regressed against midshaft diameter of the bone, and an analysis of covariance indicated that the functional categories differed significantly (p<0.05) from each other for each muscle examined. Certain taxa, notably divers, climbers and cursors, exhibited highly specialized functional adaptations that correlate to either increased or decreased muscle use at that attachment site. These results suggest that variation in osteological correlates is likely to have utility when reconstructing functional or behavioral categories from osteological specimens, including those of fossils.
Quick Forward Escape Swimming in the Stomatopod Crustacean Odontodactylus havanensis

Although metachronal beating of oar-like appendages is a common means of swimming among aquatic organisms, it is typically associated with slow swimming speeds. I characterized the escape swimming of the stomatopod crustacean Odontodactylus havanensis, which uses metachronal rowing to achieve an exceptionally fast escape response. This unique situation may be compared with most previously studied mammals. Supported by NSF I0B-0517340.

Loading patterns of the femur in opossum (Didelphis virginianis) during terrestrial locomotion

Previous studies have found that mammalian limb bones typically are loaded predominantly in bending with minimal torsion, whereas the limb bones of non-avian reptiles (and amphibians) experience considerable torsion in addition to bending. However, most data on limb bone loads for mammals have been collected from large or cursorial species (e.g., horses, dogs, sheep) in which the limbs tend to be held upright. To better clarify the evolutionary timing of the distinctions in bone loading patterns between reptiles and mammals, we measured in vivo terrestrial locomotor strains in the femur of the Virginia opossum (Didelphis virginianis), a marsupial that uses more crouched limb posture than previous mammals from which bone strains have been recorded, and which belongs to a clade phylogenetically between reptiles and the eutherian mammals studied previously. If limb bone loading patterns in opossum show torsion similar to amphibians and non-avian reptiles, then the patterns shown across these diverse taxa likely reflect the ancestral condition of tetrapod limb bone design. Strain recordings indicate the presence of both bending and a moderate amount of off-axis loading in the opossum femur, suggesting elevated limb bone torsion compared with most previously studied mammals. Supported by NSF 10B-0517340.

The post-breeding (prebasic) molt in birds is typically correlated with a drop in baseline and stress-induced concentrations of the primary avian glucocorticoid, corticosterone (CORT). However, to our knowledge, details of the relationships between CORT and molt onset, molt progression (the stage of molt), molt intensity (the number of growing feathers), and molt rate (the speed with which molt is completed) are unknown for any free-living bird. We investigated these relationships in two seasonally-breeding songbirds, the Black-capped Vireo (Vireo atricapillus) and the White-eyed Vireo (V. griseus), on their breeding grounds in Texas, USA. We detailed the timing, progress, intensity, and rate of molt in two populations of each species, and correlated these parameters with baseline and stress-induced CORT concentrations. CORT concentrations started to decline weeks before the onset of molt, were lowest near the onset of molt, and varied little with molt intensity, progress, or rate. These results do not contradict the widely held idea that CORT is lower during molt in order to avoid CORT’s negative effects on protein synthesis (i.e., feather production), but the lack of a close temporal connection between the seasonal decline in CORT and the onset of molt, and the lack of strong relationships between CORT concentrations and the intensity, progression, and rate of molt, suggest that the seasonal decline in CORT concentrations in temperate birds may have other functions as well.

One Bad Mother: Maternal Aggression in the African Cichlid Astatotilapia burtoni.

Thirty years of research have contributed to our understanding of the molecular, hormonal, and physiological mechanisms of the socially regulated switch between dominant and subordinate phenotypes among males of the African cichlid species Astatotilapia burtoni. Meanwhile, the female phenotypes have been largely ignored by all but a few studies regarding the reproductive cycle and affiliative behavior. Females of a recently collected A. burtoni wild stock from Zambia display a “good mother” phenotype that includes defensive aggression to protect free-swimming fry for up to 15 days post-release, whereas labstock females show similar aggression but eat their fry within 2-3 days post-release. The behavioral difference is likely due to inadvertent artificial selection in the lab, as suggested by good-mother phenotype observed in F1 wildstock that have been reared under standard lab conditions. We describe this behavior in detail through repeated, ten-minute focal observations using Jwatcher and an ethogram adapted from that used for males. Hormone measurements from excreted water samples are used to quantify the hormone profile during and brooding and post-release maternal care. Females have been observed under various social situations, including intruder challenge in order to address the challenge hypothesis as it might apply to female territoriality. Cross-fostering experiments were conducted to determine whether the differing level of maternal care is induced by possible differences in the behavior of the fry. We found that the genotype of the fry did not affect maternal care, however wildstock fry exhibited increased maternal affiliation but similar schooling behavior compared to labstock fry. This work establishes a female model for aggression, which will be explored at the hormonal, molecular and genetic level.
Among the great variety of reproductive modes exhibited by teleost fishes, one that has received considerable attention is the presence, within a single species, of males that practice distinct alternative reproductive tactics (ARTs). Bluegill sunfish (Lepomis macrochirus) are particularly interesting in this regard because they have three male morphs that differ in reproductive behavior, morphology, and physiology. Parental males court females and provide care for the resulting offspring. Two non-parental morphs, termed sneakers and satellites, use sneaking or female mimicry behaviors, respectively, to steal fertilizations from parental males. Among the morphs physiological differences are differences in circulating 11-ketotestosterone (KT) and cortisol levels and various sperm characteristics on the day of spawning (Neff, Fu and Gross 2003; Neff and Stoltz 2006; Knapp and Neff 2007). The morph difference in KT and cortisol is of particular interest for understanding endocrine mediation of ARTs because the biosynthetic pathways of these hormones have two enzymes in common: 11β-hydroxylase (11β-H) and 11β-hydroxysteroid dehydrogenase (11β-HSD). We hypothesize that the relative activity of these enzymes in different tissues plays a role in endocrine mediation of the morph differences in behavior and/or spermatogenesis. To begin to test this hypothesis, we are currently comparing the activity of 11β-H and 11β-HSD (measured as the amount of substrate converted to product/min/mg protein) in gonad, liver, and interrenal tissues. We will describe our findings and discuss the implications of our results for understanding the mechanisms by which steroid hormones mediate behavioral and physiological aspects of the male ARTs in bluegill and in other teleost species with ARTs.
Rainbow trout insulin receptors: cloning, patterns of mRNA expression, and regulation by fasting
In this study, a unique cDNA encoding a fourth insulin receptor subtype (IR4) was isolated, cloned and sequenced from the liver of rainbow trout. A 1525-bp cDNA encoding a partial amino acid sequence of the beta-subunit and the 3' untranslated region (UTR) was obtained. IR4 shares 75.5%, 73.1%, 68.3% deduced amino acid identity with previously characterized trout IR1, IR2, IR3, respectively. Quantitative real-time PCR revealed that the four IR mRNAs were differentially expressed, both in terms of distribution among tissues as well as in terms of abundance within selected tissues of juvenile trout. IR1 mRNA was most abundant in muscle (white, red, cardiac) but least abundant in adipose, whereas IR3 and IR 4 mRNA were most abundant in adipose and liver. All IR subtypes were detected over the course of embryonic development; levels of IR3 and IR4 remained relatively constant from pre-hatch (29 days post-fertilization, dpf) to post-hatch (90 dpf), whereas levels of IR1 and IR2 tended to increase during this period. Fasting for 4-6 weeks increased the expression of IR1 and IR4 in liver and cardiac muscle. These findings provide insight into the evolution of this period. Fasting for 4-6 weeks increased the expression of IR1 and IR4 in post-hatch (90 dpf), whereas levels of IR1 and IR2 tended to increase during the same period. From pre-hatch (29 dpf) to mature (150 dpf), mRNA were most abundant in adipose and liver. All IR subtypes were detected over the course of embryonic development; levels of IR3 and IR4 remained relatively constant from pre-hatch (29 days post-fertilization, dpf) to post-hatch (90 dpf), whereas levels of IR1 and IR2 tended to increase during this period. Fasting for 4-6 weeks increased the expression of IR1 and IR4 in liver and cardiac muscle. These findings provide insight into the evolution of this period.
Amphibians are declining worldwide, with some authors suggesting that mass extinctions have occurred over the past two decades and will continue into the future. Andean anurans are among the hardest hit by declines, with habitat destruction/fragmentation, infection by chytrid fungus, climate change, and an interaction of these factors as the most likely causes of declines. Conservation efforts should favor the protection of habitats most likely to support amphibian species and of areas with wide elevational ranges, which would allow for upward species migration in places where average temperatures increase. High-Andean amphibian communities are rich in endemic species which often have very limited distributions, yet they are vastly understudied. Gaining a better understanding of the factors that influence local and regional species richness will improve our capacity to select priority areas for amphibian conservation in the Andes. In this study, we explored the hypothesis that ecotones between forest and grassland habitats are biodiversity hotspots for high-elevation anurans in southern Peru. Our analysis was based on data collected from over 100 leaf-litter quadrats, which were sampled between 3,000 and 3,700 m. Despite a general trend towards decreasing species richness as a function of elevation, the forest–grassland ecotone had significantly higher frog density and biomass when compared to forest or grassland habitats alone. In addition, a number of newly discovered species were all collected in ecotonal habitats or forest habitats adjacent to ecotones. The results of our study suggest that forest–grassland ecotonal habitats are biodiversity hotspots for anuran species in the Andes, and that these habitats should be considered as target areas for amphibian conservation.

Cutaneous water loss and lipids in the stratum corneum of mesic horned larks (Eremophila alpestris praticola) and five species of desert larks

The stratum corneum (SC), the outer layer of the epidermis in birds and mammals, forms a barrier to water vapor diffusion through the skin. The avian SC is composed of corneocytes embedded in a lipid matrix of cholesterol, free fatty acids, triglycerides, ceramides, and cerebrosides. Cutaneous water loss (CWL) accounts for over half the total water loss in birds. Because birds in deserts face a hot, desiccating environment, selection to reduce CWL at moderate ambient temperatures may have been stronger in desert birds than in mesic birds. Previous studies in our lab have shown that changes in the ratios of lipid classes in the SC may influence CWL in birds. Appropriate ratios of ceramides, cerebrosides and free fatty acids seem necessary for the formation of intercellular lipid bilayers, called lamellae. The molecular organization of these lamellae affects CWL. In this study, we compared rates of CWL and SC lipid composition of horned larks from central Ohio (Eremophila alpestris praticola) with those of five species of larks from deserts. E.a. praticola had higher rates of CWL at thermoneutral temperatures and a higher ratio of ceramides to cerebrosides in the SC than desert larks, a result consistent with our findings in other bird species. We also found that the lipid composition of the SC was associated with CWL in horned larks.

Sexual Dimorphism of the Second-to-Fourth Digit Length Ratio (2D:4D) in the Strawberry Poison Dart Frog (Oophaga pumilio) in Costa Rica

The second- to fourth-digit ratio (2D:4D) is a well-studied sexual dimorphism that likely arises as a result of prenatal androgenic effects on homeobox gene expression. This dimorphism exhibits interesting phylogenetic patterns in which females have larger ratios than males among most mammalian species and males have larger ratios than females in most avian and reptilian species. However, 2D:4D has not been measured in more basal taxa such as amphibians. In this study, 2D:4D of all four feet and snout-to-vent length (SVL) were measured in 40 male and 44 female Strawberry Poison Dart Frogs (Oophaga pumilio) in Costa Rica. The 2D:4D of the rear feet is likely to be a result of prenatal androgenic effects on homeobox gene expression, but the 2D:4D of the front feet is influenced by factors such as environment and nutrition. In this study, males had significantly larger 2D:4D in their rear feet than females, while there was no significant difference in 2D:4D between the sexes in the front feet. These results indicate that 2D:4D in an anuran is both sexually dimorphic and follows a general trend towards decreasing species richness as a function of elevation, the forest–grassland ecotone had significantly higher frog density and biomass when compared to forest or grassland habitats alone. In addition, a number of newly discovered species were all collected in ecotonal habitats or forest habitats adjacent to ecotones. The results of our study suggest that forest–grassland ecotonal habitats are biodiversity hotspots for anuran species in the Andes, and that these habitats should be considered as target areas for amphibian conservation.

High density and high nitrogen: A dual stressor for grasshoppers?

Insects respond to high density in a variety of ways that, if exposed during larval development, can culminate in drastic changes in physiology and morphology. Some of these changes can be beneficial in aiding dispersal from a crowded habitat. For grasshoppers and other insect herbivores that tend to be nitrogen (N) limited, plant quality also affects these characters. High dietary N is correlated with increased survivorship, growth, and fecundity, while low dietary N is deleterious and can induce dispersal. Despite the intrinsic relationship between population density and dietary N, limited studies offer insight as to how the interaction of these two factors impact insect development. To gain a better understanding, we tested this in a dominant grasshopper species in Chinas Xilin River basin region, Odaleus asiaticus. Grasshoppers were assigned to one of four treatment groups (high or low density and N fertilized or unfertilized grass). There was a significant interaction effect between diet and density. Grasshoppers reared in high density and fed high N diets had a significantly lower growth rate, increased development time, decreased adult mass, and increased metabolic rate (MR) as compared with the other three treatment groups. Increased MR leads to increased energy expenditure and could explain decreased adult mass. It is also an indicative dispersal characteristic in this family. These results suggest that insects reared in high density are more sensitive to changes in dietary N, perhaps these effects are strictly deleterious due to a compound of stressors, or perhaps the interaction induces development of dispersal characters. This research was partially supported by NSF EAPSI fellowship and Sigma Xi GIAR to AJC.

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Amphibians are declining worldwide, with some authors suggesting that mass extinctions have occurred over the past two decades and will continue into the future. Andean anurans are among the hardest hit by declines, with habitat destruction/fragmentation, infection by chytrid fungus, climate change, and an interaction of these factors as the most likely causes of declines. Conservation efforts should favor the protection of habitats most likely to support amphibian species and of areas with wide elevational ranges, which would allow for upward species migration in places where average temperatures increase. High-Andean amphibian communities are rich in endemic species which often have very limited distributions, yet they are vastly understudied. Gaining a better understanding of the factors that influence local and regional species richness will improve our capacity to select priority areas for amphibian conservation in the Andes. In this study, we explored the hypothesis that ecotones between forest and grassland habitats are biodiversity hotspots for high-elevation anurans in southern Peru. Our analysis was based on data collected from over 100 leaf-litter quadrats, which were sampled between 3,000 and 3,700 m. Despite a general trend towards decreasing species richness as a function of elevation, the forest-grassland ecotone had significantly higher frog density and biomass when compared to forest or grassland habitats alone. In addition, a number of newly discovered species were all collected in ecotonal habitats or forest habitats adjacent to ecotones. The results of our study suggest that forest-grassland ecotonal habitats are biodiversity hotspots for anuran species in the Andes, and that these habitats should be considered as target areas for amphibian conservation.
Female Pheromones in Xenopus tropicalis

Amphibians produce pheromones which are known to affect communication and courtship behavior. There are several examples of courtship-related pheromonal communication occurring in urodele species and very few examples of pheromone communication in anurans. We investigated the frog, *Xenopus tropicalis*, to further identify the capacity for pheromonal communication and to determine whether treatment with gonadotropin-releasing hormone (GnRH) increases male sensitivity to pheromones. Previous studies in our lab have found that males spent a significant amount of time in the female arm of a Y-maze than the control arm (P<0.01). GnRH is a neuro-hormone that is instrumental in several reproductive physiological processes and is known to impact both reproductive behavior and response to odorants. In this study, we investigated the impact of injected GnRH on pheromone detection in males. Males were injected intraperitoneally either with 0 ug or 10 ug GnRH in Ringers. Animals were then placed in a Y-maze and given the choice of an arm containing water from female conspecifics or control water. Both GnRH and amphibian Ringers injected males combined spent more time in the arm containing water from female conspecifics or control water. Males injected with GnRH did not spend a significantly more time in the producer arm than in the control arm (P=.0395). However, males injected with GnRH did not spend a significantly more time in the producer arm than in the control arm (P=.0395). males injected with GnRH did not spend a significantly more time in the producer arm than in the control arm (P=.0395).
Molecular phylogeny of the true crabs (Crustacea: Decapoda: Brachyura) with an estimation of divergence time for the major lineages

Myostain (Mstn) is a member of the TGF-beta superfamily, known for its role as a negative regulator of muscle mass in mammals. Similarly for crustaceans, Mstn is hypothesized to take part in a reversible atrophy of muscle tissues during molting necessary for organismal growth. When crustaceans molt, their appendage muscles need to atrophy in order for them to pull through the small basi-ischial joints. We hypothesize that Mstn acts as a link between molt-inducing ecdysteroid and calpain proteases, which degrade muscle proteins. We previously identified a partial cDNA (175 bp) of a Mstn-like transcript from Carcinus maenas that is highly conserved with Mstn in land crab, Gecarcinus lateralis and lobster, Homarus americanus.

The partial sequence encodes a 58 amino acid sequence of the mature peptide. Examination of Mstn expression is conducted by using real-time RT-PCR. Mstn expression is assessed in various tissues from intermolt animals. In addition, Mstn expression in skeletal muscles is examined to assess its response to different levels of ecdysteroid at various molting stages. Supported by NSF (IBN-0618203).
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Stable Isotope Analysis of Pinniped fossils from the San Diego Formation (Late Pliocene, California)
Pinnipeds (seals and allies) represent an intermediate morphological and ecological condition between fully aquatic marine and terrestrial mammals and as such are an ideal group for study of the land-sea transition in tetrapods. Morphology has been the primary focus of most studies of fossil pinnipeds, but supplemental ecological information can be gained through stable isotope analysis of fossil material. Tooth enamel is the preferred material for stable isotope analysis because it is less prone to diagenetic alteration. For studies of fossil pinnipeds, however, this presents a problem as most taxa exhibit a reduction in enamel and in the number and size of teeth. Here we assess the use of other biogenic materials (i.e., bone, dentin) as potential archives of ecological information for pinnipeds. Bone and dentin were sampled for carbon and oxygen stable isotope analysis from the Late Pliocene San Diego Formation of southern California. Taxa sampled include three species of fossil pinniped as well as coeval species of whales, sirenians, fish and terrestrial mammals. Three types of criteria were defined to assess the extent of diagenetic alteration in bone and dentin: 1) comparison of phosphate oxygen values with carbonate oxygen values; 2) similarity and degree of overlap in carbon values among ecologically distinct taxa; and 3) how well the recorded isotope values fit predicted values for Pliocene marine consumers. Once validated, these tools will then be applied to study of earlier species representing the initial radiation of pinnipeds into aquatic ecosystems.

Aves 3D: A new online resource for avian skeletal anatomy
Here we report the launch of a new National Science Foundation funded online resource for avian skeletal anatomy, www.Aves3D.org, which will offer three-dimensional models of a wide selection of skeletal elements of extant and extinct birds. The Aves 3D database is produced through non-contact laser scanning of skeletal material from, amongst others, the Harvard Museum of Comparative Zoology and the Yale Peabody Museum of Natural History. Database growth is fueled by undergraduate student research projects, which involve a variety of functional and phylogenetic studies supervised by both affiliated and external post-graduate students and researchers. The online database will also serve as a digital archive for the collections of contributing museums and allows for rapid global dissemination of 3D digital data on common as well as rare and potentially fragile specimens, in a format ready for a wide range of two and three-dimensional computational analyses. The size of the database is currently limited, and opportunities exist for initiating new student-based projects that will contribute to database growth.

P3.36 CLAFLIN, SB; PIEN, CL; RANGEL, EN; UTZ, KE; WALTHER, HV; WRIGHT, AN; ELLERBY, DJ*; Wellesley College; delellerby@wellesley.edu
The effects of feeding on medicinal leech swimming performance
The locomotor system of sanguivorous leeches is presented with a unique challenge: how to maintain mobility while coping with a greater than 500% increase in body mass during feeding. A meal of this size is likely to disrupt the function of the muscular hydrostat during swimming, reducing speed and increasing predation risks. We quantified the effects of feeding to satiety on swimming kinematics, and the time course of recovery of swimming performance post-feeding in the medicinal leech Hirudo verbana. There was a 5.07 fold increase in mass during feeding. Despite this, leeches were able to swim immediately after feeding, reaching 27% of their pre-feeding speed. Reduced speed was a consequence of a reduction in both swimming cycle frequency and stride length to 69 and 42% of the pre-feeding values respectively. Recovery of swimming ability was rapid, despite a prolonged increase in body mass. 50% restoration of swimming speed was achieved in approximately 1 hour while body mass was still 4.2 fold greater than before feeding. Rapid mass and volume reduction immediately post-feeding, and the properties of the obliquely striated swimming muscles appear to aid recovery of swimming performance. Such features that aid post-feeding recovery of mobility may have been important in the evolution of leech sanguivory.

P3.148 CLAIRARDIN, S.G. ; GRIFFIN, A.M.; HOLGERSSON, M.C.N. ; PAITZ, R.T. ; BOWDEN, R.M. ; Illinois St. Univ.; scclar@ilstu.edu
Nest temperatures and offspring phenotype in the painted turtle: Does the magnitude of temperature fluctuations matter?
Maternal effects have been shown to impact offspring development. In oviparous reptiles, studies utilizing constant laboratory incubations have demonstrated that incubation temperatures can influence a suite of phenotypic traits, including sex. Recent work has investigated how more natural fluctuating temperatures influence offspring phenotype and shown that temperature fluctuations can produce effects that differ from what would be predicted under constant incubation conditions. This study aims to investigate the potential for female painted turtles (Chrysemys picta) to use vegetation cover as a predictor of temperature fluctuations within the nest. This relationship was characterized for 16 natural nest sites using temperature loggers to record nest temperatures and digital imagery to quantify vegetation cover. To study phenotypic outcomes of temperature fluctuations, eggs from eleven clutches were allocated to one of three incubation regimes: constant temperature (27°C), four degree fluctuation (27+/-4°C), and eight degree fluctuation (27+/-8°C). Data from natural nests incubation regimes: constant temperature (27°C), four degree fluctuation (27+/-4°C), and eight degree fluctuation (27+/-8°C). Data from natural nests indicate that daily maximum temperature, daily mean temperature, and daily temperature range, but not daily minimum temperature, were related to overstory cover. In the lab, temperature fluctuations had a significant effect on incubation duration, but not hatching length, mass or plastron coloration. Additional parameters of offspring phenotype will be measured including righting time, immunocompetence (both cell-mediated and humoral), and sex. The findings from this study indicate that overstory cover can affect nest temperature fluctuations, which can ultimately influence offspring phenotype.

P3.148 CLAIRARDIN, S.G. ; GRIFFIN, A.M.; HOLGERSSON, M.C.N. ; PAITZ, R.T. ; BOWDEN, R.M. ; Illinois St. Univ.; scclar@ilstu.edu
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January 3-7, 2009, Boston, MA
The evolution of coral feeding in the muricid gastropods

Muricid gastropods in the genus Drupella graze coral polyps and cause damage to coral reefs during population outbreaks. Another well-known group of coral-feeding muricids are the Coralliophiliinae, e.g., and endoparasites that feed sectorially. The only other report of coral feeding among muricids is of grazing on corals by Ergalatax margaritica. The phylogenetic relationship between Drupella and Ergalatax is unknown, as is their relationship with the Coralliophiliinae. We wished to investigate whether the current morphologically-based taxonomy correctly reflects three independent origins of coral feeding behavior in this family. We used four genes (28S, 16S, 12S and COI) to develop a molecular phylogeny of these coral-feeding groups, and also included a range of other muricids. Our results show a sister relationship between Drupella and Ergalatax, whereas coralliophiliines are a more distant monophyletic group. This suggests that coral grazing only arose once in the Muricidae, and that parasitism of corals appeared independently.

Temperature acclimation has a greater effect than heat shock on gill protein expression patterns in two congers of blue mussel (genus Mytilius)

We used proteomic techniques to compare protein expression profiles of gill tissue from two blue mussel congeners, Mytilius galloprovincialis (Mg) and M. trossulus (Mt). The former is invasive along the coast of southern California, and has replaced the latter, native conger there, perhaps due to greater heat tolerance. After acclimating each species to 7C or 13C for 3 wk, we exposed 6 treatment individuals to a heat shock (HS) of 32C for 1 h, followed by 24 h of recovery at acclimation temperature (AT). Six control (no-HS) individuals were sacrificed after acclimation. 2D gel electrophoresis was performed on gill protein extracts, and protein expression profiles from 48 gels (6 replicates x 2 species x 2 AT x 2 treatments) were analyzing using Delta2D software (Decodon). Over 1000 protein spots were found and associated across all gels. Using a variety of analytical tools, including ANOVA, hierarchical clustering, and principle components analysis, we found that the two species differ in protein expression pattern, regardless of AT. Further, within each species, there are significant differences in protein expression between individuals acclimated to 7C compared to those acclimated to 13C. However, HS had a weaker effect than acclimation on protein expression: Mg control and HS individuals showed little difference in protein expression (i.e., these two groups did not cluster separately), while protein expression profiles of Mt control and HS individuals showed discernable clustering, but not of the magnitude found between 7C- and 13C-acclimated individuals. These data suggest that, in Mytilius congeners, long-term acclimation may have a greater effect on tissue-wide protein expression profiles than does HS, and that Mg is relatively less sensitive to HS than Mt.

Intraclutch variation in egg characteristics facilitating hatching synchrony in Canada geese

In birds, females may regulate hatching synchrony in offspring by delaying the onset of incubation. However, the mechanisms facilitating the differential development of offspring within clutches of these species have not been identified. We quantified embryonic metabolism, conductance, shell characteristics and rapid yolk development in eggs from complete clutches from a free-living population of Canada geese (Branta canadensis). We found that metabolic rates are inherently higher for embryos from eggs laid later in the clutch, rates of water loss are also higher from eggs laid later in the clutch and shell porosity increases for eggs laid later in the clutch. However, growth of yolk during the rapid yolk phase did not differ among eggs in a clutch. We hypothesize that embryonic development is regulated through the interaction between shell characteristics and vascular development during the earliest stages of incubation in waterfowl and related species.
Cytoplasmic and Mitochondrial Arginine Kinase Isoforms in a Choanoflagellate Protozoan

Arginine kinase (AK) catalyzes the reversible transfer of phosphate from phosphoarginine to MgADP yielding MgATP and arginine. This enzyme plays a central role in mitigating temporal and spatial ATP supply and demand mismatches in cells displaying high and variable rates of ATP turnover. AK is widely distributed in invertebrates and protocodonts but is lacking in craniates. A considerable base of molecular phylogenetic data and other evidence support the view that choanoflagellate protozoans are a direct sister group of the metazoa. The recently released genomic and EST sequence database for the choanoflagellate Monosiga brevicollis contains clear-cut evidence for at least three AK genes in this protozoan. We have generated the cDNAs for two of these by RTPCR. One corresponds to a 394 residue AK with a calculated Mr of 45.71 kDa. On-line tools indicated that this AK is an N-terminal signal peptide. The majority of the tools predicted that this AK is targeted to the mitochondrion suggesting that it is a true mitochondrial AK (cytAK). Expression of the cytAK in E. coli yielded highly active soluble protein which was shown to be monomeric by size exclusion chromatography. The other AK cDNA coded for a 421 residue protein with a calculated Mr of 45.71 kDa. On-line tools indicated that this AK has an N-terminal signal peptide. The majority of the tools predicted that this AK is targeted to the mitochondria suggesting that it is a true mitochondrial AK (MIAK). Efforts are underway to express various MIAK constructs to assess activity and quaternary structure. The present results support the view that cytoplasmic and mitochondrial isoforms of AK are expressed in M. brevicollis. These AKs very likely serve to mitigate reaction diffusion constraints for energy transport between mitochondria in the cell body and the long flagellum used in motility and food entrapment. (Supported by NSF Grant IOS 0542236 to WRE.)

Development of a simple assay to measure an integral pro-inflammatory cytokine in songbird blood

Progress in ecological immunology has been hampered by a lack of techniques providing strong inference into the mechanisms of disease resistance. One important integrative immune response, the acute phase response, involves adaptive alterations in body temperature, behavior and circulating proteins all which serve to control or eliminate infection. The cytokine IL-1beta is an important regulator of these proinflammatory defenses in birds. In chickens, IL-1beta, primarily secreted by macrophages, peaks in the blood 3-5 hours after injection with gram-negative bacterial components (e.g. lipopolysaccharide, LPS). Recent advent of a polyclonal antibody to chicken IL-1beta prompted us to test whether IL-1beta is detectable using the same antibody via an enzyme-linked immunosorbent assay (ELISA) in wild birds. If so, this commercially available antibody would be a useful tool in avian ecological immunology. We found that IL-1beta from wild house sparrows (Passer domesticus) was detectable 5h post-injection with complete Freunds adjuvant (CFA), a substance that mimics a bacterial infection without pathogen replication. Sparrows unchallenged with CFA, showed some antibody binding, but less than CFA-treated birds. Studies are ongoing to i) validate that the antibody is binding IL-1beta and ii) develop a standard that can be used to quantify inter-assay variation.

Hypatia of Alexandria: A Comparative Perspective on her Role in History

Hypatia was a philosopher and mathematician during the 4th and 5th centuries AD. Her role in history has been debated over time, but during the last 15 years at least two books have addressed her role from differing perspectives. We formed an interdisciplinary undergraduate seminar that included a group composed of students from the sciences and mathematics to compare two such perspectives. The first of these was the recent contribution by M. A. B. Deakin entitled “Hypatia of Alexandria: Mathematician and Martyr” (published in 2007). We also reviewed the work by M. Dzielska entitled “Hypatia of Alexandria” (published in 1995) which is directly referenced in Deakin’s book. Our efforts focused on differences in the way in which these authors appear to be influenced by their own backgrounds (in mathematics and history, respectively) and the way in which Hypatia’s gender is relevant to the interpretation of her professional contributions. Like a recent historical counterpart in the biological sciences, Rosalind Franklin, we find that a degree of ambiguity is added to the interpretation of Hypatia’s work in accordance with the gender of the author. In addition to developing a comparison of these studies of Hypatia, the seminar provided at least three outcomes for student participants that included 1) linking critical thinking exercises with the peer-review publication process, 2) the opportunity to discuss history and nature of mathematics and science, and 3) discussion of gender issues in relationship to careers in mathematics and science.

Geographic and Seasonal Variation of Reproductive Steroids in the Diamondback Terrapin, Malaclemys terrapin

The diamondback terrapin, Malaclemys terrapin, is the only turtle in North America that exclusively inhabits the brackish environments of bays and estuaries. Studies have examined reproductive steroid levels in several turtle species. This information has been crucial in elucidating certain physiological and ecological aspects such as reproductive activity, stress levels, and sex ratios. In the current study, testosterone and estrogen levels were measured via radioimmunoassay (RIA) of blood samples from two populations of diamondback terrapins. One is a declining population located in the salt marshes of the Patuxent River region of Maryland. The other population is located in the salt marshes surrounding Dauphin Island, Alabama, and has experienced a significant decline from historic levels. Seasonal cycles of reproductive steroids were examined. Adult females showed a gradual decrease in testosterone over the nesting season whereas, adult males showed a gradual increase, peaking in late summer. Estrogen levels over the nesting season will be reported. The results provide insight into the endocrine physiology underlying the reproductive cycle in the terrapin. They also provide information regarding the number of reproducitively active individuals in a population and represent better indicators of maturity than age. A geographical comparison will be conducted to observe variation in steroid levels between two populations that experience different climate regimes. This information will be compared to those of marine and freshwater turtles to better understand how the physiology of the diamondback terrapin has evolved to adapt it to its unique marine niche.
P2.158 COOPER, Ann S.; University of KY; asc1029@hotmail.com
The Effects of Serotonin on Circadian Pattern and Behaviors in Drosophila

It is established that adult Drosophila show circadian patterns that are regulated by gene expression. Circadian cycles in adults can be induced and set by exposure to light as early as the embryo stage without any circadian patterns evident throughout the larval stages. Serotonin is known to have a role in circadian patterns in adult Drosophila as well as many other species. In this study, I addressed if the maintenance of the circadian pattern throughout the larval stages can be modulated by altering the serotonin expression levels in the larva. To approach this I exposed larvae, at various stages, to a drug (p-CPA, 10mg/ml of food) that blocks the synthesis of serotonin and then examined circadian patterns in adults. Adults were tested on 12:12 light:dark cycle and then in continuous darkness. Adult and larval locomotive behaviors were also examined for effects of p-CPA. In order to measure circadian activity patterns I built a device to measure activity of adults as individuals and groups. The results of feeding larvae p-CPA led to a more distinctive circadian pattern, which was contrary to my hypothesis. As adults, the p-CPA fed larvae showed a slower climbing response to light (p<0.05, n=15, T-test). Associative learning assays in larvae showed that p-CPA consumption improved learning. In summary, p-CPA fed larvae had altered circadian patterns and behaviors as adults and larvae. (Funding was provided by Kentucky Young Researchers Program at the University of Kentucky (A.S.C.). Equipment was borrowed from Science Alliance which is part of Partnership Institute for Math and Science Education Reform (PIMSER) Univ. of KY.)

P2.149 COOPER, Robin L.*; BIERBOWER, Sonya M.; Univ of KY; rlcooper@email.uky.edu
EFFECT OF EXERCISE AND ENVIRONMENT ON THE AUTONOMIC RESPONSE IN CRAYFISH, PROCAMBARUS CLARKII

The effects of exercise have mainly been studied in vertebrates. Unfortunately, less work has focused on the varied group of organisms, invertebrates, which have more diverse collections of mechanisms to handle physiological problems associated with locomotion. Crayfish are freshwater crustaceans that reside mostly in water, exit for various reasons (i.e. food, mates, burrowing) and do gas exchange by pulling water over the gills. During periods of stress and physical exercise, crayfish exhibit typical fight or flight responses since they show a sympathetic-like response which appears to increase excitability to sustain physical activity. To meet the increase in oxygen demand due to exercise, a response in both cardiac (heart rate, HR) and respiratory (ventilation, VR) systems are required. Typically, both HR and VR increase in an effort to increase oxygen delivery to target tissues, especially muscles used for locomotion. Crayfish were exercised at normal walking speeds for two, fifteen minute periods. In addition, crayfish were exercised in two environments, aerated (normal) and nitrogen-saturated (oxygen-deficient). The purpose of this study is to examine the effect of intermittent periods of exercise in normal and low-oxygen environments on the HR and VR of crayfish since very few studies focus on the whole animal autonomic response. Preliminary results suggest increases in both HR/VR during the first and second periods of exercise. Crayfish returned close to baseline levels during the first recovery period in both environmental conditions, whereas VR levels remained elevated in the nitrogen-saturated environment during the second recovery period (after the second period of exercise).
P3.24 CORBETT, Alyssa H.; REED, J. Michael*; Tufts University; michael.reed@tufts.edu

Adam and Eve events: is successful population establishment from small introductions a myth?

Although small populations are at high risk of extinction, there are regular reports in the scientific literature of purported small, isolated, persistent populations. One source of evidence of the viability of small populations comes from the successful introduction of species to areas outside their original range. We evaluated 23 purportedly successful establishments of bird populations from deliberate translocation of very few (≤30) individuals that are reported in the scientific and secondary literature. We found that all but 2 of the claims were unsubstantiated, primarily due to a lack of evidence in original sources if the number of birds released and because of supplemental individuals from earlier releases, releases in nearby regions, and natural invasion. Our results support the general theory that small, isolated populations are at high risk of extinction, and they suggest that successful introductions using few individuals is actually rare. Because of the potential misuse of ecological results in land use planning, in particular assuming that small populations of vertebrates are viable, we suggest that a high standard be set for asserting the viability of small, isolated populations.

P1.29 COSTELLO, MJ*; BOXSHALL, GA; BOYKO, CB; HOEG, JT; MARKHAM, J; APPLETONS, W; University of Auckland, Natural History Museum, London, American Museum of Natural History, University of Copenhagen, Arch Cape Marine Laboratory, Flanders Marine Institute; m.costello@auckland.ac.nz

Development of sustainable authoritative online species databases

The internet provides great opportunities for making scientific information available to everybody everywhere. However, the range of information available on the internet can be bewildering for users. Unlike conventional print media, the authority behind the information is often unclear and there is no peer-review, when they were created is often not stated, and they may not be permanently maintained. Personal and institutional web pages may suffer from limited expertise in web page design and information management tools. A more ideal situation is where communities of experts collectively create and maintain online content in a database with long-term professional information support. The European Register of Marine Species created an online inventory of (almost) all marine species in Europe in which each taxon was edited by a peer-selected taxonomic expert. The editors formed the Society for the Management of Electronic Biodiversity Data (www.smebd.eu) to hold this IPR, and they collaborate with the Flanders Marine Institute (Belgium) which acts as the technical manager and host institution. This model has been expanded to create a World Register of Marine Species, with several associated all-taxon regional (European, Antarctic, North Atlantic) and all-environment (not just marine) global (e.g. Porifera, Curnacea, Isopoda) species databases. All species names are centralised in the common host database called Aphia. Editors are sought and invited by SMEBD, and they can directly control the content by editing it online. As the resource develops more editors are required to expand the content and keep it current.

P2.191 COSTANZO, J.P.*; LEE, R.E.; Miami Univ., Oxford, OH; costanzo@muohio.edu

Urea Loading Enhances Freezing Survival and Postfreeze Recovery in a Terrestrially-Hibernating Frog

We tested the hypothesis that urea, an osmolyte accumulated early in hibernation, functions as a cryoprotectant in the freeze-tolerant wood frog, Rana sylvatica. Relative to saline-treated, normouremic (10 mmol l⁻¹) frogs, individuals rendered hyperuricmic (70 mmol l⁻¹) by administration of an aqueous urea solution exhibited significantly higher survival (100% versus 64%) following freezing at -4°C, a near-critical temperature. Hyperuricmic frogs also had lower plasma levels of intracellular proteins (lactate dehydrogenase, creatine kinase, hemoglobin), which presumably escaped from damaged cells, and more quickly recovered neurobehavioral functions following thawing. Experimental freezing/thawing did not alter tissue urea concentrations, but did elevate glucose levels in the blood and organs of all frogs. When measured 24 h after thawing commenced, glucose concentrations were markedly higher in urea-loaded frogs as compared to saline-treated ones, possibly because elevated urea retarded glucose clearance. Like other low-molecular-mass cryoprotectants, urea coligatively reduces both the amount of ice forming within the body and the osmotic dehydration of cells. In addition, by virtue of certain special properties, it may bestow additional protection from freeze/thaw damage not afforded by glucose. Supported by NSF grant IAB 0416750.

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Novel splicing variation of a myostatin-like gene in the decapod crustacean, Gecarcinus lateralis

Alternative splicing of myostatin transcripts is exceedingly rare. Myostatin-like genes have been identified in over one hundred species, but variation in mRNA splicing is only reported to occur in chicken and trout. We recently reported the identification of a myostatin-like gene in the blackback land crab, Gecarcinus lateralis. Sequencing of PCR products generated by rapid amplification of cDNA ends indicates that a single myostatin-like gene in the land crab is the subject of extensive alternative splicing. Clear splicing sites occur within the propeptide domain and 3 untranslated region. Both intron retention and alternative donor/acceptor sites occur alone or in combination to generate unique protein coding sequences that include a complete mature peptide domain. The mature peptide sequence for land crab is greater than 50% identical to that of mammalian myostatins and all nine conserved cysteines are present. At least two splice variants produce frame shifts that introduce premature stop codons in the propeptide domain. Interestingly, alternative splicing in the chicken also produces a transcript that encodes a truncated myostatin protein which lacks the mature peptide. The differential expression of a truncated myostatin-like gene in two disparate species suggests that the expression of a propeptide domain alone could have functional significance. All transcripts exhibit a broad tissue distribution, which suggests that the functional repertoire of the crustacean myostatin is more diverse than that of the mammalian protein. The predominant expression of myostatin-like transcripts in muscle tissue suggests that this TGF- factor plays a role in regulating muscle physiology in crustaceans. Supported by NSF IBN-0618203.
P3.204 COX, Christian L.; *MAKOWSKY, Robert; ROELKE, Corey E.; University of Texas at Arlington; clcox@uta.edu

Determining an optimal sequence divergence for phylogenetic analyses

Determining the appropriate gene for phylogeny reconstruction can be a difficult process. Rapidly evolving genes tend to resolve recent relationships, but suffer from alignment issues and increased homoplasy between distantly related species. Conversely, slowly evolving genes work well for deeper relationships, but lack sufficient variation to resolve recent relationships. We attempt to determine the optimal level of sequence divergence for resolving phylogenetic relationships at different levels using a known phylogeny. We compiled the known phylogeny using well-supported relationships between 28 taxa within the phylum Chordata. Sequences of 7 mitochondrial protein coding genes, 1 mitochondrial ribosomal gene, 2 nuclear protein coding genes and 2 nuclear ribosomal genes were acquired for each taxon, and Bayesian posterior probabilities for the correct nodes were calculated for each gene. Across all genes, we found that 15-25% sequence divergence was optimal for resolving the correct relationships. However, the ability of a gene to resolve the correct relationship varied among gene type, with protein coding genes correctly resolving relationships at very low divergence (less than 15%), while ribosomal genes correctly resolved at greater sequence divergence (20%). This information should be useful for selecting the right gene to clarify intractable relationships, as well as minimizing both cost and confounding information during project design.

P1.113 CRAWFORD, Sherine*; SADDLER, Claudette; CARROLL, Margaret, A.; CATAPANE, Edward, J.; Medgar Evers College, Kingsborough Community College; shanell1207@optonline.net

Effects of Chelating Agents, Calcium Disodium EDTA and Diaminocyclohexanetetraacetic Acid, on Manganese Disruption of Mitochondrial Respiration in Crassostrea virginica

Manganese (Mn) is a metal that at excessive levels in brain produces Manganism which is similar to Parkinsons disease. The mechanism of action of Mn is not completely understood and thought due to decreasing dopamine levels in brain, affecting dopamine receptor activity and producing oxidative stress to mitochondria. Previously, we showed Mn caused a dose dependent decrease in mitochondrial 02 consumption, and p-aminosaliclyc acid (PAS), a drug which alleviate symptoms of Manganism, protected mitochondria against Mn. PAS has anti-inflammatory and chelating abilities. The ability of PAS to ameliorate symptoms of Manganism is thought to be related to its chelating actions. To test this we studied effects of 2 chelating agents, calcium disodium EDTA (EDTAc) and diaminocyclohexanetetraacetic acid (DACH) on mitochondrial respiration the bivalve mollusc, Crassostrea virginica, using a YSI Micro-Biological Oxygen Monitor with a micro-batch chambers. Mn (5 µM - 5 mM) caused dose dependent decreases in respiration. Pretreating mitochondria with 1 mM EDTAc blocked the effects of Mn. Adding EDTAc to Mn treated mitochondria partially reversed the effects of Mn. DACH was not effective in blocking or reversing actions of Mn, and had its own inhibitory effects on respiration. The study shows EDTAc was an effective blocker against the effects of Mn and may be beneficial in reversing the negative effects of Mn accumulations. It also provides evidence the ameliorating effects of PAS on Manganism is likely related to its chelating actions. This work was supported by grants 2R25GM06003-05 of the Bridge Program of NIGMS, 0516041071 of NYSDOE and 0622197 of the DUE Program of NSF.

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An Investigation of the Mechanics of Ventilation and Sliming in Pteraster tesselatus

While the body of Pteraster tesselatus is similar to other sea stars, it is also covered by a supradorsal membrane. The resulting space, the nidamental cavity, can inflate with water and deflate, allowing the sea star to actively ventilate as well as release a defensive slime. Water is pulled into the nidamental cavity through ambulacral pores, located at the junction between the supradorsal membrane and the body wall. During ventilation, water and mucus are expelled through spiracles in the supradorsal membrane and the body wall. During sliming, water is expelled through an opening at the top of the supradorsal membrane, the osculum. During sliming, water and mucus are expelled through spiracles in the supradorsal membrane, rather than the osculum. The goal of this study was to better understand this water pumping system and to identify any variations with size. Histology illustrates the muscles and connective tissue that allows for these changes in pressure.

P3.3 CROSSLEY II, DA*; TATE, KB; EME, J, University of North Dakota, University of California, Irvine, dane.crossley@und.nodak.edu

The impact of periodic dehydration stress on cardiovascular function in the embryonic American alligator (Alligator mississippiensis)

Reptilian embryos are unique among amniotic vertebrates due to a virtual absence of parental care following oviposition in most species and high eggshell permeability in comparison to birds. This reproductive strategy leaves the developing embryo subject to abiotic fluctuations in the surrounding nest environment, such as reductions in gas conductance, hypoxia and bouts of dehydration. These fluctuations can be recurrent during long incubations (~70d for alligators), but their impact on the physiology of developing reptiles is poorly understood. We studied the effects of periodic dehydration events on embryonic alligators, including changes in hemodynamic and blood composition parameters. Dehydration (net 15% loss in egg mass across 60-80% of development) significantly (p<0.05) increased hematocrit (34±2 vs 29±1% rbc), plasma osmotic concentration (361±9 vs 290±2 mOsm/kg), yolk mass (18±1.5 vs 11.1±1.5 g) and ratio of heart to body mass (5.0±0.3 vs 4.0 ± 0.3 mg/g) compared to control embryos at 90% of development. Conversely, mean arterial pressure (1.2±0.2 vs 1.8±0.2 kPa) and embryonic mass 16.9±2.7 vs 32.9±2.7 g were significantly reduced by this stress compared to controls, with no significant difference in embryonic stage. Our findings suggest that dehydration state of the nest environment can dramatically alter the physiology of developing American alligator and may impact hatching survival.
Forkhead gene family in medaka: a view on gene evolution and embryonic expression

Using the genome sequence of the medaka, Oryzias latipes, we examined the genomic complement of Fox genes in this organism to gain insight into the evolution relationship and expression pattern of this gene family. Here we identified 31 Fox genes by searching the Forkhead domain in medaka and by PCR using primers designed from the result of the homology protein alignment. All the medaka Fox genes are encoded in 18 subclasses as follows: 5 Fox genes in subclass D; 3 Fox genes in subclass O; 2 Fox genes in subclass A, B, E, F, G, I, N and P respectively; 1 Fox gene in subclass C, H, J, K, M, Q and R respectively. Together with the Fox protein sequences of human, chicken, frog, zebrafish, C. elegans, the phylogenetic relationship was analyzed and compared. The genes structure, general features and 3 dimensional model of this Fox gene family were also discussed. In addition, we examined the expression pattern of part of these genes in different adult tissues and during embryo development in medaka by using quantitative PCR and in situ hybridization, and the different spatial and temporal expression profiles were found.

Effects of betamethasone on the fetal rectus abdomenus of the guinea pig (Cavia porcellus)

Betamethasone is a corticosteroid often used to stimulate the development of the lungs and initiate the production of pulmonary surfactant proteins of infants. The intent of this project was to examine the effects of betamethasone on the fetal rectus abdomenus, an expiratory muscle of Cavia porcellus. Corticosteroids accelerate tissue and organ development by stimulating cells to stop dividing and start differentiating. Therefore, we hypothesize that the expression of adult myosin heavy chain isoforms (fast: IIa, IIX; slow: I) will be higher in the muscles of treated fetuses. Pregnant guinea pigs were injected twice (0.5 mg/kg maternal weight), twenty-four hours apart at 70% gestation with either betamethasone (treated) or sterile water (control). Rectus abdomenus samples were collected from each treated and control fetus and prepared for SDS-polyacrylamide gel electrophoresis. Aliquots of diluted myosin were electrophoresed for 24 hours at 275V and 8C in a 7% acrylamide, 30% v/v glycerol separating gel. Gels were silver stained, dried, and scanned into a computer. Scion Image was used to quantify the proportions of the adult myosin heavy chain isoforms present within the total myosin of each sample. If increased expression of adult myosin isoforms occurs in the treated rectus abdomenus, these muscles may have contractile properties more similar to adult muscles than rectus abdomenus muscles not exposed to prenatal steroids. Thus, when the steroid-exposed fetuses are born, their breathing muscles will be better able to deal with ventilatory challenges, such as infection, than the muscles of unexposed neonates.
A "Silver Ovipositor" Effect in the Walnut Fly, *Rhagoletis juglandis.*

Variation in the quality of habitats can result in variation in the physiological and morphological traits of animals that develop within them. One potential consequence of this is that the phenotypes of animals from high quality habitats may provide them advantages when it comes to finding, defending and/or utilizing similarly high quality habitats. Such "Silver Spoon" effects can have important population consequences, but are rarely tested for. Here, we test for a silver spoon effect in the walnut fly, *Rhagoletis juglandis.* Previous research has demonstrated that the size of this fly is negatively influenced by the number of larval competitors inhabiting the fruit in which it develops. However, while unused fruit provides the best larval environment, it can be difficult for females to penetrate unused walnut husks and females are frequently observed re-using sites where eggs have previously been laid. We tested whether larger females have an advantage in penetrating surfaces with their ovipositors, thus providing them more opportunities to get their offspring in unused fruit. We demonstrated that larger females are more able to penetrate fruit models, and as a consequence lay more eggs per minute, but fewer eggs per oviposition bout. Such a pattern indicates that some of the variation in size and fecundity seen in this species may be non-genetically inherited via a host-mediated maternal effect.

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**Trail following and tentacle movements in the carnivorous rosy wolf snail, *Euglandina rosea***

A variety of predatory gastropods, including *Euglandina rosea* were introduced to Hawaii and other Pacific islands in a failed attempt to limit the spread of the giant African land snail, *Achatina fulica.* Instead of consuming *Achatina fulica*, *E. rosea* has been implicated in the decimation of many species of endemic island snails. *Euglandina rosea* is native to the southeastern United States, and can follow the mucous trails of its prey. Although experiments have examined food choice, it is unknown if the ability of *E. rosea* to follow mucous trails differs with prey snail species. This study compared the ability of *E. rosea* to follow trails of two groups of gastropods: those found within its local habitat (southeastern USA) and those found outside its native range (Kansas). Each predator (*n = 10*) was tested against a total of 24 individuals from eight species of gastropods (four species from each area) and three individuals of each species. Unlike previous studies, *E. rosea* followed trails in the direction that they were laid. The results of the study indicate that prey gastropods from Florida and Kansas were followed at almost identical frequencies by all ten predators tested. In addition, there were differences in the predators’ inter-tentacle angle between trail following and not-following behaviors.

**P2.132** DE MIRANDA JR., M.A.*; MAYBERRY, J.K.; PEARSON, L.E.; KANATOUS, S.B.; Colorado State University, University of Alaska Anchorage; Jaime.Mayberry@colostate.edu

**Are Skeletal Muscle Adaptations to Diving in Weddell Seals (Leptonychotes weddelli) a Response to Environmental Stimuli?**

The purpose of this study was to determine whether the elevated aerobic capacities in the skeletal muscle of Weddell seals (*Leptonychotes weddelli*) is due to a genetic predisposition or a response to environmental conditions. Cells were harvested from adult Weddell seal longissimus dorsi, the primary swimming muscle. The primary cells were compared to a C<sub>12</sub>12 cell line under normoxic (21% O<sub>2</sub>) and hypoxic (1% O<sub>2</sub>) conditions for six days, as the myoblasts differentiated into mature myotubes. Myoglobin concentrations and aerobic enzyme assays were used to measure skeletal muscle aerobic capacity. We hypothesized that there would be a significant difference between seal and mouse cells under hypoxic conditions. However, we found no significant difference in citrate synthase activity or myoglobin concentrations between the seal and mouse cells under normoxic or hypoxic conditions. This indicates that the adaptations to diving in Weddell seal skeletal muscle are not determined by a genetic predisposition, but are a response to environmental stimuli.

**P3.4** DEATON, L.E.; Univ. of Louisiana at Lafayette; led9784@louisiana.edu

**FMRFamide and 5HT Increase IP3 levels in gastropod hearts**

The hearts of molluscs are myogenic, but the cardiac output is modulated by a variety of classical neurotransmitters and endogenous neuropeptides. Both 5-hydroxytryptamine (5HT) and the molluscan neuropeptide FMRFamide are cardioexcitatory in gastropod molluscs. However, the mechanisms involved in the effects of these agents on the ventricle are poorly understood. To clarify the possible roles of cellular signaling pathways in the excitatory effects of FMRFamide and 5HT on the hearts of molluscs, ventricles were isolated from the marine snail *Melongena corona* and exposed to seawater (SW) or to SW containing either 5HT or FMRFamide for 10 sec. The tissues were then homogenized and assayed for cAMP and IP<sub>3</sub> with commercial kits. The cAMP content of controls was 0.38 pmol/mg wet wt. The cAMP level in 5HT (10<sup>-6</sup> M) and FMRFamide (10<sup>-6</sup> M)-treated tissues was, respectively, 0.42 and 0.47 pmol/mg. Ventricles treated with forskolin (10<sup>-5</sup> M) had a cAMP level of 0.31 pmol/mg. Control ventricles contained 0.13 pmol/mg IP<sub>3</sub>. The level of IP<sub>3</sub> was 0.32 pmol/mg in 5HT-treated tissues and 0.55 pmol/mg in FMRFamide-treated hearts. In addition, phospholipase C caused positive inotropy similar to the effects of 5HT and FMRFamide in isolated hearts. Neither forskolin nor cholina toxin had any effect on the mechanical activity of isolated hearts. These results suggest that the excitation of gastropod hearts by 5HT and FMRFamide involves the activation of the phosphoinositid phosphate cellular signaling pathway, but not the cAMP second messenger pathway.
Molecular markers for studying the distributions of the intertidal ghost shrimp Neotrypaea californiensis and N. gigas

The vigorous burrowing activities of thalassinidean shrimp have such dramatic effects on their soft sediment habitats that these animals have sometimes been considered both ecosystem engineers and keystone species. Because they are such strong interactors, basic information about their life histories and population dynamics is needed to effectively manage the habitats in which they live. These data, however, can only be obtained if the shrimp can be accurately identified. On the west coast of the United States, two species of burrowing intertidal shrimp in the genus Neotrypaea, N. californiensis and N. gigas, are currently recognized (a third species, N. bifani, does not burrow in soft sediments). The two burrowing species are not easily differentiated morphologically except as adult males that bear a master claw (which is often lost in collection), which has led to uncertainty about their distributions. Here we describe and validate (using mtDNA data) allozyme markers that can be scored rapidly and inexpensively for the identification of these species. Surveys using these markers reveal that both species coexist at most sites surveyed in southern California, with some sites dominated by one or the other, but that N. californiensis is heavily dominant to the north of Pt. Conception. We also report on morphological analyses aimed at identifying characters useful for differentiating male, female and juvenile ghost shrimp on the west coast of the US.

Inhibition of the canonical Wnt signaling pathway during craniofacial development: impact on the craniofacial phenotype of Xenopus tadpoles

The head is anatomically the most complex part of the body. Given the complexity of the craniofacial structures, many genes and embryonic tissue sources are known to be involved in their ontogeny. Among other processes, Wnt proteins are implicated in the induction and differentiation of neural crest cells. These cells give rise to most of the craniofacial skeleton and to the peripheral nervous system. As such, many craniofacial defects may originate from abnormal regulation of Wnt signals. We want to examine the implications of the postembryonic Wnt activity in the Xenopus head. Therefore, we tested to what degree inducibly inactivating the canonical Wnt signaling pathway during early development results in skeletal deformations of the cartilaginous skull. Additionally, relations between abnormal development of the central nervous system and the architecture of the cartilaginous brain-case are studied. Our focus lies on two particular aspects: the macro-anatomy of the brain and the craniofacial skeleton. Comparison of the head morphology and histology between wild-type and transgenic tadpoles allows us to investigate and describe the variation of the craniofacial structures, as well as the brain anatomy. Transgenic stage 40 tadpoles were exposed to dexamethasone, activating an inducible Wnt-inhibiting chimeric transgene, and fixed at stage 46. Serial histological sectioning of the craniofacial region was performed. Detailed anatomical 3D analysis of the craniofacial region in the wild-type and the transgenic model organism at stage 46 were carried out, and compared to the wild-type stage 40 phenotype. We aim to find out what modifications are linked to inactivating the Wnt signaling pathway, and to what degree the observed phenotypes reflect a constancy.

Bending regimes of capuchin limb bones

Capuchin monkeys, like many other primates, have a highly versatile locomotor repertoire. We investigated how locomotor versatility influences the loading regimes of distal limb bones by documenting substrate reaction forces (SRF) and 3D limb postures for capuchins moving on a flat substrate (terrestrial), on an elevated pole (arboreal), and performing turns. The SRF vector forms discrepant angles with the forearm and leg, indicating that they are loaded in bending. The bending axes are not in principal anatomical planes but at oblique angles, and frontal plane bending is a major component of the overall bending regime. The bending moments are higher for the leg than for the forearm. The discrepancy angles between the limb segments and the SRF vectors are more variable in simulated arboreal locomotion than in overground locomotion. This confirms the notion that arboreal locomotion is associated with greater variation in long bone loading than terrestrial locomotion. Directional changes of about 30 degrees are also associated with discrepancy angles that vary in orientation. Even at the moderate level of locomotor variation simulated in the lab, bending regimes were found to be variable. Most primate long bone shafts do not have highly biased cross sections that preferentially reinforce one plane, and are therefore well-suited to withstand variable bending regimes. Supported by NSF BCS 0548892

Durophagivores vs. mixed feeders: niche differentiation using stereoscopic dental microwear

Because dental enamel preserves a record of foods recently chewed, the microwear of teeth has long been used to differentiate diets in living and extinct groups of mammals. For this work, I used a stereoscopic low-magnification method to observe enamel use-wear features of 92 species of Paleogene mammals. Most of the species sampled were from the White River Group of the American Great Plains, which are well-studied assemblages that span the Eocene-Oligocene transition. I found previously that despite substantial climatic change during the Eocene-Oligocene transition, the mammals known from the White River Chronofauna overlapped substantially in use wear when sorted into biostratigraphic zones. This work describes a distinct group of “durophagivores” within the ungulates that was recognized based on their differences in use wear with the common browsers and grazers of the time period. The durophagivores or rooters accumulated fewer but heavier scratches and many more pits than seen in more mixed-feeding species. In addition to the durophagivores present in the White River Chronofauna (particularly entelodonts and anthracotheres), I found evidence for abrasive diets in early members of several artiodactyl families and archaic groups such as “condylarths” and tillodonts. Similar evidence of abrasive parts of the diet is seen when comparing the use wear of carnivores that chew bones as opposed to meat specialists that avoid it in their diets. In this case, skeletal elements rather than silica-based grit are likely to have caused their heavy wear. The likely source of dietary abrasion is delimited by considering morphological differences among species’ teeth and the foods that they were likely adapted to comminate.
P.1.125 DORNHOFER, T.M.*; WEIGAND, K.L.; DEAROLF, J.L.; Hendrix College, Conway, AR; dornhoffertm@hendrix.edu

Does fetal betamethasone exposure increase the potential for fatigue in the scalenius muscle of guinea pigs (Cavia porcellus)?

Betamethasone is a corticosteroid, a group of drugs often used to reduce mortality in premature infants. Its effects on breathing muscle development, however, are not well known. Studies have shown that similar corticosteroids significantly reduce the oxidative capacities of adult diaphragm muscle. Based on these studies, we hypothesize that betamethasone will significantly reduce the oxidative capacity of the scalenius. This reduction could have significant ramifications for a fetus exposed to such steroids, reducing the fatigue capacity of the ventilatory muscles. A secondary goal of this project was to see if differences in oxidative capacity can be used to subtype the fast-twitch fibers in the fetal muscles. Guinea pigs were injected with betamethasone (0.5 mg/kg maternal weight) or sterile water twice a week (24 hours apart) for three weeks. After a gestation period of 59 days, scalenus samples were obtained from treated and control fetuses and prepared for muscle histochemistry. Sections of the muscle samples were stained for their NADH-tetrazolium reductase activities to quantify oxidative capacity and counterstained with eosin to highlight fiber margins. Additional serial sections were stained with slow antibodies to locate slow fibers within the sections. Images of stained sections were captured and analyzed using Scion Image, and the mean staining density of a representative sample of fibers was measured. At the time of writing, data collection is insufficient to determine the effects of betamethasone on oxidative capacity. Preliminary data indicate the presence of multiple peaks within a mean density plot of staining densities of the fast-twitch fibers, which suggests that oxidative capacity can be used to subtype these fibers.

P2.196A DILLY, G.F.*; GIRGUIS, P.R.; Harvard University; gdilly@fas.harvard.edu

Exploring the Boundaries of Metazoan Thermotolerance at Hydrothermal Vents: Respiration and Protein Expression of Paralvinellid Worms

Eukaryotic thermotolerance is pushed to its limits at one of the most extreme ecosystems on the planet, deep-sea hydrothermal vents. Temperatures around vent sulfides (or chimneys) range from 2°C to well over 300°C. This wide thermal regime has given rise to some of the most thermally tolerant organisms on earth including the annelid Paralvinella sulfincola. These worms are found at vents on the Juan de Fuca Ridge, in 2200m water depths off the coast of Washington, USA. Paralvinellids are amenable to recovery and shipboard experimentation and can withstand prolonged exposure to temperatures between 5°C and 55°C, one of the largest thermal ranges known.

Our experiments utilize live worms in flow-through chambers at in situ pressure and chemistry that replicate vent conditions. Coupling high-pressure respirometry with tandem mass spectrometry, this work examines oxygen consumption rates and differential protein expression of P. sulfincola and P. palmiformis, maintained under two thermal regimes (30 and 53°C, and 12 and 35°C respectively). Our data suggest that P. sulfincola exposed to 53°C exhibit an up-regulation of proteins involved in maintaining cellular structure and a down-regulation of enzymes associated with energy metabolism. Surprisingly, P. sulfincola exhibited high concentrations of HSP70 in both treatments. We suggest that the continual production of HSPs, as well as an increased synthesis of proteins that confer structural stability allow P. sulfincola to survive exposure to temperatures greater than 50°C. These data provide the first insights into the biochemical factors that enable an organism to exist at the edge of eukaryotic thermotolerance.

P3.165 DICKENS, M. J.*; ROMERO, L. M.; Tufts University; molly.dickens@tufts.edu

Transient disruption in corticosterone negative feedback resulting from captivity

Maintaining wild animals in captivity has long been used for conservation and research. While the potential for causing chronic stress has been widely suggested, how captivity affects the underlying stress physiology is poorly understood. In our study, we used a model species, chukar (Alectoris chukar) to assess the effects throughout ten days of captivity on the corticosterone (CORT) secretory pathway: the Hypothalamic-pituitary-adrenal (HPA) axis. Specifically, we were interested in the changes in negative feedback sensitivity along the axis since many studies have linked chronic stress to a disruption in CORT secretion feedback. To test changes in negative feedback we used two approaches. In one experiment, we restrained the individuals for 15 minutes in a cloth bag and then injected, intramuscularly, a synthetic glucocorticoid, dexamethasone (DEX), to stimulate negative feedback and sampled for CORT 30 minutes after the injection. In the second experiment, we restrained individuals for 30 minutes and then returned them to the aviary, thus ceasing the stressor, and allowed 30 minutes without disruption before sampling for CORT. In both experiments the strength of negative feedback (as indicated by the decrease in CORT over the 30 minutes) decreased by day 5 but was regained by day 9. We concluded that introduction into captivity shifted the chukar into a state of chronic stress; however, the observed alterations to negative feedback began to recover by day 9. Also, since the patterns of disrupted negative feedback across the days of captivity, as determined by DEX stimulation, corresponded to the pattern seen while using stressor cessation (natural negative feedback), these data demonstrate the validity of using the DEX suppression test as an indication of negative feedback disruption.

P2.192 DOHERTY, AH*; VINYARD, CJ; NEOUCOM; ahdoherty@gmail.com

A cross-sectional analysis comparing woodchuck (Marmota monax) skeletons before and after hibernation

Long periods of inactivity in most mammals result in significant bone loss that may not be completely recoverable during an individuals lifetime regardless of changes in activity. Prolonged inactivity is the norm for hibernating animals, but it is unknown whether they suffer from adverse bone health after hibernation that affects their ultimate survival. We examined woodchuck (Marmota monax) skeletons using computed tomography (CT) to test the hypothesis that bone cross-sectional area and density is lost during hibernation due to prolonged inactivity. Museum specimens were grouped into pre- and post-hibernation samples based on the collection date, approximating time of death, from museum records. CT scans were taken at the diaphyses and distal metaphyses of the tibia and femur and through the midline of the fourth mandibular premolar. We analyzed scans using Image J and XCT540 to measure bone cross-sectional area, density, and biomechanical indices of pre- and post-hibernation specimens and compared the two groups using ANOVAs. Initial results from the size-adjusted diaphyses of the two long bones suggest that there is no significant loss of bone during hibernation. In fact, indications of bone formation were evident in that absolute values of femoral cortical diaphyseal area (p=0.014), femoral cortical density (p=0.047), and tibial cortical density (p=0.009) were significantly larger in the post-hibernation sample. Given that our sample included a percentage of yearlings, we speculate this absolute increase in bone parameters relates to continued growth during hibernation. While these results suggest woodchucks have derived mechanisms for maintaining bone health during hibernation, longitudinal studies are underway to identify which aspects of bone metabolism regulate the skeleton in hibernating woodchucks.

P1.125 DORNHOFER, T.M.*; WEIGAND, K.L.; DEAROLF, J.L.; Hendrix College, Conway, AR; dornhoffertm@hendrix.edu

Does fetal betamethasone exposure increase the potential for fatigue in the scalenius muscle of guinea pigs (Cavia porcellus)?

Betamethasone is a corticosteroid, a group of drugs often used to reduce mortality in premature infants. Its effects on breathing muscle development, however, are not well known. Studies have shown that similar corticosteroids significantly reduce the oxidative capacities of adult diaphragm muscle. Based on these studies, we hypothesize that betamethasone will significantly reduce the oxidative capacity of the scalenius. This reduction could have significant ramifications for a fetus exposed to such steroids, reducing the fatigue capacity of the ventilatory muscles. A secondary goal of this project was to see if differences in oxidative capacity can be used to subtype the fast-twitch fibers in the fetal muscles. Guinea pigs were injected with betamethasone (0.5 mg/kg maternal weight) or sterile water twice a week (24 hours apart) for three weeks. After a gestation period of 59 days, scalenus samples were obtained from treated and control fetuses and prepared for muscle histochemistry. Sections of the muscle samples were stained for their NADH-tetrazolium reductase activities to quantify oxidative capacity and counterstained with eosin to highlight fiber margins. Additional serial sections were stained with slow antibodies to locate slow fibers within the sections. Images of stained sections were captured and analyzed using Scion Image, and the mean staining density of a representative sample of fibers was measured. At the time of writing, data collection is insufficient to determine the effects of betamethasone on oxidative capacity. Preliminary data indicate the presence of multiple peaks within a mean density plot of staining densities of the fast-twitch fibers, which suggests that oxidative capacity can be used to subtype these fibers.
Food Restriction Inhibits Growth Rate but Not Expression of Hepatic IGF-I Message in Yarrows Spiny Lizard, Sceloporus jarrovii

The growth hormone/insulin-like growth factor-1 axis is the central growth regulatory axis in vertebrates, and nutrition is a major regulator of this axis. In particular, the growth-promoting actions of GH are primarily mediated by IGF-I. To determine the effects of nutrition on growth and the expression of hepatic IGF-I message, captive male and female Sceloporus jarrovii were fed diets of high food (3 crickets/d) and low food (1 cricket/d) availabilities for a 10-week treatment period. We predicted that food restriction would inhibit growth and decrease the expression of hepatic IGF-I message in comparison to high food availability. In the present study, food restriction inhibited growth rate by about 50% in snout-vent length (SVL) and decreased mass of fat bodies relative to high food availability. At the conclusion of the treatment period, levels of plasma corticosterone (B) did not differ between treatment groups, but the low-food group had higher production of basal B in adrenocortical cells relative to the high-food group. Taken together, these data demonstrate that food restriction did not chronically stress animals in either treatment group. Furthermore, food restriction did not decrease the relative expression of hepatic IGF-I message compared to high food availability. Although differing levels of available nutrition led to dramatic differences in growth between treatment groups, these results indicate that the food regimen in this study was not sufficient to elicit a response that would negatively regulate the GH/IGF-I axis at the level of hepatic IGF-I message. Future studies will need to be designed such that the nutritional treatment produces a negative energy balance. Supported by NSF (IBN 0135167 to HBJ-A).
P2.83 Dwyer, Laurel A*; Landberg, Tobias; University of Connecticut; lauriel.dwyer@uconn.edu

Feather Growth Bars Do Not Predict Nutritional Status in Nestling Eastern Bluebirds

Ptilochronology is a method of determining nutritional status in adult birds by measuring the width of growth bars on their feathers. The width of a pair of adjacent light and dark growth bars represents the amount of growth during a 24-hour period. Thus, ptilochronology assists in providing a complete record of the daily nutrition of a bird during the growth of the feather.

Ptilochronology has been validated in the induced feathers of many species of adult birds, but a recent study suggests that this technique may not be applicable to first developed wing feathers in nestlings. To further investigate this finding, we performed an experiment with Eastern Bluebird (Sialia sialis) nestlings in which we examined the relationship between the width of the feather growth bars on two developing wing feathers of chicks and other measures of their growth, including wing length, tarsus length, and body mass. We predicted that if the method of ptilochronology is applicable to nestling bluebirds, a significant correlation between daily growth and the width of the growth bars on these feathers would exist. However, we found no correlation between the measures of growth and the width of the feather bars. Furthermore the bars were found to be approximately half the width that was expected for a 24-hour period based on daily growth rates of the feathers themselves. Thus, our data support previous findings in nestlings of other species, suggesting that ptilochronology may not be a reliable method in determining nutritional status in nestlings.

P1.3 Echeverry-Galvis, M.A.; Princeton University; mechever@princeton.edu

Breeding and molt in Neotropical bird communities

The temporal regulation of key events, such as molt and reproduction in the life cycle of individual birds requires highly sensitive internal mechanisms that can respond to variations in environmental conditions. For most tropical high-altitude species little information is available regarding the annual regulation of molt and reproduction. I surveyed breeding and molting periods of various bird species found at 2700-2900 meters altitude in four patches of cloud mountain forest of different sizes in Colombia. I used laparotomies to determine breeding condition, and scored molt in flight and contour feathers in 775 individuals. Weather conditions and resource availability were monitored. Breeding occurred on a seasonal basis with individuals fully regressing their gonads at different times of year. In the two big areas (larger than 800ha) breeding seemed to be bimodal with a hiatus of about 4 months, while in the small areas (smaller than 15ha) breeding was unimodal. Breeding periods were correlated with increased resource abundance (insects and flowers) as well as photoperiodic conditions in different areas. Molt was not restricted to the post-breeding period in any area, overlapping with enlarged gonads. Like breeding, molt occurred earlier in males than in females. Molt periods were correlated with ambient temperature, photoperiod and insect abundance. Molt/breeding overlap was more common in the small compared to the big areas, and was present in 46% of all species. These data raise questions about the ecological factors and the physiological mechanisms that allow these two events to occur simultaneously in certain species. Current studies are investigating the hormonal profiles of individuals that show molt/breeding overlap to understand the proximate factors that are at the basis of this phenomenon among Neotropical cloud mountains birds.
**P3.94 ELLISON, J.A.; TURMELLE, AS; MENDONCA, MT; MCCracken, GF; RUPPRECHT, CE, Auburn Univ., Univ. of Tennessee, Centers for Disease Control and Prevention; ellj1@auburn.edu**

**Interleukin 2 expression in the big brown bat Eptesicus fuscus**

Bats have recently been recognized as hosts and vectors to a variety of emerging pathogens but very little is known about their immune system. As part of a larger study to investigate susceptibility of big brown bats (Eptesicus fuscus) to rabies virus infection, we evaluated expression of interleukin-2 (IL-2) in a standardized in vitro assay, to measure immunocompetence in individual big brown bats. IL-2 is necessary for the development of T-cell immunologic memory, and the expansion of antigen-specific T cell clones, but only partial cDNA sequences are available for any bat interleukins. We compared IL-2 gene sequences in GenBank from 16 different mammalian species and found several regions that were 78-80% conserved, from which degenerate forward and reverse primers for RT-PCR were designed. Concanavalin A (ConA), a T-cell mitogen which specifically induces IL-2 production, was used to stimulate in vitro expression of IL-2 in whole blood samples from big brown bats. Total RNA was extracted from stimulated whole blood cells, and sequence data from amplified products shared 85% identity with reference IL-2 sequences. The proposed bat IL-2 sequences most closely resembled those found in humans (Homo sapiens). A semi-quantitative RT-PCR analysis detected dose-dependent induction of IL-2 message from white blood cells in response to ConA stimulation, whereas IL-2 expression was not detected from un-stimulated controls. This is the first study to investigate the IL-2 gene expression response in chiropteran hosts.

**P2.193 ELNITSKY, M.A.*; BENOIT, J.B.; DENLINGER, D.L.; LEE, R.E.; Mercyhurst College, Ohio State University, Miami University; melnitsky@mercyhurst.edu**

**Desiccation tolerance and drought acclimation in the Antarctic collembolan Cryptopygus antarcticus**

Within the maritime Antarctic, arthropods may be challenged by drought stress during both the austral summer, due to increased temperature, wind, and periods of reduced precipitation, and winter, as a result of the lower vapor pressure of the surrounding icy environment. The purpose of the present study was to assess the desiccation tolerance of the Antarctic springtail, Cryptopygus antarcticus, under conditions characteristic of the Antarctic Peninsula, and examine the physiological effects of mild drought acclimation on the subsequent desiccation tolerance. Under ecologically-relevant desiccating conditions, springtails lost water at all relative humidities below saturation (100% relative humidity - RH). However, slow dehydration at high relative humidity dramatically increased the desiccation tolerance of C. antarcticus. A mild drought acclimation at 98.2% RH further increased the springtails desiccation tolerance. Drought acclimation was accompanied by the accumulation of several sugars and polyols that would function to stabilize membranes and proteins during dehydration. The springtails were also susceptible to desiccation at subzero temperatures in equilibrium with the vapor pressure of ice; springtails lost ~40% of their body water over 28 d when cooled to -3.0°C. The concentration of solutes in the remaining body fluids as a result of dehydration, together with the synthesis of several osmolytes, depressed the melting point to approx. -2.2°C, and may therefore allow C. antarcticus to survive much of the Antarctic winter in a cryoprotectively dehydrated state.

**P3.5 EME, J.; CROSSELY II, DA; HICKS, JW; U Cal Irvine, U N. Dakota; jeme@uci.edu**

**Hemodynamics of embryonic Alligators**

Embryonic reptiles and birds as well as fetal mammals have cardiac morphologies that allow mixing of oxygenated and deoxygenated blood (cardiac shunts). This anatomical arrangement is common in developing vertebrates, but the significance of cardiac shunts in embryonic reptiles is unclear. Given hypoxic nest conditions of embryonic reptiles, impacts of vertebrates, but the significance of cardiac shunts in embryonic reptiles is (cardiac shunts). This anatomical arrangement is common in developing morphologies that allow mixing of oxygenated and deoxygenated blood.

**P3.80 EEMERA, D.; WAGNER, G.P.; Yale University; deena.emeram@yahoo.com**

**Molecular evolution of MER-39 and consequences on the evolution of menstruation in primates**

Menstruation only occurs in species that exhibit spontaneous decidualization of the endometrial stroma: namely, anthropoid primates and some bat species. The adaptive significance of spontaneous decidualization is unknown, although some have suggested that it evolved to protect the uterus from a deeply invasive primate placenta. To understand the causes of spontaneous decidualization in anthropoids, this study investigates the evolution of transcriptional regulation of prolactin, a well-known marker of decidualization. It is hypothesized here that decidual genes like prolactin have become more responsive to luteal phase signals in the primates that menstruate. It was previously reported that human decidual prolactin is regulated by an alternative promoter that occurs in a primate-specific transposable element: MER-39. To investigate the consequences of the MER-39 insertion on prolactin expression, the taxonomic distribution of MER-39 was first investigated by PCR and BLAST searches. Contrary to what was previously reported, MER-39 inserted upstream of prolactin prior to the diversification within Euarachontogillae, as we found the element in rodents and primates. The evolution of transcription factor binding sites (TFBS) within MER-39 was also investigated. A number of changes in potential and experimentally verified TFBS occurred in the stem lineage of the anthropoids, the clade in which menstruation first appears. These TFBS include those for PR, ETS-1, C/EBP, and FOXO1, proteins that are present and active in the luteal phase of the menstrual cycle. The impact of MER-39 TFBS evolution on prolactin expression is also investigated by functional tests comparing the kinetics of reporter gene expression driven by anthropoid and non-anthropoid prolactin promoters.
Effects of multiple abiotic stressors on microcrustaceans, Gammarus spp. and Artemia spp., in light of ozone depletion

Many aquatic ecosystems, including lakes, ponds, marsh, and inter-tidal regions, are very clear waters, which expose the organisms living in these waters to high levels of solar light, including UV radiation. These systems are especially susceptible to climate change, as they are directly influenced by atmospheric (UV) and terrestrial (runoff and anthropogenic inputs) ecosystem components. UV has been shown to play a critical role in these systems and have significant effects on aquatic organisms. Small freshwater organisms, such as microinvertebrate crustaceans (zooplankton) that inhabit these systems, are highly susceptible to damage from any environmental stresses, particularly UV. This project investigates the comparative effects of variable UVA and salinity on two related microcrustaceans from marine and freshwater systems, Gammarus spp. and Artemia spp. Reproductive success of both species is correlated to both UVA exposure during maternal development and overall salinity of the environment. Understanding the interaction of abiotic stressors on aquatic invertebrates is critical during this time of rapid environmental changes. Species likely must develop adaptable fitness across their populations in order to survive these highly variable environmental factors. This will lead to new ecological and evolutionary methodologies when considering species survival beyond their current habitat.

Don’t put all your eggs in one basket: Growth, self-maintenance, and fledgling survival in Savannah sparrow (Passerculus sandwichensis) chicks raised in experimentally manipulated broods

Early environmental conditions can have profound and long-lasting effects on the life history trajectory of an organism. Individuals face tradeoffs as they allocate available energy to the competing demands of growth and self-maintenance, and poor environmental conditions may compromise both physiological and life history traits. We manipulated brood size in a wild population of Savannah sparrows (Passerculus sandwichensis) nesting on Kent Island, New Brunswick, Canada, to create reduced (2-chick) and enlarged (6-chick) broods in order to alter food availability via intra-nest competition. Chicks were moved between nests at age 2 days, and we collected a blood sample and measured wing length, tarsus length and weight at age 7 days. We recaptured fledglings 3-6 weeks post-hatch to collect a second blood sample. Compared with reduced-brood and control chicks, enlarged-brood chicks had shorter wings (P=0.01) and lower weights (P=0.05) at age 7 days. Nestlings were recaptured as fledglings in a higher proportion from reduced broods (42%) than from either control (22%) or enlarged (11%) broods (P=0.04). Preliminary analysis suggests that catalase activity, a measure of investment in self-maintenance, did not differ between groups but was positively correlated to day 7 weight (P=0.04). We will also present data on lipid peroxidation and telomere length, but our initial results suggest that chicks allocate energy to self-maintenance rather than growth when faced with limited resources in the wild, and this size reduction may lower chances of survival to independence.

Correlations of bone strain, jump performance and limb kinematics in frogs and toads

During locomotion, the magnitude and regime of loads on limb bones can be influenced by modifications of limb posture. In frogs, jumps of similar overall performance (e.g., take-off velocity) show variable magnitudes of limb bone loading during jumping in frogs, we collected high speed video of bullfrogs (Lithobates catesbeianus (Rana catesbeiana)) and cane toads (Chausus (Bufo) marinus) during jumps in which we simultaneously recorded bone strains, and regressed strain magnitude values on several kinematic and performance variables. Despite a large range in strain magnitude in each species, few individuals showed correlations between magnitudes of peak longitudinal strain and values of performance and kinematic variables at the time of peak longitudinal strain (e.g., maximum velocity and acceleration, and angles of femur retraction, femur adduction, knee, ankle, tarsometatarsus, and metatarsophalangeal joints). This suggests that unlike many other species previously examined, variation in strain magnitude is not strongly influenced by limb position. Instead, strain magnitudes are commonly correlated with the rate of loading. (Supported by the NSF IOB - 0517340)

Effects of habitat quality on maternal investment in two Georgia populations of Gopherus polyphemus

Food for Gopherus polyphemus hinges on diversity of burn influenced herbaceous ground cover. 2 populations with different burn regimes were studied. Fort Stewart Army Reservation (FSAR) is frequently burned, George L. Smith State Park (GLS) is infrequently burned. FSAR females are significantly larger & produce significantly larger eggs & hatchling masses. Females at GLS might be sacrificing size & the potential of larger clutches to start reproduction earlier. Our objective was to examine the change in maternal investment between sites & its affects on the hatchling growth & survivorship. Female tortoises were collected from May-July (2007, 2008), measured, X-rayed, & examined to determine clutch size. X-rays from 07-08 were measured to obtain egg size, female size, & pelvic opening. 8 nests in 07 were located at each site & temperature dataloggers were set to measure incubation conditions. Eggs were allowed to incubate in the field for the majority of development. During 08, 2 nests from GLS and 6 nests from FSAR were monitored in the same manner as 07. During 08, 1 egg from each nest was removed for component analysis. Hatchlings from 07 were given equivalent resources & measured bi-weekly for 1 yr to obtain growth rates. Females from both locations appear to be investing equivalent amounts of energy into reproduction in proportion to body size. Measurements from X-rays demonstrate females from both locations are constrained by pelvic size & are produce eggs as large as possible for body size. Hatchlings from both locations had similar growth rates, indicating that observed phenotypic plasticity is due to habitat quality. So far, variables measured indicate that habitat quality is leading to different reproductive patterns in the 2 populations of G. polyphemus.

Correlations of bone strain, jump performance and limb kinematics in frogs and toads

During locomotion, the magnitude and regime of loads on limb bones can be influenced by modifications of limb posture. In frogs, jumps of similar overall performance (e.g., take-off velocity) show variable magnitudes of limb bone loading during jumping in frogs, we collected high speed video of bullfrogs (Lithobates catesbeianus (Rana catesbeiana)) and cane toads (Chausus (Bufo) marinus) during jumps in which we simultaneously recorded bone strains, and regressed strain magnitude values on several kinematic and performance variables. Despite a large range in strain magnitude in each species, few individuals showed correlations between magnitudes of peak longitudinal strain and values of performance and kinematic variables at the time of peak longitudinal strain (e.g., maximum velocity and acceleration, and angles of femur retraction, femur adduction, knee, ankle, tarsometatarsus, and metatarsophalangeal joints). This suggests that unlike many other species previously examined, variation in strain magnitude is not strongly influenced by limb position. Instead, strain magnitudes are commonly correlated with the rate of loading. (Supported by the NSF IOB - 0517340)

**Developing a Comprehensive Long-term Database on Nesting Beach Temperatures of the Loggerhead Sea Turtle in the Southeastern U.S.: Applications and Implications for Global Climate Change**

One of the world's largest loggerhead populations nests in the southeastern United States. Loggerheads have temperature-dependent sex determination (TSD) which has implications for their ecology and conservation. The IPCC indicates that global surface temperature has significantly increased during the last century, and the impact on species with TSD is uncertain. The current study is a long-term evaluation of nesting beach temperatures throughout the range of loggerheads in the southeastern U.S. During the last five years, beach temperatures were simultaneously examined from South Carolina to Alabama (including 23 nesting beaches in Florida) using data loggers buried at mid-nest depth (40 cm). The results reveal the range of beach temperatures throughout the population and provide insight on hatching sex ratios. Overall beach temperatures suggested female-biased sex ratios. The temperature data were examined relative to previously published data on the pivotal temperature and transitional range of temperatures (TRT) for loggerheads. The results suggest many beach temperatures are above the pivotal temperature and some are near the upper limit of the TRT. Although loggerheads may be able to adapt behaviorally or physiologically to increased environmental temperatures, future increases in nesting beach temperatures could result in extreme female biases. (This research was supported by the Florida Sea Turtle License Plate Grant Program)

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**Synchrotron x-ray imaging reveals tracheal system response to hypoxia in the tobacco hornworm, Manduca sexta**

Some insects are able to tolerate very low levels of oxygen by increasing tidal volume and breathing frequency. Tobacco hornworm caterpillars also tolerate extreme hypoxia. However, the mechanism of ventilation is unknown in caterpillars, because they do not show abdominal pumping and lack air sacs. Preliminary data showed that caterpillars in 3-5% oxygen exhibit rhythmic body contractions. To test the hypothesis that these movements are related to breathing, we used synchrotron x-ray imaging in conjunction with high-speed respirometry to document tracheal system compression as it correlates with body movements and gas exchange in these caterpillars. We found that caterpillars do not show tracheal system compressions in normal air and carbon dioxide emission is not correlated with any particular body movement. However, in hypoxia, tracheae rhythmically compress, and the tracheal compressions are highly correlated with external body movements and carbon dioxide emission peaks. To further test the hypothesis that these external movements are driving gas exchange and not just an artifact of x-ray exposure, we performed a similar experiment in the lab using high-speed respirometry in conjunction with videography. We again found a high correlation between body compressions and carbon dioxide emission peaks. These data support the hypothesis that caterpillars use ventilatory movements to breathe in low oxygen. While caterpillars are not likely to experience hypoxia in nature, caterpillars may experience low internal oxygen during exercise, at high altitude or near the end of an instar when gas exchange is more difficult.

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**Mathematical analysis of Betta Splendens display behavior**

Aggressive behavior amongst male animals of the same species is common. This aggression often manifests in threatening displays, violence, or both. The Siamese fighting fish, Betta splendens, for instance, are well known for their aggressive behavior that is often triggered by sight alone. Inspired by the elaborate displaying behaviors of these fish, I used probabilistic tools to describe and analyze male-male, male-female and male-mirror (self) encounters. My initial observations allowed me to categorize twelve distinct and consistent behaviors that occur during aggressive displays between these fish and summarize them in an ethogram. I then recorded and analyzed confrontations, translating the observed displays into behavioral sequences. With this data I have been able to create first-degree Markov chains, showing the likelihood of each fish's next behavior based on its current behavior. Furthermore, in the case of male-male interaction, I have used my data to show the probability of each fish's next behavior based on both its own current behavior, as well as the current behavior of the other fish. In determining these various probabilities, three major behavioral patterns seemed to have emerged, which I chose to describe as aggressive, passive, and defensive.
Behavior and Home Range of the Arctic Ground Squirrel

Behavior of free-living male arctic ground squirrels (Spermophilus parryii) (AGS) was observed near the Alaskan Brooks Range during the summer months of July and early August in 2007 and 2008 to quantify aggressive, foraging and caching behavior. In 2008, home range (HR) boundaries and locations of aforementioned behaviors were also observed. HR use expanded during early and mid July, centralizing around a burrow in late July and early August. Total HR of the males was smaller than expected. This difference was attributed to the rigid territories males defend and the limiting burrow space. While others have noted little to no aggression among males during July, our behavior observations and assessment of physical condition suggest aggression occurs consistently throughout July within areas of HR overlap. The intensity of the interactions increased following the second week of July around the time males began accumulating food caches. It has been noted that hibernators will undergo a period of hyperphagia to increase fat mass needed for hibernation. In the current study, foraging time increased from July to August, but decreased in proportion to time above ground correlating with increased time spent protecting a cache and engaging in aggressive interactions. The arctic poses unique constraints to AGS. A short active season results in a shortened breeding season as compared to more temperate zone hibernators and thus, males must accumulate a cache in the fall to allow them to end heterothermy and become reproductively active in early spring. We hypothesize that the presence of a cache and limited number of hibernacula account for the persistent territorial aggression observed in male AGS. These constraints also appear to drive the majority of HR and foraging behaviors.

Dehydration Tolerance in the Rusty Crayfish (Orconectes rusticus)

Orconectes rusticus is a species of crayfish frequently found in rocky-bedded streams and rivers. Although adapted to an aquatic environment, O. rusticus does occasionally make terrestrial excursions, and may need to do so in situations such as when waterways dry and where rocky beds inhibit effective burrowing. During these terrestrial movements, O. rusticus may be at considerable risk of dehydration. In this study, we examined the desiccation tolerance of O. rusticus of various sizes to determine the ability of these crayfish to cope with dehydration. Loss of righting response (LRR) occurred when crayfish had lost 9.16 +/- 0.36% of their total body mass and 11.89 +/- 0.47% of their estimated body water contents. Hemolymph osmolality increased linearly with mass loss during desiccation, from ca. 470 mOsm to 800 mOsm at mean LRR. Larger crayfish had overall higher rates of evaporative water loss than did small crayfish, but had longer estimated survival times under dehydrating conditions. Our findings suggest that O. rusticus, like most crustaceans, is relatively intolerant of dehydration, and rely primarily on avoidance of desiccating conditions as protection from dehydration. Most terrestrial activity likely occurs during periods of relatively low temperatures and high humidities, when risk of dehydration is minimized. Moreover, it appears that only larger individuals may be capable of prolonged overland forays.
P2.69 FISH, F.E.*; TIMM, L.L.; MURRAY, M.M.; HOWLE, L.E.; West Chester Univ., U.S. Naval Academy, Duke Univ.; fish@wcupa.edu
Ecological morphology of the flippers of cetaceans based on two-dimensional geometry

The pectoral flippers of cetaceans are mobile control surfaces with a wing-like morphology that are associated with the ecology of these aquatic mammals. The flippers contribute to lateral turning, diving, surfacing, braking, trim control, and reduction of recoil from propulsive movements. Biomechanically, the flippers are subjected to flows in water, which must be controlled by the flipper geometry to reduce drag and produce lift. The flippers of 36 species from 9 taxonomic families of cetaceans were analyzed with regard to body length, body mass, flipper span, and flipper area. Body mass of cetaceans was measured directly or estimated from body length. Both flipper span and area increased isometrically with body mass with exponents of 0.32 and 0.66, respectively. The humpback whale (Megaptera novaeangliae) and the right whale (Eubalaena glacialis) had larger flipper areas for their size than expected, whereas the sei whale (Balaenoptera borealis) had smaller flippers than expected for its size. The aspect ratio, span squared divided by area, and the flipper loading, animal weight divided by flipper area, were calculated as indicators of shape and functionality, respectively. To compare species, the effects of size were removed by using principal-components analysis. In general, cetaceans with low loadings are inshore and coastal species that specialize on fish prey, whereas high loadings are found in cetaceans that feed on cephalopods or crustaceans. High aspect ratio flippers are associated with pelagic species. The cetaceans show a broad range of flipper shapes, which reflect different operational habitats and prey types.

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Increased territorial responses in urban populations of two Sonoran Desert birds: Hormones or Ecology?

In many birds, the onset of breeding is marked by territory establishment and its subsequent defense from conspecific intrusion. Territories may be defended for various reasons including the monopolization of spatially limited resources. These resources can vary between habitats, which in turn may influence territorial behavior. We measured the territorial behavior of male Curve-billed Thrashers, Toxostoma curvirostre, and Abert’s Towhees, Pipilo aberti, belonging to urban and rural Arizona populations through direct observation of birds in response to conspecific song playback recordings. Corticosterone (CORT) has been associated with avoidance behavior in some species. In circulation, most CORT in birds is reversibly bound to corticosterone binding globulin (CBG) and this interaction presumably mediates the amount of free (unbound) hormone available to interact with cellular receptors. We measured total and estimated free plasma CORT concentrations in urban and desert thrashers and towhees and correlated these concentrations to behavioral responses to song playback. We also measured population densities of the two species in urban and rural areas as it may influence aggressive interactions between conspecifics. Both urban thrashers and towhees were significantly more aggressive than desert conspecifics but this difference was not related to total or free plasma CORT or to differences in population density between habitats. These results will be discussed in the context of the effects of urbanization on behavior and endocrine physiology.

P2.183 FORD, C. F.*; VANDENBROOKS, J. M.; HARRISON, J. F.; Arizona State University; colleen.ford@asu.edu
Parabolic Effects of Atmospheric Oxygen on Body Size, Development Time, and Growth Rate in Zophobas morio, the Giant Mealworm

Changes in atmospheric oxygen over evolutionary time have been hypothesized to be important in controlling maximal insect body size. Previous investigations using fruit flies and mealworms have shown that decreases in atmospheric oxygen cause linear decreases in body size. Hyperoxia (40% oxygen) has had no effect or slightly increased size in these species, but it is unclear whether the relationship between oxygen and size above 21% is linear, parabolic, or flat. We measured the effect of rearing oxygen level (10, 21, 25, 30, 40, and 60%) on the growth and development of Zophobas morio (the giant mealworm) in both solitary and crowded conditions. Atmospheric oxygen had a strong parabolic effect on body size, growth rate and development time on individually reared mealworms, with the optimal oxygen level being 30%. At 30% oxygen, these mealworms grew the fastest, reached the largest size, and attained adulthood in the least time. These data suggest that at oxygen levels below 30%, oxygen delivery limits metabolism and growth, while at higher oxygen levels, oxidative stress inhibits growth. One factor in studying the effects of oxygen on development in mealworms is that it is known that they have higher juvenile hormone levels, additional juvenile instars, and reach larger sizes when reared under crowded conditions. So the question becomes - Do crowding and high oxygen together produce superworms, or are similar maximal sizes obtained when crowding and hyperoxia are combined? Crowded mealworms were larger at 10, 21 and 40% oxygen, but had sizes statistically indistinguishable from solitary mealworms at 25, 30 and 60% oxygen, suggesting that hyperoxia and juvenile hormone are not additive effects, but may affect mealworm development by a similar mechanism. This research has been funded by NSF IBN 0419704 and DOD 3000654843.
P2.10 FORMBY, K. J.*; HO, W. W.; TURNER, C. R.; SMITH, G. T.; University of Wisconsin - Whitewater, Indiana University; formbykj@uww.edu

Sexually Dimorphic Communication Behaviors in Sternarchogiton nattereri

The electrocommunication signals of electric fish differ across individuals, species, and sexes. Each individual emits an electric organ discharge (EOD) at a relatively stable frequency (EODf) that can serve as an indicator of sex or species. Individuals modulate their EOD, to produce chirps and gradual frequency rises (GFRs) that serve as social signals. Although EOD frequency, waveform, and modulations have been studied in many species (Turner et al. 2007; Hopkins, 1988; Kramer et al. 1981), sex differences in these behaviors have been studied in only four apteronotid species, three of which belong to a single genus, Apteroropinus. To further examine sex diversity in the sexual dimorphism of electrocommunication signals, we examined sex differences in EODs and chirping in Sternarchogiton nattereri. We recorded each fish while they were presented with an array of sinusoidal stimuli (+5Hz, 20Hz, 150Hz) relative to the fishes EODf. These stimuli encompassed the species-specific range of EODf. S. nattereri responded robustly to playback stimuli. EODf, chirp duration, and chirp rate were sexually monomorphic. However, S. nattereri males produced chirps with a greater amount of frequency modulation than those of females. Combined with previous studies on sex differences of electrocommunication signals in other species, our data suggest that sex differences in chirp structure (FM and/or duration) are relatively widespread in apteronotids, but that the magnitude and/or direction of sex differences in EODf and chirp rate vary considerably across species.

P2.11 FOSHA, K. R.*; DZIROWSKI, E. M.; University of North Texas, Denton; University of North Texas, Denton; katie.fosha@gmail.com

Developmental physiology of the gut as an air breathing organ during hypoxia-rearing in the suckermouth catfish, Hypostomus plecostomus

Hypostomus plecostomus are facultative air breathers, switching to aerial breathing when exposed to the low oxygen conditions (hypoxia) that commonly occur in their habitat. Digestive tract modifications, such as a thin blood-air barrier associated with numerous capillaries running close to the stomach lining, allow the gut of these fish to be used as an efficient accessory respiratory organ. While much is known regarding adult H. plecostomus, little is known about the maturation of this air-breathing organ (ABO) in juveniles throughout early development. Initial hypoxia tolerance tests determined that loss of righting occurred at approximately 20mmHg in juvenile H. plecostomus without access to air. In response to acute hypoxia (60 and 98 mmHg O2), adult fish relied almost entirely on aquatic respiration. In contrast, juvenile H. plecostomus took between 10 and 40% more aerial breaths per hour during hypoxic exposure than did adult fish. Due to these observed differences in breathing rates per hour based on H. plecostomus mass, fish have been evaluated for simultaneous oxygen uptake across the gills, stomach and skin. Eggs were allowed to develop in hypoxia and normoxia and aerial and aquatic respiration was measured. The information gained from this study aids in the understanding of the development and evolution of air breathing in fishes.

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Activity patterns and huddling behavior in the rare austral marsupial (Dromiciops gliroides)

Marsupials as other mammal species present a high diversity of physiological and behavioral strategies to coping environmental condition in that living. These include type of diet, diurnal pattern activity and group and solitary living. During summer 2007 we using 108 tomahawk live-trapping for evaluating morphometric traits and population aspects of Dromiciops gliroides an inhabitant from the Temperate Rainforests of Austral South America. This specie is the only living representative of the Order Microbiotheria, and an important component of Chilean biodiversity which contributes in the regeneration of native forest. Despite of the ecological and evolutionary importance of D. gliroides, only recently begin to know features of its natural history. Based in this fact, the aims of this study were (1) to describe the daily and annual activity time of D. gliroides, and (2) to describe the huddling patterns during torpor. We conducted this study at the San Martin Experimental Forest at the Southern Chile. During March and April 2008 we put four automatic camera traps mounted on tree for detecting daily activity time. We founded not significant differences in the morphometry between sexes. However, the body mass differ significantly among months and only tail width was significant between sexes. The sex proportion was relatively constant and showed no differences among months. But, the males were more abundant than the females. Our results suggest that this camundong marsupial has periods of great activity during the early morning (2:00-4:00). Finally, we show preliminary data evidencing the huddling as an important strategy for the survival of this marsupial in the forests of Austral South America.

P1.114 FRIESEN, Chris/R.; POWERS, Donald/R.; MASON, Robert/T; Oregon St. Univ., George Fox Univ.; friessen@science.oregonstate.edu

Cost of male courtship: Using whole group metabolic rate to assess cost of courtship

Reproductive effort is an important aspect of life history, as reproductive success is arguably the most important component of fitness. Females of most sexually reproducing organisms invest more in the production of offspring than do males. Males then tend to compete for access to females and in the process expend their energetic capital on mate searching, male-male competition and courtship rather than directly on offspring. Red-sided garter snakes (Thamnophis sirtalis paranalis) are an exceptional model for the study of energetic costs of courtship and mating as they fast during the spring mating season segregating the cost of energy acquisition from the cost of courtship and mating. However, in this species measuring an individual males metabolic rate during courtship is complicated by the fact that male courtship behavior in red-sided garter snakes is dependent on the detection of female sexual attractiveness pheromones, and facilitated courtship, i.e., vigorous courtship is only exhibited in the presence of other males. Thus, traditional techniques of masking individuals prevents male courtship behavior, and single animals placed in a flow-through chamber would not yield ecologically realistic levels of courtship, which are only seen in the context of a group or mating ball. Because of these difficulties, we placed groups of males in a flow-through metabolic chamber together with a single female whose respiratory gases were vented outside the chamber to yield a whole group metabolic rate during competitive courtship. Conservative estimates of peak group metabolic rates during courtship are 10-20 times higher than resting group metabolic rates. These measurements indicate that costs of male courtship are high for males and may have implications for the evolution of alternative male mating strategies in this system.
The calculation of the body surface areas of Manduca sexta larvae using serial sections followed by image reconstruction and the creation of parametric body surface models.

We have attempted to calculate 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 radius measurements were taken from the centroid to the surface in 10° increments. Each set of radii values was imported into MAPLE, in which a parametric model of the boundary curve was constructed from 10 sections in the 2nd instar, 30 sections in the 3rd instar, and 28 sections in the 4th instar. 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. These calculated surface areas were then divided by the body weights to find the BSA/BW values for each instar: 2nd instar, 18.8 cm²/g (BW = 0.039g); 3rd instar, 8.5 cm²/g (BW=0.309g); 4th instar, 7.6 cm²/g (BW=0.787g). This work was supported by the Kenyon College Summer Science Scholars Program.

Nitric oxide is the agent of seasonal temperature compensation of clearance rates in isolated gills of Mercenaria mercenaria

The gills of the clam Mercenaria mercenaria contain a seasonally expressed nitric oxide (NO) signaling cascade. In gills isolated in winter, NO potentiates the effects of 5HT on both muscle contraction and the rate of particle clearance, but NO has no effect during the summer. We wondered whether NO acts by mitigating the effects of lower temperatures on clearance rates during the winter. To test this hypothesis, we acclimated clams to 5, 10 and 22°C during the summer and the winter. One set of isolated gills was exposed to 10⁻⁶ M 5HT to maximize the rate of clearance, and the other set to both 5HT and 10⁻⁵ M L-NAME, the latter to inhibit the synthesis of NO. A three-way full factorial ANOVA, with season, temperature and treatment (5HT or 5HT and L-NAME) as the main effects, revealed that only season and season*treatment were significant. Post hoc analysis of the season*treatment means revealed that: 1) temperature had no effect on clearance rates in either season; and 2) L-NAME had no effect during the summer, when the NO signaling cascade is not functional; but 3) during the winter and at all temperatures, L-NAME significantly reduced clearance rates. These results support our hypothesis that NO is the agent of seasonal temperature compensation of clearance rates.

The developmental basis for craniofacial morphology of cichlid fishes

Cichlid fishes of Great African Lakes are excellent examples of explosive adaptive radiation. One of the most important traits by which we can distinguish each species is the shape of feeding apparatus, which has been adapted to the wide variety of trophic habitats present in the lake. To study the molecular mechanism underlying the diversification of cichlids jaw shape, we need to understand the developmental basis of craniofacial morphology in the cichlids. First, we described the developmental stages for the embryonic, larval and early juvenile periods of Nile tilapia Oreochromis niloticus. We newly defined 32 stages using a numbered staging system. For embryonic development, we defined 18 stages (St.1-18), which were grouped into seven periods. For larval development, we defined seven stages (St.19-25), which were grouped into two periods. For juvenile development until 30 dpf, we defined seven stages (St.26-32) in the early juvenile period. Second, we described the identification, the timing and the sequence of the skeletal elements of Nile tilapia, categorized by the developmental stages. The chondrogenesis started in St.17. The deposition of osteoid for the dermal bones started in Stage 18. The uptake of calcium dramatically shifted from the surface of the larvae to the gills in St.20. The bone mineralization of the skeleton started in St.25. Third, we assessed the shape changes of the lower jaw bone during development of Nile tilapia and a Lake Victoria cichlid Haplochromis chilotes using geometric morphometrics. Principal component analysis showed both commonalities and differences in the morphological changes between the cichlids. These data provide basic information as a starting point for understanding the molecular mechanisms underlying this adaptive trait of East African cichlids.

The Effects of Temperature on Metabolic Rate, Venom Synthesis and Potency in Peucetia viridans (Araneae: Oxyopidae)

We examined the effects of temperature on metabolic rate, venom synthesis and potency in the green lynx spider, Peucetia viridans, from Yavapai County, AZ. After acclimation for 7-12d at 10, 20, or 30°C, metabolic rates were measured using flow-through respirometry (n=14/group). Venom was extracted every 6d using electrical stimulation (n=20, 19, 16, for 10, 20, and 30°C, respectively). Potency was tested by injecting 0.5l of crude venom into crickets (Acheta domesticus), and recording the time from initial injection to loss of the righting response and to death (no visible heartbeat). Metabolic rates increased with temperature (10°C: 0.036±/-.004; 20°C: 0.107±/.018; 30°C: 0.288±/.061 lCO₂/g h⁻¹). After 6d, the volume of venom extracted was considerably higher at 20°C (3.41mg/spider), than 10 (0.478mg/spider) or 30°C (1.002mg/spider). By day 18 venom production was low in all groups. Spiders at 10°C produced very little or no venom throughout the experiment. Crickets injected with venom from spiders at 20°C (n=21) had a faster collapse time and were less likely to recover than those injected with from the 30°C spiders (n=21). Chemical analysis will be conducted in the fall 2008 to identify differences in protein content and composition.


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**Effects of progesterone and corticosterone administration on offspring primary sex ratio in the zebra finch (Taeniopygia guttata)**

Researchers have documented significant skew in the primary sex ratios of avian offspring in relation to a variety of environmental and social cues. Zebra finches, in particular, adjust offspring sex ratio according to both the quality and quantity of available food, as well as the attractiveness of the male. The mechanisms behind such manipulation of offspring sex, however, remain elusive. Recent studies suggest that progesterone may exert influences on the sex of offspring in birds. Progesterone administered to leghorn hens during the segregation of sex chromosomes stimulated the production of significantly more females, and corticosterone implants resulted in a significantly higher ratio of female offspring in Japanese quail. We tested the effects of administering a pharmacological dose of progesterone or corticosterone to females at the time of sex chromosome segregation on the primary sex ratio of zebra finch offspring. Females were injected intraperitoneally with 20μg of either progesterone or corticosterone dissolved in 100μl of peanut oil, or with a control oil vehicle six hours prior to the predicted time of ovulation. Follicles ovaulated immediately after injection were laid two days later, and were marked and returned to the nest. Following three days of incubation and embryonic development, eggs were collected and embryos sexed through PCR amplification of a portion of the W chromosome, after which sexes of eggs injected with progesterone or corticosterone were compared with control eggs. Results and implications will be discussed.

**P3.193 GARCIA, NW**; **GREIVES, TJ**; **DEMAS, GE**; Indiana University; nwgarca@indiana.edu

**Insulin affects immune responses differentially in reproductive and non-reproductive Siberian Hamsters (Phodopus sungorus)**

Many animals living in temperate clines experience relatively predictable seasonal changes in environmental conditions and utilize photoperiodic cues to predict these environmental changes. Most non-tropical mammals must re-allocate finite energy reserves from systems not critical to immediate survival (e.g., immunity) to systems critical to immediate survival (e.g., thermoregulation) and rely on environmental cues (i.e., photoperiod) to trigger these adaptations. The seasonal attenuation of immune function is likely regulated by endocrine signals indicating the amount of energy available to the animal. For example, recent research has demonstrated changes in immune function in response to the adipose hormone leptin. In addition, the pancreatic hormone insulin is also released in response to elevated blood glucose levels and may indicate readily available energy to the central nervous system. The aim of the present study was to determine the role of insulin in signaling energy status and investment in immune function in animals held under varying photoperiodic conditions. To this end, exogenous insulin was administered to reproductive long-day (16:8 L:D) and non-reproductive short-day (8:16 L:D) housed Siberian hamsters (Phodopus sungorus). Hamsters were then challenged with an innocuous antigen, keyhole limpet hemocyanin, and immune response was measured. Insulin treatment significantly enhanced immune response in short-day but not long-day hamsters. These data suggest a role for insulin as a neuroendocrine signal integrating seasonal energetic changes and immune responses.

**P3.22 GAO, S.**; **BENFORD, R.**; **SHUSTER, S.M.**; **BALDA, R.P.**; The College of New Jersey, Ewing, Northern Arizona University, Flagstaff; gao2@tcnj.edu

**Temporal Changes in Population Dynamics of the Pinyon Jay**

Drought-induced pinyon pine die-off in Flagstaff, Arizona during 2002-03 had cascading effects in the pinyon jay. Effects include changes in flock demographics and organization. Two hypotheses have been generated to explain the changes. The first hypothesis suggests that changes in reproductive behavior have affected relative fitness among flocks. The second hypothesis suggests that changes in dispersal patterns have caused a source/sink dynamic to form among flocks. Observational analysis of relative fitness, and observational and genotyping analysis of dispersal behavior have found support for both hypotheses. Varied relative fitness and rates of dispersal among flocks before and after the drought have changed age and population structure, and have caused flocks to become sources and sinks. Changing patterns of fitness and dispersal suggest adaptive changes in behavior.

**P1.95 GASSER, B.A.**; **PANESSITI, M.**; **YAGER, D.D.**; Univ. of Maryland, College Park; ddyager@umd.edu

**Sudden shadow triggers a short-latency behavioral response in flying praying mantises**

An abrupt decrease in light intensity from a small overhead source elicits a complex behavior in flying praying mantises both in tethered flight and in free-flight. In Pseudocreobotra ocellata, the response comprises a complete extension of the prothoracic legs, changes in wing beat pattern, dorsal abdominal muscle contraction, and sometimes a head roll. In addition, the mesothoracic and metathoracic legs move slightly away from their normal tucked position. An abrupt increase in light intensity (flash or sustained) did not trigger any behavior. The latency to the beginning of the prothoracic leg movement is 40-60 ms and the wing beat changes start within two cycles (60-80 ms). Wing beat rate, phase, and amplitude changes were obvious in laser/photocell and EMG records, but were markedly inconsistent in magnitude. Shadow never caused flight cessation, and it triggered flight in non-flying animals hanging without tarsal contact. Lowering the contrast between full light and shadow reduced the response magnitude. Three additional mantis species also responded strongly to sudden shadow. Although closely resembling the ultrasound-triggered evasive response, there are differences between the behaviors, most obviously in the prothoracic leg extension. High-speed video shows that for ultrasound, the sequence of extension of the three leg joints is proximal to distal, but it is distal to proximal for shadow stimuli. Also, the response to ultrasound greatly outlasts the stimulus, but stimulus and response durations are the same for shadows. P. ocellata and Hierodula grandis flying untethered in a large room responded to lights-off with an abrupt dive followed by acceleration upward. Direction change ranged from 0 to 180 to either side. Suddenly increased light intensity had no effect. We suggest that sudden shadow and ultrasonic stimuli during flight may tap into the same CNS module for defensive behavior.

**P1.159 NAVARA, K.J.**; **GARCIA, NW**; **GASH, A.E.**; **MENDON, M.T.**; **DEMAS, GE**; Indiana University; nwgarca@indiana.edu

**Insulin affects immune responses differentially in reproductive and non-reproductive Siberian Hamsters (Phodopus sungorus)**

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**P1.95 GASSER, B.A.**; **PANESSITI, M.**; **YAGER, D.D.**; Univ. of Maryland, College Park; ddyager@umd.edu

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January 3-7, 2009, Boston, MA

Expression of the intestinal brush border disaccharidases and Na+/glucose cotransporter genes of zebra finch (Taeniopygia guttata)

Digestive function of passerine birds (i.e. rates and capacities of intestinal nutrient hydrolysis and absorption) and its ecological implications has been studied extensively in different species at different levels of integration. However, to our knowledge the level of expression of the different intestinal membrane-bound enzyme and nutrient transporter genes that participate in the digestion and its regulation has yet not been assessed in passerines. Thus, our objectives were: (1) to assess mRNA levels along the small intestine for the intestinal enzymes sucrase-isomaltase (SI) and maltase-glucosamylase (MG) and the Na+/glucose cotransporter (SGLT1), and (2) to associate the mRNA levels of the enzymes to their specific activities. Our passerine bird models were adult zebra finches, because they are easy to obtain and maintain, and their genome is being sequenced. We designed several primers using predicted sequences of SI, MG and SGLT1 genes for chicken and selected those that produced fragments with the highest percentage of homology to the zebra finch genome. cDNA fragments obtained by RT-PCR were cloned and sequenced for validation. We determined the abundances of mRNAs and activities along the small intestine for SI and MG, whereas for SGLT1 only mRNA abundance was assessed. SI mRNA abundance and activity were correlated and exhibited significant positional differences along the small intestine possibly indicating a transcriptional regulation. Interestingly, neither MG nor SGLT1 revealed a significant correlation or differences in the activity or mRNA abundance along the intestine. Supported by FONCYT PICT 25561, UNSL-CyT 22Q751 to EC-V, and NSF IOS-0615678 to WHK.

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Playing in the mud: Cumacea (Crustacea) of the Comau Fjord, Chile

Cumaceans are small, benthic marine crustaceans that are commonly encountered in mud and soft sand substrates, at depths from the intertidal to deep-sea trenches. As peracarid crustaceans, cumaceans brood their young in a pouch on the ventral surface of the body, with the young directly developing into small copies of the adults. Distributions tend to be patchy and seasonal, although cumaceans can be extremely abundant. Cumaceans are frequently recorded as part of the diets of bottom feeding fish and shore birds. However, very little is known about these organisms, including total diversity, biogeography, ecology, etc. Recent benthic sled collections in the Comau Fjord and connected smaller fjords yielded 11 cumacean species in 7 genera, from 3 families. At each sample site, from 1-9 species were collected. Many of the populations were reproductive, with adult males and eggs in the brood pouches of the females. No specimens were collected via light trapping (usually a successful collection method), despite several attempts and prominent eye lobes present in some of the species.

P1.27 GAULKE, Christopher A.; IRWIN, Jason T.; Central Washington Univ.; gaulke@cwu.edu

High infection rates of the fungus Batrachochytrium dendrobatidis in biological supply and wild-caught frogs in central Washington State, USA.

The fungus Batrachochytrium dendrobatidis (Bd) has been linked to mass mortality events and population declines in amphibians worldwide. To describe the distribution and prevalence of Bd in central Washington State we sampled three montane ponds between June and September 2008 (1430-1550m). Each anuran was swabbed with a sterile cotton tipped swab to dislodge epithelial cells. The cells were then visualized using differential interference contrast microscopy for the presence of zoosporangia. Batrachochytrium dendrobatidis was found at all sample locations with a total prevalence of 49%. Species-specific infection rates were not significantly different: 52% in the Columbia Spotted Frog (Rana luteiventris) (n=15), 53% in the Cascade Frog (Rana cascadae) (n=67), and 40% in the Pacific Treefrog (Pseudacris regilla) (n=10). There were also no significant differences in infection rates between sites and all frogs appeared healthy. In addition, Northern Leopard Frogs (Rana pipiens) shipped to Central Washington University in October 2006 and July 2007 were screened for Bd. All frogs tested positive for Bd (n=38). These data confirm the presence of Bd in central Washington and in the amphibian trade. We urge the use of proper sterilization techniques when handling and disposing of amphibian wastes to reduce the risk of accidental spread of the pathogen.

P1.52 GERRY, S.P.; SCOTT, A.J.; Arcadia University, University of Rhode Island; gerry@arcadia.edu

Prey selection by two species of sharks

The degree of plasticity or degree of specialization of an organism can often determine its distribution within a community. More specifically, the morphology or behavior of a predator can influence resource acquisition. Foraging in the presence or absence of a competitor was investigated by quantifying prey selection in a trophic generalist, spiny dogfish, and a trophic specialist, smooth-hounds, when offered five types of prey. The diet of spiny dogfish consists of small fishes, squid, ctenophores and bivalves. Therefore, dogfish are expected to be nonselective predators and will show no preference for any one prey item. Smooth-hounds have morphological specializations for crushing and primarily feed on crustaceans, thus, they are predicted to select crabs over non-crustacean prey types. Prey selection was quantified according to a selection index that ranks each prey item by the order in which it was consumed. The percentage of consumed prey, missed strikes at a prey and ignored prey were calculated as a proxy for predator efficiency. In the absence of competition, both species showed a preference for herring, squid and shrimp and no preference for crabs. Smooth-hounds frequently selected crabs, but chose not to consume them. Smooth-hounds did not show a feeding specialization according to published diet studies, yet by showing a preference for some prey types, they can be characterized as a selective predator. In the presence of a competitor, spiny dogfish selected four of the five prey items equally, as predicted for a generalist nonselective predator. Similarly, smooth-hounds showed no preference for any one prey type. It is possible that the presence of a competitor influenced both species to select any available prey in order to gain maximum fitness.
**P1.116 GERSON, A.R.*; GUGLIELMO, C.G.: University of Western Ontario, Canada. agerson2@uwo.ca**

**Evidence for increased protein catabolism as a result of water-restriction in House sparrows.**

During migration, non-stop flights are fuelled exclusively by endogenous energy stores and pose a significant physiological challenge, especially when considering fuel and water management. Long distance migrants mobilize a fuel mixture consisting of up to 90% lipid and 10% protein. Although many theories have been proposed, the role of protein catabolism in endurance exercise remains unclear. The catabolism of lipids yields little metabolic water (0.029 g H₂O kJ⁻¹) relative to protein catabolism (0.155 g H₂O kJ⁻¹). Thus, it has been proposed that protein may be metabolized as a source of water during long distance flights under dehydrating conditions. Protein is catabolized directly from muscles and organs, which may have consequences to flight performance and stopover refueling efficiency. Thus, the goal of this study was to investigate the possible affect of water restriction on fuel use during rest and simulated endurance exercise (shivering) in house sparrows (*Passer domesticus*). Magnetic resonance body composition analysis was used to measure changes in body composition (fat and lean mass) through an 18 hr water restriction followed by a 4 hr shivering trial. Blood samples were taken before and after the shivering trial for the determination of plasma osmolality and plasma metabolite analysis. Flow through respirometry was used to measure metabolic rate and total evaporative water loss before and during shivering. Water restriction resulted in significantly greater lean mass loss relative to control birds, elevated plasma uric acid levels, and higher plasma osmolality. These data provide preliminary evidence supporting the hypothesis that negative water balance may result in increased protein catabolism, possibly as a strategy to offset high rates of evaporative water loss.

**P1.48 GERSTNER, GE; University of Michigan; gerger@umich.edu**

**Chewing Rate Allometry Requires Natural Selection**

Mammalian chewing is produced by brainstem circuits called central pattern generators, which can be functionally subdivided into burst-generating neurons and a central timing network (CTN). The CTN generates a rhythm that sets chewing rate. Chewing rate scales allometrically to body mass, and it is generally assumed that feedback and feedforward systems adjust chewing rate to match the jaws natural resonance frequency. However, studies have shown that oral motor rhythms are unaffected by experimentally increasing jaw mass. But these studies were not specifically designed to explore chewing rate scaling, and none involved determining whether chewing rate required developmental time scales to adapt to experimentally increased jaw mass. Therefore, we studied chewing rate and body mass relationships among 20 dog breeds, ranging in size from 3.6 kg (beagle) to 68 kg (Newfoundland) and 20 matched wild mammalian species. Chew duration was not significantly correlated with body mass among dog breeds (p = 0.418, r² = 0.023). By contrast, a significant correlation between body mass and chew duration was found among the 20 mammalian species (p = 0.002, r² = 0.284). Next, canine jaw masses were estimated by taking the product of body mass and the ratio of head length to body length. Estimated jaw mass was also not significantly correlated with chew duration among the dog breeds (p = 0.627, r² = 0.098). The results suggest that chewing rate allometry requires natural selection; neural feedback and feedforward mechanisms alone do not necessarily guarantee the allometric relationship. The results demonstrate that, at least among domestic dog breeds, relaxed selection pressure can greatly reduce the allometric scaling relationship, which may have significant implications for neuromotor, biomechanical, functional morphological, ethological and ecological investigations.

**P3.90 GIAMBONE, T.P.; LIGNOT, J.-H.; SECOR, S.M.; FREDERICK, J.*; University of Alabama, CNRS, DEPE, Strasbourg; ssecor@biology.as.ua.edu**

**Maintenance of digestive performance is ontogenetically stable for the American alligator**

We investigated whether the American alligator (*Alligator mississippiensis*) experiences ontogenetic shifts in the magnitude of their postprandial metabolism and in the regulation of gastrointestinal morphology and function with fasting and feeding. Neonate (38-62 g), juvenile (740-989 g), and subadult (2340-5240 g) alligators all experienced a rapid postprandial increase in metabolic rate following rodent meals weighing 5% of body mass that peaked at 2.73, 2.92, and 3.64-fold of standard metabolic rate, respectively, at 36 or 48 hours postfeeding. Specific dynamic action, independent of body mass, was significantly higher for subadult alligators. We observed no significant postprandial change in the mass of the small intestine or any other organ for neonate, juvenile, and subadult alligators. Alligators also did not exhibit any postprandial change in intestinal microvillus length. Gastric pH and the pH of other sites of the GI tract did not differ between fasted and fed alligators. For each age class, feeding did not generate any significant change in pancreatic trypsin activity or total pancreatic trypsin capacity. For the three age classes, small intestinal nutrient uptake rates seldom differed between fasted and fed alligators, and there was no postprandial change for each age in intestinal nutrient uptake capacity. Independent of alligator body mass, intestinal mass and uptake rates and capacities decreased with age. Similar to species of frequently feeding reptiles, alligators maintain gastrointestinal form and function between bouts of fasting and feeding.

**P1.57 GIBB, A; MELVILLE, B*; WALSH, K; FERRY-GRAHAM, L; Northern Arizona University, Moss Landing Marine Laboratory; jm348@nau.edu**

**Why don’t kissing gourami capture prey from the water column?**

The kissing gourami *Helostoma temminckii*, are members of the monotypic family Helostomatidae (Anabantoidae), characterized by their unusual jaw morphology and associated “kissing” behavior. However, the jaws in this species appear to be additionally modified to enable scraping algae from the substrate. We quantified the cranial movements produced during feeding in *Helostoma* and in two gouramis from the closely related family Osphronemidae: *Betta splendens* and *Trichogaster trichopterus*. We observed that *Helostoma* will take attached food by scraping it from the substrate or detached food by capturing it between the upper and lower jaws from the water’s surface or from the tank bottom; they will rarely take it from the water column. *Helostoma* appear to produce very little suction while feeding; food was only drawn into the buccal cavity after being encompassed by the anterior jaws, and was never drawn into the buccal cavity from a point anterior to the mouth. Correspondingly, *Helostoma* produced very little cranial rotation (~6 deg.) and hyoid depression (~4%) during scraping; although they produced somewhat more when removing unattached food from the bottom of the tank (~10 deg. and ~12%, respectively). *Trichogaster* produced similar rotation and hyoid depression to *Helostoma* when feeding on detached prey resting on the bottom. However, *Betta* produced substantially more cranial rotation (~16 deg.) and expansion (~22%) when suction-feeding in the water column. We suggest that the highly-modified jaw morphology of *Helostoma* is associated with a reduction in suction feeding performance, potentially to the extent that they are unable to produce the buccal expansion necessary to capture prey from the water column.
Effects of Habitat Structure on Predation of *Agalychnis callidryas* tadpoles by Giant Water Bugs (*Belostomatidae*)

Predation success is often affected by abiotic factors such as a habitats structural complexity. Habitat structure can inhibit predator efficiency by hindering search efforts, impeding pursuit of prey, or providing refuge for prey. Conversely, habitat structure can increase predation success when prey are associated with particular structural features or when elements of the habitats structure enhance a predators searching behavior. In this study, I characterized giant water bug (*Belostomatidae*) foraging behavior and success in different structural environments. Observations revealed that the insects alternate between active searching and use of habitat structure in a sit-and-wait strategy when foraging for red-eyed tree frog (*Agalychnis callidryas*) tadpoles. To test whether structure affects the behavior and foraging success of belostomatids I constructed mesocosms with artificial structure placed in bottom, mid, or upper water-column, all water-column levels, and without structure. The belostomatids behavior was observed to quantify use of structure and predation success was measured by running 24 hour predation trials. I found that belostomatids tended to use structure when available and they tended to use structure in the lower water column when given a choice. The belostomatids had higher predation success when in tanks with rather than without structure, and predation success was highest when there was structure lower in the water column. In addition, when given a choice, belostomatids tended to use structure in the lower water column where they tended to have the highest foraging success.

**References**

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*Eriocheir sinensis* megalopae abundance in regions of the San Francisco Bay Estuary

Little is known about the population dynamics of the megalopa stage of the Chinese mitten crab, *Eriocheir sinensis*, in the San Francisco Bay estuary. The aim of this study was to determine megalopa abundance in regions of the San Francisco Bay estuary. Megalopae abundance may be determined by the use of light traps. Larval light trap samples were obtained from the Smithsonian Environmental Research Center. The light trap samples were deployed biweekly in areas of the San Francisco Bay/Delta system including Point San Pablo, McNears Beach, and Point Pinole Regional Shoreline during March 2007 - June of 2007. Light trap samples were deployed biweekly during March - July of 2008 from sample sites including Point San Pablo, Point Pinole Regional Shoreline and Point Molate. Previously, a dichotomous key was made for the brachyuran megalopae of the San Francisco Bay, thus allowing us to identify and quantify *E. sinensis* megalopae in light traps samples taken from the bay in 2007 and 2008. Site Point San Pablo was the only sampling site where *E. sinensis* megalopae were found. *E. sinensis* megalopae were found in light trap samples taken during April 2007 - May of 2007 and May of 2008. Almost all megalopae were found in the month of May. For 2007, all *E. sinensis* megalopae were found in samples taken on the day after the new moon. For 2008, *E. sinensis* megalopae were found in samples taken on the day of the full moon. It is possible that *E. sinensis* megalopae use lunar cycles to disperse to areas that are more suitable for settlement and metamorphosis. However, given the minimal amount of data collected in this study, further research would have to be done to support this hypothesis.
Absorption Hypothesis: Attachment of Beetles to Nano-Porous Substrates

It has been repeatedly reported that microstructured waxy surfaces of plants strongly reduce insect attachment. To explain anti-adhesive properties of such plant substrates, four hypotheses were previously proposed. Recently, only the two first hypotheses (roughness hypothesis contamination hypothesis) and were proven. The aim of this study was to test the third, fluid absorption hypothesis, claiming that the structured wax coverage may absorb the fluid from the setal surface of insect adhesive pads and by this reduce the adhesion force. Traction force measurements were performed with tethered seven-spotted ladybird beetles Coccinella septempunctata L. (Coleoptera, Coccinellidae), walking on five different substrates: (1) smooth glass plate; (2) smooth solid Al2O3 (sapphire) disc; (3 - 5) porous Al2O3 discs (anodisc membranes, back side) with the same pore diameter (220 - 235 nm), but different porosity (28, 42 and 51%). The force ranged from 0.16 to 16.59 mN in males and from 0.32 to 8.99 mN in females. The highest force values were obtained on the smooth surfaces, where males generated considerably higher forces compared to females. On all three porous substrates, forces were significantly reduced, and the only difference for surfaces was obtained between anodisc membranes with the highest and lowest porosity. Males produced essentially lower forces than females on porous samples. The reduction of insect attachment on anodisc membranes may be explained by (1) possible absorption of the secretory fluid from insect pads by porous media and (2) surface roughness, reducing real contact area between tenent setae and substrate.

Assessing the function of larval zebrafish pectoral fins during slow swimming

The biomechanics and neural control of vertebrate limbs have been subjects of much recent interest. During low frequency (slow) swimming, 5 day old larval zebrafish execute alternating pectoral fin beats coupled with tail beats. Here we extend our previous description of the kinematics and dynamics of the slow swimming gait using computational techniques and flow visualization. We describe the phase relationship between pectoral fin oscillations and axial curvature, which better reflects the timing of motoneuron input to axial muscle. In addition, we describe the swimming performance of an fgf morpholino (finless) larval fish, which lack pectoral fins, using a suite of kinematic parameters including swimming frequency, tail beat amplitude, head yaw, midline curvature, forward velocity, swimming episode length, distance traveled, and the advance ratio, a measure of tail beat efficiency. Flow visualization indicates that the pectoral fins of wild type larval zebrafish move water from anterior to posterior during slow swimming and thus may be involved in producing thrust or stabilizing force. However we find similar advance ratios and axial swimming kinematics in finless and wild type fish. It is possible that the larval pectoral fins are important for aspects of kinematics that we have not yet assessed; alternatively, this fin-axis coordination may represent a coordination pattern that is important for function in slow swimming later in the larval stage or in a different behavioral context.
**P3.96 GREENLEE, Kendra J.*; VISHNUVARTHAN, Smitha; TOTH, Andy; North Dakota State University; North Dakota State University, F, University of Wisconsin, Superior; kendra.greenlee@ndsu.edu**

**Identification of matrix metalloproteinases in the tobacco hornworm, Manduca sexta**

Matrix metalloproteinases (MMPs) are zinc-dependent endopeptidases which function to break down various extracellular matrix proteins. The degradation by these proteinases contribute to damage resulting from chronic inflammatory diseases such as arthritis, asthma, and even tumor progression. However, MMPs are also important for proper function of the innate immune system. Larval Manduca sexta, the tobacco hornworm, are a good model organism for studies of innate immunity due to their large body size and hemolymph volume. While two MMPs have been characterized in Drosophila and one has been recently identified in the wax moth, Galleria mellonella, the function of MMPs in insects is relatively unknown. Our hypothesis is that MMPs are important for immune function in M. sexta. To begin testing this hypothesis, we first used degenerative primers to isolate MMP from the fat body of 5 th instar caterpillars. We obtained a partial sequence that is 86% similar to MMP-1 in G. mellonella and 93% similar to the putative MMP-1 in the silkworm, Bombyx mori. The homology shared between our gene and MMPs in closely related species, as well as the presence of the highly conserved catalytic zinc-binding region, indicate that the gene we sequenced is an MMP. We predict that this MMP is expressed in immune-related tissues and cells and is upregulated during infection.

**P3.76 GROSS, T.N.*; MANZON, R.G.**; Univ. of Regina, Biology; richard.manzon@uregina.ca

**Identification and characterization of developmentally regulated serum thyroid hormone distributor proteins in sea lamprey, Petromyzon marinus.**

The lamprey appears to be the one vertebrate that contradicts the well-established anuran model of an increase in thyroid hormone (TH) concentrations initiating and driving metamorphosis. Previous studies have shown that unlike other vertebrates, goitrogen-treated larval lamprey undergo precocious metamorphosis, whereas, exogenous TH-treatments fail to induce metamorphosis. By identifying changes in the patterns of serum lamprey serum thyroid hormone distributor proteins (THDP) and their affinities for THs throughout development, we hoped to clarify if this difference is in part a physiological phenomenon related to TH availability or a fundamental difference in the role of THs in lamprey metamorphosis. The sea lamprey has four developmentally regulated serum THDP. The albumin-like glycoprotein AS is the dominant THDP in the sera of larval and metamorphosing phase sea lamprey. In stage seven of metamorphosis, three additional THDP appear, including the albumin-like SDS-1 glycoprotein, the glycolipoprotein CB-III, and an unidentified low molecular weight protein temporarily entitled Spot-3. In sera of parasite and spawning phase lamprey, SDS-1, CB-III are the main THDP. Despite the shift in the number and type of THDP densitometric and statistical analyses indicate there is only a marginally significant difference (p = 0.049) in total serum T4 and T3 binding capacities between sea lamprey phases. Lastly, preliminary data suggest that all four THDP bind T4 and T3 with similar affinities.

**P1.126 GROVE, T.J.*; SMITH, S.B.; FORT, T.J.**; Valdosta State University; tgrove@valdosta.edu

**Sequence Comparison of the Calcium-Binding Protein Calsequestrin from Poikilothermic Killifish Species**

Isoforms of the sarcoplasmic reticulum (SR) calcium-binding protein calsequestrin (CSQ) are differentially expressed in fast twitch skeletal muscle (CSQ1) and slow twitch skeletal and cardiac muscles (CSQ2). CSQ regulates calcium (Ca²⁺) release from the SR, enabling muscle contraction and relaxation to occur without a cycle by cycle decline in force development. Upon binding (and releasing) Ca²⁺, CSQ undergoes dramatic conformational changes. The mechanisms by which this structurally dynamic protein is able to undergo these changes and remain functional under variable physiological temperatures are not known. Killifish are small intertidal fish adapted to the wide variety of thermal environments observed in the coastal waters of North America. Fundulus heteroclitus populations are exposed to different mean annual temperatures along a latitudinal cline (1° per degree latitude) and rapid fluctuations during tidal cycles (up to 15°C in less than an hour). Two congenic species, F. grandis and F. similis, are found in the warm (22-26°C) coastal waters of eastern Florida and Gulf of Mexico. Partial sequences of putative CSQ have been identified from fast twitch muscle of F. similis and F. heteroclitus and two putative isoforms have been identified from F. grandis, CSQ-A and CSQ-B. Analyses of deduced amino acid sequences indicate that CSQ from F. heteroclitus, F. similis and CSQ-A from F. grandis are highly conserved showing 94-98% identity (98-100% similarity). The putative CSQ-B isoform from F. grandis is less conserved when compared to CSQ from other Fundulus CSQ sequences, showing 58%-84% identity (77-99% similarity). Research is continuing to obtain full length sequences of these putative CSQ isoforms. Supported by NSF IOS-0817805 to TJG and TJF.

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**Temperature-dependent preferences for advertisement-call frequency in females of Hyla versicolor**

Global climate change has the potential to impact many components of biological systems, including the behavior of various animal species. Ectothermic animals face an interesting communication challenge, in that ambient environmental temperatures can significantly impact characteristics of the species-specific advertisement call. Male treefrogs produce loud and persistent acoustic signals called advertisement calls to attract mates. The mate-choice preferences of female gray treefrogs (Hyla versicolor) have been extensively studied, and it has been found that females tested at 20°C prefer calls with standard bimodal frequency peaks of 1.1 + 2.2 kHz over calls with higher and lower frequencies. However, we do not know how this preference might be affected by temperature. To determine whether acoustic preferences based on frequency are temperature-dependent, I collected female frogs during their breeding season and tested their preferences in a temperature-controlled anechoic testing chamber. I generated ten different computer-synthesized advertisement calls that ranged in frequency between 0.55 + 1.1 kHz and 1.5 + 3.0 kHz. In two-speaker choice tests conducted at three different temperatures (15°C, 20°C and 25°C), I observed the choice (moved within 10 cm of a speaker) females made between a call with standard frequency peaks of 1.1 + 2.2 kHz and one of the nine alternative calls. Preliminary results indicate the preferred frequencies appeared to remain at 1.1 + 2.2 kHz at lower temperatures. However, at higher temperatures, female frogs were more likely to approach high-frequency calls. These results will be discussed in the context of well-known temperature-dependent physiological processes in the inner ear of frogs.
Genetic temporal change in the bacterial symbiont Vibrio fischeri isolated from natural host squid populations of Euprymna tasmanica (Mollusca: Cephalopoda)

Vibrio fischeri is a bioluminescent bacterial symbiont of sepolid squids (Cephalopoda: Sepioidae) and monocentrid fishes (Actinopterygii: Monocentridae). Vibrio bacteria are transmitted environmentally; that is, they are obtained from the surrounding seawater subsequent to hatching. The infection is highly specific; only species from the genera Vibrio are capable of fully infecting E. tasmanica juveniles. Previous results have shown that although this association is stable, numerous V. fischeri strains are capable of infecting populations of the same species of sepolid from different biogeographic locations. Thus, in an effort to provide insight into the factors that drive the evolution and biogeography of this symbiosis, we have isolated V. fischeri from E. tasmanica collected from the same wild populations between 2000 and 2008. Genomic DNA was extracted from these isolates and analyzed by PCR amplification and sequencing of the glyceraldehyde phosphate dehydrogenase subunit A (gapA) locus. Identification of population changes with this nine-year span represents over 16,000 bacterial generations. Results obtained from our analysis provide detailed information regarding the rate at which evolution has occurred in natural populations of symbiotic V. fischeri. Thus, our findings will establish a baseline that can be incorporated in future genetic analyses of symbiotic strains experimentally evolved under various abiotic conditions such as salinity and temperature that mimic ecological parameters found in nature, allowing further predictions of speciation in the Vibrionaceae.
Investigations of structural dynamics during bleaching in two species of anemone, *Aiptasia pallida* and *A. pulchella*.

Bleaching involves the loss of symbiotic algae from cnidarian tissues and may be a combined stress response of host and algae. There is little known of structural changes that occur at the interface between symbiont-containing endodermal cells and surrounding tissues during the bleaching process. In this study, light and transmission electron microscopy are utilized to examine histology/ultrastructure of two model organisms, *Aiptasia pallida* and *A. pulchella* under both symbiotic and aposymbiotic conditions. Histological observations reveal that symbiont-containing, endodermal epithelium exhibits either simple cuboidal or columnar cell types, varying at different locations within the anemone. Alternatively, aposymbiotic anemones display simple, cuboidal endodermal cells throughout, but further ultrastructural examination is necessary. These results suggest that different regions within the anemone are lined with different types of epithelial cells, and may indicate that metaplasia, or cell type transformation, is occurring. Additionally, factors such as symbiont number and/or external conditions (i.e. light intensity) may influence epithelial type and possible cellular transitions. Preliminary ultrastructural results indicate the presence of previously undescribed cells or cell processes, located between the basal host endodermal cell membrane and the mesogleal layer. This suggests that reported host cell detachment during bleaching involves more than simple release from the mesoglea. Future investigations will be conducted to progressively examine endodermal epithelia while thermal bleaching occurs.

Fish can aggregate into groups known as shools or, in the case of synchronized and polarized swimming behavior (Pitcher and Parrish, 1993), schools. More than half of the 30000 fish species known form schools at least at some point in their ontogeny. Our previous work has shown that hydrodynamic energy savings do not generally play a significant role in the formation of schools, contrary to the hydrodynamic hypothesis formulated by Weiths (Nature, 1973). However, a reduced tail beat frequency of the fish in the back of a school as compared to those in front has repeatedly been reported and has been interpreted as a sign of energy savings (Herskin and Steffensen, J. Fish. Biol. 1998; Svendsen et al., J. Fish. Biol. 2003). Here we present data from three species of fish (*Devario aequipinnatus*, *Fundulus delineatus* and *Lepomis gibbosus*) that do not show a reduced tail beat frequency of the fish in the back of a school. We suggest an explanation for the earlier, contradicting results based on wall and ground effects. Furthermore, we quantified the tail beat phase relations between individual fish in our schools and found that they were not fixed, as would be expected in case of a strong influence of the wake of a fish on a following conspecific. We confirm our conclusion that hydrodynamic effects have not been the driving force in the development of fish schooling. Furthermore we review the literature once more and raise some methodological concerns about experiments that have measured the actual endurance of single swimming fish versus groups.
Most benthic nemerteans possess the ability to sense and respond to light and have evident ocellar structures. However, the fine structure of nemertean eyes has been studied only in two closely related species, which revealed microvillar photoreceptive cells within a pigment cup. The nemertean Micrura verrilli bears, anteriorly within the head, two prominent orange bulbs thought to be ocelli, although histological sections have been inconclusive. We examined these bulbs with transmission electron microscopy and show that each is a pigment cup ocellus directed anteriorly and that each photoreceptor cell has an apical crown of microvilli within the cup. These results accord with observations that newly hatched juveniles possess a pair of small orange-pigmented ocelli.

**P3.128 HARN, L.J.*; HAUSSMANN, M.F.; MAUCK, R.A.; Kenyon College, Gambier, OH; Bucknell Univ., Lewisburg, PA; hamli@kenyon.edu**

*Don’t count your chicks before they hatch: an experimental manipulation of incubation effort in Leach’s storm-petrel (Oceanodroma leucorhoa)*

Parents must allocate available energy between the competing demands of self-maintenance and offspring care. Long-lived species such as Leach’s storm-petrel (Oceanodroma leucorhoa) may invest preferentially in self-maintenance because any one reproductive event comprises only a small proportion of lifetime reproductive success. Recently, our lab has shown that sex of storm-petrel individuals may also influence allocation of resources, since females invest energy into egg production while males may expend more energy during incubation and chick rearing. During the early incubation period we increased the energetic cost of flight by trimming the incubation period. We used length of the incubation period and egg neglect as measures of parental effort and the re-growth rate of an induced outer right rectrix as an index of energy allocated to self-maintenance. Mean feather growth rates for breeding pairs were positively correlated with length of the incubation period (P=0.009). However, incubation length, individual feather growth rate, and mean feather growth rate were not affected by Julian lay date (P>0.7) or experimental group (P>0.5). Preliminary analyses of known- sex individuals indicate that feather growth rate did not differ by sex (P=0.18). Feather growth rate for sham treatment individuals (0.86 +/- 0.07 SE mm/d) did not differ significantly (P=0.15) from that of trim treatment individuals (1.01 +/- 0.07 SE mm/d). Analysis of Botten temperature and PIT technology data will allow us to assess the relationship between incubation period, individual attendance patterns, egg neglect, and feather growth.

**P3.33 HARRISON, J.S.*; BURTON, R.S.; Georgia Southern University, Statesboro, Scripps Institution of Oceanography, La Jolla, California; rharrison@georgiasouthern.edu**

*Sex-biased gene expression in the intertidal copepod Tigriopus californicus*

The intertidal copepod *Tigriopus californicus* has become an exciting system to investigate the genetics of population structure and outbreeding depression. Recent studies in this species suggest that the detrimental effects of hybridization between genetically differentiated populations are not always expressed equally in both sexes. In fact, little is known about the genetic, and/or physiological differences between sexes of this copepod species; the mechanism underlying sex determination itself remains undetermined. Here we use a custom 2000 feature cDNA microarray to investigate patterns of gene expression in males and females of *T. californicus*. The main objective of this study is to characterize differences in the transcriptome between sexes. Using conservative criteria in our analysis, 17.2% of the ESTs exhibited sex-biased expression levels (a minimum estimate). Of the ESTs showing sex-biased expression, 58.6% were expressed at a higher level in males and 41.4% were expressed at a higher level in females. The ESTs showing the highest levels of differential expression were strongly biased in the female direction, while those showing lower levels if differential expression were partitioned equally between the sexes. Similar to studies in other arthropods, a high proportion of female biased genes fell into two general functional groups; 1) protein processing, and 2) RNA/DNA processing. However, genes functioning in innate immunity such as those involved in antimicrobial response also showed strong female biased expression. The suite of ESTs showing male biased expression was largely dominated by genes involved in muscle function and development.
P1.1 HARTKE, T.R.*; ROSENGAUS, R.B.; Northeastern University, Boston; hartke@neu.edu

Opening the Black Box of Colony Foundation in a Polygamous Termite

Most termite colonies are founded by a monogamous pair (king and queen) following the dispersal flight, but a few species have variable breeding strategies whereby new colonies may be founded by multiple queens and/or kings. About one-third of mature Nasutitermes coriniger colonies are headed by multiple queens and/or kings; two-thirds of those bear genetic hallmarks of foundation by non-relatives. Little is known about the incipient stage of colony development, or the costs and benefits of polygamous versus monogamous founding in termites. In the present study, laboratory and field studies were undertaken to open the black box between dispersal of reproductives and appearance of young arboreal colonies. Nest-collected N. corniger alate reproductives were collected in and around Gamboa and Galeta, Panama. Between 2006 and 2008, 3,572 experimental incipient N. corniger colonies were established in the lab, while manipulating group size (pairs, trios, quintets) and origin of founders (nestmates, non-nestmates). Incipient colonies were censused daily for 120 days to record demographic information: deaths of founders, first appearances of eggs, larvae, workers, and soldiers. Naturally-established incipient colonies from the field were preserved and analyzed to compare their demographics with those of lab-established colonies. Data from the field appear to be consistent with laboratory results. Results from mesocosm experiments indicate that additional reproductives may be accepted during colony foundation, while preference for group or pair founding could depend on colony of origin.

P2.76 HAYASHI, M.*; FEILICH, KL; ELLERBY, DJ; Wellesley College; delerby@wellesley.edu

The mechanics of explosive seed dispersal in Orange jewelweed

Explosive dehiscence aids seed dispersal in a number of plant species. Orange jewelweed (Impatiens capensis, Meerb.) is an herbaceous annual exhibiting this type of dispersal mechanism. High speed video analysis was used to determine the sequence of events during seed release in this species. Longitudinal splitting of the pod into 4 rapidly coiling segments launched the seeds. Splitting and coiling took 4.2 +/- 0.4 ms (mean +/- SEM, N = 8). Stored elastic energy as a result of turgor pressure is the likely driving force behind rapid plant movements. Isolated coils were attached to an ergometer and their stress-strain relationships were determined. Stress increased with coil hydration, confirming the role of turgor pressure. The energy storage capacity of the coils was 124 +/- 37 J/kg (mean +/- SEM, N = 8), similar to that of spring steel. Analysis of the kinetic energy of the launched seeds will determine the effectiveness with which stored elastic energy is transferred to the seeds.

P2.98 HAUGHEY, Michael/D*; GREEN, Steven; LOGAN, Michael; BOBACK, Scott; MONTGOMERY, Chad; Salem State College, University of Kent, Canterbury, Univ. of Texas, Arlington, Dickinson College, Truman State University; mhaughey86@gmail.com

A Comparison of Body Size and Condition of Boa constrictor imperator on the Cayos Cochinos Archipelago

The islands of Cayo Pequeno and Cayo Grande within the Cayos Cochinos archipelago of Honduras each support dwarfed populations of Boa constrictor. Despite their close proximity (< 1 km), these islands differ in habitat structure, potential prey species, and prey availability. For instance, populations of Agouti paca, Dasypus novemcinctus, Dasypus punctatata, and Rattus rattus occur solely on Cayo Grande. On Cayo Pequeno, B. constrictor are known to prey (almost exclusively) upon lizards and migratory birds, prey that are generally much smaller than the mammals found on Cayo Grande. We predicted that these differences in prey availability and diversity would result in differences in mean snout-to-vent-length (SVL), mass, and body condition between boa populations. The residuals from a linear regression of LogMass versus LogSVL were used as an index of body condition. Contrary to our hypothesis (for both males and females), SVL (P=0.157), mass (P=0.367) and body condition (Male P=0.068 Female P=0.315) did not differ between Cayo Pequeno and Cayo Grande. This suggests that, despite differences in prey availability and diversity, snakes are maintaining similar body sizes and conditions. Interestingly, despite a lack of difference in overall body size and condition between males and females between islands, B. constrictor on Cayo Grande were found to display a greater degree of sexual size dimorphism than those on Cayo Pequeno (SVL P=0.034 Mass, P=0.037).

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Effects of road deicers on survival and behavior of larval and adult wood frogs

Use of road deicers (primarily NaCl) in the northeastern U.S. has increased dramatically over the last century. Salts applied to roads can travel considerable distances from the site of application, and may contaminate local watersheds to levels above 100 mM. Amphibians that breed in vernal pools early in the spring, when salt levels could still be high, may be especially vulnerable to increased salinities. We integrated responses of larval and adult wood frogs (Lithobates sylvaticus) to increased salinity to determine whether adult frogs would be able to detect and avoid salinities that would be detrimental to them or to their offspring. Tadpoles were raised in groups at concentrations ranging from 0-200 mM NaCl. No tadpoles at higher concentrations survived to metamorphosis. At low salinity, tadpoles had slightly higher mortality and lower growth and development rates than control animals. Adult frogs were mildly dehydrated to induce thirst, then placed in a shallow dish of water ranging from 0-500 mM NaCl. Location (in or out of the dish) and behavior (moving, standing, sitting, or water absorption response) were recorded during a 10-minute trial. In contrast to arid-adapted anuran species, the wood frogs showed no aversion to salt, remaining in even 500 mM NaCl for the full 10 minutes. Mass loss during the 10-minute trials increased with increasing salinity. The results have important ecological implications. Tadpoles showed sublethal effects even at relatively low concentrations and high mortality at higher concentrations, but adult wood frogs may not be capable of evaluating the salinity of potential breeding sites, leaving this species potentially vulnerable to increased mortality or subtler sublethal effects due to road salt runoff.

January 3-7, 2009, Boston, MA
P3.30 HERNANDEZ, Erica C.; HARRISON, John F.; Arizona State University; erica.heinrich@asu.edu
Critical periods for oxygen effects on adult size in Drosophila melanogaster
In many organisms, including humans, lowered oxygen concentrations have been seen to have an effect on development and adult size. In previous studies, it has been shown that flies reared in hypoxia are significantly smaller than those reared in normoxia. However, the mechanism which creates this size effect remains unknown. If oxygen effects on size occur during a specific developmental stage, this would narrow down the possible pathways responsible for the oxygen effect on size. Prior studies have suggested that the pupal phase may be critical for oxygen effects on body size in fruitflies. We examined this question by rearing flies in normoxia (21% oxygen) except for specific 24 hour time periods when atmospheric oxygen level was changed to 10% oxygen. We also conducted the converse experiment. We hypothesized that the late larval phase would be particularly oxygen-sensitive as that is when most mass is gained, and that the early pupariation stage would also be very sensitive as this is when the adult cuticle is formed. However, fly size was significantly affected by oxygen (by about 6%) no matter at what point during development that the atmospheric oxygen was switched, including the egg stage. Therefore, either there are multiple independent mechanisms by which oxygen affects size (e.g. suppression of feeding during the larval stage, effects on cuticle cell size in the pupal stage) or there is a developmental pathway mediating oxygen effects on size available at all times during development. The effects of egg oxygen level on adult size are particularly intriguing, as they suggest that oxygen effects on the embryo organ and body sizes of adults This research was supported in part by funds from the ASU School of Life Sciences and the Howard Hughes Medical Institute through the Undergraduate Science Education Program and by NSF IBN 0419704 to JFH.

P1.65 HERNANDEZ, L. P.; MORGAN, R. J.; George Washington University, Washington, DC; phemeand@gwu.edu
Size and distribution of muscle fiber types within chondrichthyan muscles
Vertebrate morphologists have long appreciated the importance of muscle fiber type composition. Although they vary widely in their size and distribution, different isoforms of slow and fast myosins comprise the bulk of all skeletal muscle tissue. Combined, these different myosins coordinate to perform a variety of important functions associated with locomotion, feeding and breathing. Evolutionarily, amniotes and anamniotes have shown a remarkable disparity in muscle fiber type distribution. In amniotes and adult anamniotes, muscle fibers show a mosaic distribution whereby specific fiber types group together within muscles. Here we describe the distribution and relative proportion of fast and slow fibers in adult shark and skate muscles. Muscles were stained for a variety of specific myosins using standard immunohistochemical methods. Antibodies considered to stain all vertebrate myosins (based on data from a large number of amniotes and anamniotes) did not recognize myosins within many irregularly shaped muscle fibers in skate. While our results do not indicate the mosaic pattern seen in amniotes, they also do not fully support the strictly zoned fast and slow regions seen in most anamniotes. Antibodies against slow myosin stained the peripheries of certain larger muscle fibers, but stained entire smaller diameter fibers in other muscles as seen in anamniotes. Thus skate muscles may be comprised of a number of intermediate fiber types and consist of a unique pattern of distribution. It is likely that a range of intermediate muscle fiber types may be an ancestral character. We discuss the functional, evolutionary, and developmental implications of our data.

P1.142 HENRY, R.P.; Auburn University; hennyrp@auburn.edu
A carbonic anhydrase repressor found in the sinus gland at the level of mRNA expression in the euryhaline green crab, Carcinus maenas
The enzyme carbonic anhydrase (CA) is known to be a central molecular component of branchial ion uptake mechanisms in crustacean gills. Cytoplasmic CA catalyzes the conversion of respiratory CO2 and water to protons and bicarbonate ions, which then serve as counterions for the active uptake of cations (Na+) and anions (Cl-), respectively. In the euryhaline decapod, Carcinus maenas, CA activity is induced up to 12 fold in the posterior, ion-transporting gills, upon exposure to low salinity (15 ppt). CA induction is believed to be under transcriptional regulation (i.e., gene activation followed by synthesis of new enzyme). mRNA for the cytoplasmic isoform (CAC) increases 10 fold after 6 hr of low salinity exposure and 100 fold after 24 hr. This precedes the initial induction of CA activity, which takes place at 48-72 hr post-transfer. CA gene activation appears to be under the control of a repressor found in the sinus gland (SG). Injection of SG extract, twice per day over a 4 day period, into crabs transferred from 32 to 15 ppt, results in an approximate 50% inhibition in the induction of CA activity. Injection of extract of the surrounding medullary tissue of the eyestalk has no effect. Hourly injections of SG extract for the initial 6 hours of low salinity transfer inhibits the initial 10 fold increase in CAC mRNA by up to 70%. These results indicate that the putative CA repressor acts at the level of gene expression to maintain low, baseline concentrations of CAC mRNA and hence baseline levels of CA activity in high salinity. Supported by NSF IBN 02-30005.

P2.178 HEYLAND, A*; REITZEL, A; HODIN, J; U. of Guelph, Canada, WHOI, USA, Hopkins Marine Station, USA; aheyland@uoguelph.ca
Thyroid hormone signaling in echinoderms: Comparative genomics, cross-kingdom signaling and life history evolution
Hormones orchestrate life history transitions in animals and non-animals, canonically via environmental inputs that directly or indirectly regulate internal (endogenous) hormonal release and/or response. Less well studied are cases in which the sources of the hormones themselves are external (exogenous). One such example is echinoderms, where thyroid hormones (THs) regulate metamorphic timing. In planktotrophic echinoderm larvae (i.e. those that need to feed to complete metamorphosis), the primary source of THs appears to be exogenous: they are derived from the unicellular algae that these larvae consume. By contrast, lecithotrophic echinoderm larvae (i.e. those that need not feed) apparently have a greater capacity for endogenous TH synthesis. We have proposed that such variation in internal hormone synthesis capacity may bias the evolutionary origin of lecithotrophy, a developmental mode that has evolved repeatedly in echinoderms. First, we will review what we know about THs in echinoderm development and evolution, in the context of a general discussion of hormones and life history evolution in multicellular euarkyotes. We will also report on our ongoing measurements of THs from sea urchin developmental stages and unicellular algae using HPLC coupled mass spectrometry. Lastly, we will discuss the current state of knowledge regarding invertebrate TH signaling. Comparative genomics and EST analyses have confirmed that many TH signaling components are conserved among deuterostomes, and that orthologs of vertebrate TH receptors are identifiable throughout the Bilateria. We will describe our current research on TH signaling modalities and metabolism in echinoids (sea urchins and sand dollars).
P3.53 HITCHCOCK, Amanda C.; PROPERT, Matthew W.G.; MARSH, Richard L.; Northeastern University; hitchcock@neu.edu

Stability despite rapid large fluctuations in calculated net muscle moment at the knee during normal level running in guinea fowl.

We calculated the net muscle moments at the leg joints of guinea fowl using 2-D inverse dynamics. Birds ran along a trackway and over a force plate. Force plate data were synchronized with high-speed video recording of markers, which allowed the calculation of the joint centers. These data along with previously measured segment properties allowed the calculation of net muscle moments and powers at all of joints in the limb. Generally, peak moments at all joints were extension moments occurring during stance and were highest at the knee and hip. However, at the hip and knee relatively large moments are required in late swing due to the inertia of the limb segments. At the knee this inertial moment is in flexion and it reaches a peak near footdown, at which point it falls suddenly by 50% of the peak value and then rises again to approximately its former value before switching to an extension moment as stance proceeds. The sudden large drop and restoration of the flexion moment occurs in approximately 20 ms for a full cycle. During this time the knee joint angle is undergoing a stable flexion trajectory, i.e., the knee appears highly damped. We hypothesize that the large damping apparent at the knee is due to strong co-contraction occurring in knee extensors and flexors in late swing and throughout stance.

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P3.12 HOANG, L.K.; MCCOY, K.A.; ST MARY, C.M.; GUILLETTE, L.J.; University of Florida, Smithsonian Tropical Research Institute; kristam@ufl.edu

Renal pathologies in giant toads (Bufo marinus) vary across land-use practices

Kidneys are the principle excretory organs for many vertebrates and excessive or chronic exposure to exogenous toxins can lead to renal pathologies and chronic renal failure. Although many studies have linked exposure to specific chemicals (e.g., pesticides, pharmaceuticals) with specific renal diseases, none compare renal pathologies occurring in wildlife living in different types of human-dominated landscapes which have characteristic chemical milieus. In this study, we use light microscopy to characterize renal morphology and identify pathologies diagnostic of toxin exposure in the giant toad (Bufo marinus) living in suburban and agricultural habitats. We identify tubule and interstitial pathologies that have been associated with toxicant exposure in other organisms, including humans. Pathologies consistent with toxin-induced tubule disease were observed at three sites (one suburban and two agricultural), whereas interstitial pathologies were most severe at one agricultural site. Indeed, some of the pathologies we identify are similar to those found in human drug abusers and patients suffering medication-induced nephropathy. The mechanisms causing differences in toxin-induced renal pathologies across sites and the implications of these pathologies on wildlife health are unknown and warrant further study. A more detailed understanding of the toxicological mechanisms as well as the chemicals involved could help us devise strategies to avoid or mitigate the impacts of toxins on humans and animals living in human modified environments.

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Endocannabinoid signaling and energy balance in Siberian hamsters (Phodopus sungorus)

Maintenance of energy homeostasis is critical for all organisms and the importance of understanding the control of energy balance is evident in the face of the growing prevalence of human obesity. Siberian hamsters exhibit marked seasonal changes in body weight and food intake, losing ~30% of their body weight in short winter-like day length. Profiles of classical energy balance genes, however, provide little explanation for these dramatic changes. The endocannabinoid (EC) system has been noted for its influence on appetite and energy expenditure, and a well-established literature indicates these effects are mediated by the cannabinoid receptor, CB1. CB1 receptors are widely expressed in the brain and empirical data support the involvement of hypothalamic areas in cannabinoid-induced eating. To date, few studies have examined the influence of cannabinoids on energy balance in a temporal context and no studies have examined EC signaling across energetic state in Siberian hamsters. Thus, we examined seasonal changes in EC signaling and its correlation with body weight in Siberian hamsters. Specifically, we transferred hamsters from long day photoperiod (16 h light:8 h dark) to short day photoperiod (8 h light:16 h dark) and compared them to long day controls at 0, 2, 6, and 12 weeks. Data will be presented on blood EC levels as well as CB1 levels in brain nuclei involved in energy regulation including those of the hypothalamus. The results of this study will contribute to the general understanding of energy regulation. Because these animals naturally fluctuate between energy states comparable to those of obesity and leanness, they serve as an important model for studying the physiological control of energy balance and may provide novel insight to energy regulation not offered by non-seasonal rodent models.

P3.123 HODIN, J*; MILLER, P; HUANG-VOSS, C; EPEL, D; Hopkins Marine Station, Stanford University, CA, USA; seastar@stanford.edu

Inquiry-based web curricula in development, microscopy, physiology and environmental science

We are developing a range of inquiry-based, freely available biology education resources distributed through several web sites. VirtualUrchin (http://virtualurchin.stanford.edu) highlights sea urchins as fertile ground for investigating core biological principals, applying the scientific method, investigating environmental problems, and learning to use biology lab tools. VirtualUrchin is a companion site to the very popular Sea Urchin Embryology teacher support site (http://www.stanford.edu/group/Urchin). VirtualUrchin features microscopy tools, with resource tutorials on the use and care of microscopes, measurement of microscopic objects, and tools for comparing specimens using different microscopic techniques. Our resources also emphasize the usefulness of sea urchin development in studying anthropogenic impacts on marine organisms, including pollution and ocean acidification. Our third site (http://esi.stanford.edu), in cooperation with Swedish universities, uses a CSI approach to engage students in an investigation of why salmon have been disappearing during their migration up the most productive salmon river system on the planet: Canada’s Fraser River. Students use interactive virtual tools to investigate salmon life cycles, determine the destination of migrating salmon, observe changes in respiration patterns, circulation, migration and energetics, and explore general information on global climate change and its real-world impacts. All of our projects are developed under the umbrella of the Virtual Labs project at Stanford (http://virtuallabs.stanford.edu), where our resources are compiled alongside a wide range of freely-available, high quality educational resources in biology and biomedicine.
P2.81 HOLGERSSON, M C N*; NICHOLS, W A; PAITZ, R T; BOWDEN, R M; Illinois St. Univ.; mcholge@ilstu.edu

Cloning and Characterization of Crustacean Calcium-Sensing Receptors (CaSRs)

Many marine invertebrates experience significant changes in the ionic composition of environments they encounter during their life histories. In terrestrial animals and fish, G-protein coupled receptors called calcium-sensing receptors (CaSRs) have been identified as key regulators of ionic and nutrient homeostasis. Recent genome projects, including those for *Ciona intestinalis* and *Strongylocentrotus purpuratus*, have suggested CaSR gene homologs are present in invertebrates (Loretz, 2008) but their possible tissue specific expression is unknown. We report here the cloning of a full-length CaSR gene from the lobster *Panulirus interruptus* (LobCaR), and compare it to other known or putative CaSRs. Using CaSR specific antibodies we also demonstrate the existence of CaSRs in other crustaceans. The gene structure and sequence are highly conserved relative to CaSRs from mammals and teleosts. Studies using anti-LobCaR antibodies reveal that crustacean CaSRs are expressed predominantly in osmoregulatory and calcium regulating tissues including antennal gland, gill, and gastrointestinal tract. We conclude that CaSRs are expressed in lobsters and likely play an integral role in multiple physiological functions in crustaceans including nutrient and salinity sensing, calcium homeostasis and biomineralization.

P2.114 HOLLIDAY, Casey M; Marshall University; hollidayc@marshall.edu

New Insights into the Mandibular Symphyses of Reptiles

The morphology of the mandibular symphysis likely reflects the functional environment in which it resides and numerous analyses have focused on the correlation between symphysisal structure and masticatory behavior among mammals. However, few studies have investigated symphysisal evolutionary and functional morphology among reptiles. Whereas turtles, birds, and crocodilians have characteristically fused or interdigitated the symphysis, lepidosaurs maintain open symphyses. To further illustrate structure-function relationships of the joint, data on soft and bony tissues that comprise the symphysis were collected among a diverse sample of extant lizards including iguanians, geckos, skinks, and varanids using microCT scanning, followed by standard and polarized light microscopy of undecalified serial histological sections. Among lizards, soft-biting taxa possessed mostly parallel-fibered, elastic connective tissues whereas hard-biting taxa possessed significantly more cartilaginous and mineralized tissues within the symphysis. Other species displayed connective tissue morphologies within this spectrum and histology suggests a three-dimensionally complex organization of tissues including a laminar organization of loose parallel-fibered tissues, cartilaginous domains and dense parallel and woven fibers. Some of these fibers attach directly to Meckels cartilage whereas most are embedded as extrinsic fibers within the bony symphysis. All species investigated rely on soft tissues, rather than bony interdigitations, to support the joint. These and other data provide the foundation to further explore the adaptive plasticity and in vivo function of the joint among extant taxa as well test hypotheses of the structures evolution among fossil taxa.

P1.144 HOLM, C.; KEACH, S.; BETKA, M.; HARRIS, H.W.; JURY, S.H.*; MariCal Inc.; ajury@marical.biz

Dietary fat influences carotenoid-based coloration in the American Goldfinch Dietary

Yellow, orange and red ornamental coloration in vertebrates is often the result of carotenoid-based pigments. Carotenoid pigments cannot be synthesized by vertebrates de novo and thus carotenoids must be consumed to be expressed. Carotenoid expression in bird feathers is condition-dependent; color properties are correlated with total carotenoid intake, total food intake, and parasite load. In several bird species, males that express greater pigmentation have been shown to be preferred as mates by females, so it is assumed that females assess male pigmentation as an indicator of male condition. Carotenoids are fat-soluble pre-vitamins that are efficiently absorbed across the gut epithelium when associated with lipids in the intestinal lumen. Yet, little is known about the effect of dietary fat on carotenoid absorption and color expression in birds that express carotenoid-based ornaments. American goldfinches express bright yellow body and dark orange bill coloration that are both carotenoid based. We examined the effect of dietary fat on body and bill color expression American Goldfinches maintained throughout the molt on diets with low (7%), moderate (14%), or high fat (21%) but similar concentrations of carotenoids and total energy. Treatment has no significant effect on feather coloration, but the hue of the bill was greater (orangier) for animals consuming the 14% and 21% fat diet compared to those consuming only 7% fat. These finding suggest the fat content of diet plays a role in expression of carotenoid coloration in birds.
**P2.57** HOPKINS, B.A.*; HOMBERGER, D.G.; Louisiana State Univ., Baton Rouge; bhopki1@lsu.edu

*The gular glands of Alligator mississippiensis condition the interscale skin of the intermandibular and gular regions*

Crocodilians swallow prey items that are large relative to their body size. Swallowing large prey items requires an expansion of the pharynx and esophagus and, thus, an expansion of the intermandibular and gular skin. In the scaly skin of crocodilians only the soft interscale skin is stretchable and pliable, and, therefore, needs to be conditioned to maintain its physical attributes. In contrast to mammals, which condition their skin with sebum from numerous and dispersed integumentary glands, alligators have only three kinds of locally restricted integumentary glands, one which is a pair of gular glands. The gular glands have been thought to produce pheromones; however, their lipid secretion consists of many of the same components as those found in cosmetic skin care products. In the alligator, deep stretchable interscale skin grooves radiate rostrally from the orifice of the gular gland and interconnect with smaller stretchable interscale skin grooves in the intermandibular and gular regions. The interscale skin grooves form a network of hierarchically arranged channels of particular width and characterized by particular epidermal microstructures. The epidermal microstructure of the stretchable interscale skin grooves varies significantly from that of the less stretchable interscale skin in the abdominal region, but bears some resemblance to the microstructure of the channels that carry water from wet skin to the mouth of some desert lizards. We hypothesize that the stretchable skin in the intermandibular and gular regions of alligators serves not only to accommodate the passage of large prey items, but also to channel and distribute skin conditioning lipids from the paired gular glands.

**P2.58** HORTON, Jaquan M.*; GOSLINE, John M.; Univ. of California, Irvine, Univ. of British Columbia; jhorton@uci.edu

*Fish have GUTS too: The material properties of the intestinal tissues in teleost fishes*

Durophagous fishes are predators that specialize in eating hard prey, generally by crushing the shells of mollusks and crustaceans. Others have investigated many of the mechanisms and morphologies that enable fish to consume hard prey and exploit this trophic niche (e.g. dentition and cranial specializations, bite force and mechanical advantages). However, few have examined the effects of hard prey consumption on visceral tissues. If indigestible shell or exoskeletal fragments are consumed, the material properties of the intestinal tissues must withstand the potential mechanical damage caused by sharp foreign bodies (e.g. shell shards) passing through the gut. In this study, we test the hypothesis that the intestines of durophagous fish are more extensible than fish that do not eat hard prey. The whole intestines of six fishes were inflated using a custom, static-pressure system to investigate their material properties. The J-shaped stress-strain curves showed that the initial stiffness ranged from 6 to 60 kPa and that the final stiffness ranged from 4 to 24 MPa. The maximal extension-ratio of the inner lumen ranged between 3.5 and 10.9, and this extension-ratio provides an indication of the size limit for an indigestible shell item or processed unit of food that can travel down the intestine. This work offers significant insight into the material properties of intestinal tissue in teleost fishes. Future studies will focus on the possible adaptive properties of teleost intestinal tissues in a phylogenetic context.

**P3.206** HOUGEN, Helen Y.; HIEBERT, Sara M; Swarthmore College; rhougen1@swarthmore.edu

**Effect of diets rich in saturated and polyunsaturated fatty acids on performance of Mus musculus in warm and cold environments**

The homeoviscous adaptation hypothesis predicts that cell membranes should incorporate higher proportions of unsaturated fatty acids at lower temperatures to counteract cold-induced increases in membrane viscosity and thus to maintain membrane function. In a previous experiment in our laboratory, the obligate homeotherm, *Mus musculus*, increased its preference for a diet rich in polyunsaturated fatty acids (PUFAs) when exposed to cold. However, cold-induced changes in diet preference over three weeks were not associated with improved performance in the cold, nor were there substantial differences in membrane composition after this three-week period. In the current experiment, mice in each of three treatment groups (N = 15 in each group) were fed a single diet [chow rich in n-3 PUFAs, in n-6 PUFAs, or saturated fatty acids (SFAs), respectively] for ten weeks at 23 C. Grip strength, memory, and nociception were then tested in each diet group at 5 C and at 23 C; fatty acid composition of their membranes was also assayed. While some trends were consistent with the homeoviscous adaptation hypothesis, preliminary analysis showed no significant effects of diet or temperature on most measures of performance. Further studies are needed to determine the function of cold-enhanced preference for PUFAs in this species.

**P3.83** HRANITZ, J.M.*; SAVITSKI, A.N.; BARTHELL, J.F.; CLEMENT, M.L.; SONG, D.S.; PETANIDOU, T.; Bloomsburg Univ. of Pennsylvania, Univ. of Central Oklahoma, Edmond, Univ. of Central Oklahoma, Edmond, Univ. of California, Berkeley, Univ. of Aegean, Mytilene, Lesvos (Greece); jhranitz@bloomu.edu

**Nucleotide Diversity in Native and Invasive Island Populations of the Leafcutting Bee (Megachile apicalis)**

Megachile apicalis is a solitary bee that rapidly invaded cavity-nesting bee communities in the western U.S. during the 1980s. In the Central Valley of California, *M. apicalis* appears more eurythermal than native megachilid bees and, in addition to nesting in riparian zone and marsh habitats, successfully reproduces in hot, dry grassland habitats that provide summer conditions surpassing native bee larva stress tolerance. Such a broad range of habitat use suggests that *M. apicalis* populations contain either a generalist genotype or genetic variants suited for diverse habitats. To compare the genetic diversity of invasive versus native *M. apicalis*, we examined the genetic diversity of samples collected from an invasive population on Santa Cruz Island (USA) and the Aegean Island of Lesvos (Greece). Bees collected at two or three sites on each island were genotyped for 658 bp of the cytochrome oxidase subunit I (COI) mitochondrial DNA locus. Leafcutting bees on Santa Cruz Island carried identical COI haplotypes whereas those on the Island of Lesvos yielded three COI haplotypes. While samples from mainland populations may reveal different results, similar samples of two island populations support the hypothesis that invasive populations of *M. apicalis* have lower genetic diversity than native populations of this species.
These long-term measurements. was fitted with a microphone which continually sampled calls over the
Hyla versicolor
200 captive male gray treefrogs (measured these variables over a two-month period from a group of nearly
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acoustic advertisement signal, the length of which affects its attractiveness to
characteristics. In gray treefrogs, males produce an energetically expensive
mating success than are values of particular advertisement call

extended breeding seasons suggest that the number of nights during which
sexual characteristics. This issue is particularly salient in species with
tradeoffs, snapshot measures of sexually-selected traits may be inadequate
reproductive effort and residual reproductive value. As a result of such
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reproductive effort and residual reproductive value. As a result of such
tradeoffs, snapshot measures of sexually-selected traits may be inadequate
to understand the strength and direction of selection acting on secondary
sexual characteristics. This issue is particularly salient in species with
extended breeding seasons; for example, previous studies of anurans with
extended breeding seasons suggest that the number of nights during which
an individual participates in a breeding chorus is a stronger predictor of
mating success than are values of particular advertisement call
characteristics. In gray treefrogs, males produce an energetically expensive
acoustic advertisement signal, the length of which affects its attractiveness to
females. In order to understand how allocation to various aspects of
reproductive effort influences selection on male mating displays, we are
testing for phenotypic and genetic correlations among call characteristics,
nightly calling effort, chorus participation and season-long calling effort. We
measured these variables over a two-month period from a group of nearly
200 captive male gray treefrogs (Hyla versicolor) resulting from artificial
crosses. Frogs were housed individually in an outdoor array, and each
cage was fitted with a microphone which continually sampled calls over the
two-month period. We will present preliminary results of calling behavior from
these long-term measurements.

The concentration of oxygen in the atmosphere has strong effects on adult
body size in a variety of animals, including fruit flies, Drosophila
melanogaster. Prior experiments have indicated that lower oxygen levels
lead to linear decreases in the body size of fruitflies while hyperoxia (40% oxygen)
increases size. However, all of these prior studies have reared fruitflies in bottles of fly populations, precluding clear differentiation of
phenotypic plasticity from evolution occurring within a single generation. To
address this concern, we reared fruitflies individually under 7 test oxygen
levels (10%, 16%, 21%, 24%, 27%, 31%, 40%) and measured adult mass.
Hypoxia suppressed body size, but body sizes of all flies reared at 21% oxygen
and above were identical. These data suggest that prior studies
indicating phenotypic plasticity of fly body size in response to hyperoxia may
have instead been indicative of rapid evolution. Supported by NSF
HRD-0114712 (WAESO at ASU) and NSF IOS-0619704 (JFH).

Sexually-selected traits are often costly to produce or maintain. Because of
these costs, investment in sexual attractiveness may come at the expense of
survival or energetic allocation to other aspects of reproductive effort. These
costs may therefore lead to life-history tradeoffs between current
reproductive effort and residual reproductive value. As a result of such
tradeoffs, snapshot measures of sexually-selected traits may be inadequate
to understand the strength and direction of selection acting on secondary
sexual characteristics. This issue is particularly salient in species with
extended breeding seasons; for example, previous studies of anurans with
extended breeding seasons suggest that the number of nights during which
an individual participates in a breeding chorus is a stronger predictor of
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acoustic advertisement signal, the length of which affects its attractiveness to
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cage was fitted with a microphone which continually sampled calls over the
two-month period. We will present preliminary results of calling behavior from
these long-term measurements.

Phenotypic plasticity of body size in response to atmospheric oxygen
in Drosophila melanogaster

P1.106 HUNTER-SMITH, Sarah; HUANG, Liquan; HIEBERT, Sara M*; Monell Chemical Senses Center, Swarthmore College; sieber1@swarthmore.edu
Fatty acid taste receptor expression during cold-induced changes in
dietary lipid preference in Mus musculus

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Phenotypic plasticity of body size in response to atmospheric oxygen
in Drosophila melanogaster

P1.135 HUGGINS, T.; LICORISH, R.; CARROLL, M.A.; CATAPANE, E.J.; Medgar Evers College, Kingsborough Community College;
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p-Aminosalicylic Acid Blocks Manganese from Impairing the
Dopaminergic Innervation of the Gill of the Bivalve Mollusc,
Crassostrea virginica

Previous work in our lab showed that treating Crassostrea virginica for 3
days with μmolar concentrations of manganese (Mn) impaired the
cilio-inhibitory innervation of the gill which is mediated by dopamine neurons
originating from the cerebral and visceral ganglia of the animal. High levels of
Mn are neurotoxic to people and cause Manganism, a Parkinsons-like
disease. Clinical interventions for Manganism have not been successful.
Recently, p-aminosalicylic acid (PAS) was reported to provide effective
treatment of severe Manganism in humans. The present study sought to
determine if the effects of the 3 day treatments with Mn could be decreased by
cotreating animals with PAS. Animals were treated with Mn (500 μM),
PAS (50 and 500 μM), or PAS plus Mn, for 3 days. Control animals were
similarly treated without Mn or PAS. Beating rates of the lateral cilia of gill
epithelial cells were measured by stroboscopic microscopy of gill
preparations which had the ipsilateral visceral ganglia attached (VG
preparations) and then tested by superfusion of the visceral ganglia with
dopamine and serotonin. Short term treatments with Mn resulted in a dose
dependant impairment of the dopaminergic, cilio-inhibitory system, which is
in agreement with our previous work. Cotreating animals with Mn and PAS
significantly decreased the neurotoxic effects of Mn. The study shows that
PAS can protect the animal against the neurotoxic effects of Mn and that this
preparation is useful as a model to study Mn neurotoxicity and the
pharmacology of drugs affecting it. This work was supported in part by grants
2R25GM06003-05 of the Bridge Program of NIGMS, 0516041071 of
NYSDOE, and 0822197 of the DUE Program of NSF.
Perceptual modeling of egg color mimicry in cuckoo-host coevolutionary arms races

Coevolution between the common cuckoo, Cuculus canorus, and its passerine host has resulted in a female parasite laying eggs in nests of other birds, matching the eggshell coloration of the host that she most frequently parasitizes. This apparent visual mimicry reduces the chance that hosts recognize and reject foreign eggs. Past research used the human visual system or instrumental measures of light reflectance to assess the extent of color-mimicry by cuckoo eggshells. We used sensory modelling of the avian visual system to test if color matching by cuckoos is representative of coevolved perceptual mimicry. We studied eggs from three cuckoo host-races, from Hungary, the Czech Republic and Finland, together with a non-host species. We tested the alternative hypotheses that egg color matching between cuckoos and hosts is due to (i) shared habitat or (ii) shared eggshell structure, rather than owing to (iii) coevolutionary selection on mimetic coloration. The avian-perceived match between cuckoo egg colors was closer between the parasites and respective hosts compared to non-host species. In contrast, eggshell structure, as measured by shell thickness, was consistently similar amongst cuckoos compared to hosts and, thus, independent of cuckoo-host evolutionary interactions. These results strongly support the (iii) coevolutionary arms-race hypothesis.
**P3.16 IVANINA, Anna*; KUROCHKIN, Ilya; EILERS, Sike; SOKOLOVA, Inna; University of North Carolina at Charlotte, University of North Carolina at Charlotte, Hochschule Bremen, Bremen, Germany; alivanina@unc.edu**

**Effect of cadmium and environmental anoxia and re-oxygenation on metabolism of eastern oysters (Crassostrea virginica).**

Heavy metal pollution is a worldwide problem, and cadmium (Cd) is an important toxicant in estuarine and coastal environments. Alternating hypoxia/anoxia and re-oxygenation during the tidal cycle is a common stress in the marine intertidal zone, but physiological consequences of these cycles and effect of Cd contamination in intertidal organisms are not fully understood. We have studied the effects of air exposure (1-6 days) and the subsequent recovery in normoxic water on metabolism of control and Cd-exposed intertidal bivalves, the eastern oyster (Crassostrea virginica). Determination of hemolymph oxygen content (PO2) indicates that oysters become anoxic very rapidly (after 10-20 minutes of air exposure). The hearts also stopped beating in air-exposure oysters indicating cessation of the tissue hemolymph supply. During air exposure control and Cd-exposed oysters accumulated anaerobic end products (succinate, acetate and L-alanine) in tissues, but the concentrations of anaerobic metabolites were significantly higher in control oysters compared to the Cd-exposed ones indicating lower anaerobic capacity in Cd-exposed oysters. There was a significant decrease in ATP levels and ATP/ADP ratio during the air exposure. Concentration of tissue metabolites (including anaerobic end products and adenylylates) returned to the control levels after 12h of re-oxygenation in control but not in Cd-exposed oysters. These findings show that in presence of Cd the metabolic response of oysters to anoxia and subsequent recovery of upon reoxygenation are inhibited. Supported by NSF CAREER (IBN-0347238).

**P3.174 IYENGAR, EV*; PETCHLER, E; HUTCHINSON, KA; Muhlenberg College; iyengar@muhlenberg.edu**

**He is heavy & he aint my brother: Marine snails catching a ride**

Symbiotic interactions beg the question as to the degree to which the guest has specialized on a particular host and the relative costs and benefits of the association to each participant. On San Juan Island, Washington, the suspension-feeding marine snail Crepidula adunca is found almost solely residing in a characteristic, external location on the body whorl of the snail host Calliostoma ligatum. Numerous other hosts are available, including Margarites pupillus, a sympatric snail in the same taxonomic family as Calliostoma with a similar shell shape. Field transects indicated that individuals of Crepidula in the San Juans reside on Calliostoma more than on any other host. The incidence of infection across sites ranged to >80%, with an average epibiont load of up to >3 individuals per host, representing an addition of >7% of the body weight of the host. In laboratory choice experiments, individuals of Crepidula preferred Calliostoma hosts to the other common potential hosts, including hermit crabs in Calliostoma shells. Crepidula did not show a preference for intact versus sanded Calliostoma shells. These results suggest that the cue used by Crepidula to identify an appropriate host is likely from live Calliostoma tissue or is in Calliostomas shell and rapidly degrades post-mortem. In general, predators (two species of sea stars, two species of crabs, one snail) did not eat many Calliostoma, whether they were infected with Crepidula or not. Thus, Crepidulas presence does not confer a protective benefit to Calliostoma against the common predators. This symbiotic interaction is likely parasitic, as the additional weight and surface area from Crepidula epibionts likely result in energetic costs for the Calliostoma host and no benefit for the host has been identified.

**P3.81 JANANANDA, B.G.*; WIKRAMANAYAKE, A.; BUTLER, M.; University of Miami, University of Hawaii at Manoa; bhagya@bio.miami.edu**

**Molecular Evolution of Damselfly Opsin Genes**

In the Hawaiian archipelago, Megalagrion damselflies have radiated, entering new breeding habitats independently at least six times and have evolved bright body coloration numerous times. We are investigating whether they have undergone visual system adaptations to shifts in the light environment. The visual pigments or the opsins are a group of light-sensitive, membrane-bound G protein-coupled receptors found in photoreceptor cells of the retina of the eye. Variation in amino acid sequences of the visual pigments is one potential source of variation in visual sensitivity among photoreceptors. We will examine amino acid changes and whether they are correlated with or precede habitat shifts. We cloned and sequenced the cDNAs of ultraviolet (UV) absorbing rhodopsin of five different Megalagrion species using RT-PCR. The UV sequences, each encoding 387 amino acids are 72-73% identical to the UV absorbing rhodopsin of Apis mellifera. Even among these very closely related species, we find several synonymous and nonsynonymous substitutions. We will test for adaptive evolution in different domains of the opsin protein, and whether evolutionary changes are correlated with shifts in light habitat and body coloration.

**P3.196 JANKOWSKI, Mark D*; FRANSON, J Christian; HOFMEISTER, Erik; Los Alamos National Laboratory; mdjankowski@lanl.gov**

**How might changes in corticosterone levels in breeding greater-sage grouse affect immunity?**

Greater sage-grouse (GRSG, Centrocercus urophasianus) populations are thought to have decreased by up to 93% since pre-settlement times. Male GRSG participate in spring mating rituals that involve intraspecific competition and reduced feeding. We investigated whether cattle grazing could be a stressor by studying GRSG fecal corticosterone (CORT) concentrations in exposed and unexposed populations. We found that CORT was higher in exposed GRSs compared to control GRSs. Field trapping allowed for the collection of immune samples from both populations. CORT and antibody concentration were negatively correlated in male GRSG. Higher CORT was associated with lower antibody concentrations. CORT has been shown to suppress antibody production, and we found that CORT levels negatively correlate with antibody levels. The relationship between CORT levels and immunity is likely to be complex, and we need to investigate the relationship between CORT and antibody production in greater-sage grouse populations.
Mammichog (Fundulus heteroclitus) from Cape Cod have a lower frequency of spontaneous ovarian contractions than has been reported from a Delaware population.

It is well established that the ovaries of teleost fish spontaneously contract. However, the purpose of these contractions is not well understood largely because there is so much variability in the frequency, amplitude, and timing of the spontaneous ovarian contractions between different species of fish. Our lab has been working with Danio rerio (zebrafish) and Fundulus heteroclitus (mammichog) to try and elucidate the purpose of these contractions. We have previously reported the presence of spontaneous contractions in the zebrafish and lack of regular spontaneous contraction in a northern population of mammichog. Both of these findings led us to the conclusion that there is indeed some reproductive role for spontaneous ovarian contractions in fish. We are currently presenting data that indicate that the Cape Cod population of mammichog that we are working with has a much lower frequency of spontaneously occurring ovarian contractions in sexually mature fish than has been reported in their southern counterparts (southern Delaware). Both the northern and southern populations are strongly responsive to Acetylcholine, indicating they are both capable of contracting. The fact that the northern population generally lack spontaneous contractions indicates that function of these contractions may have little importance in the mammichog further confusing our understanding of the role of spontaneous ovarian contractions in fish. Additionally, the current study points to physiological difference in the reproduction of the northern and southern populations of mammichog in the past behavioral differences were primarily noted.
Does Maternal Stress Alter Egg Composition?

Ozone ($O_3$), a highly reactive gas, is a common air pollutant in many urban settings and in adjacent wildlife habitats. Acute $O_3$ inhalation causes airway inflammation and decreased lung function, with effects more pronounced in exercise and other factors that elevate metabolic rate. In previous studies with amphibians and reptiles exposed to $O_3$, we noted decreased breathing rates and reduced oxygen consumption at rest. We tested whether an acute $O_3$ exposure (4 h) would affect specific dynamic action (SDA), the increase in metabolism associated with food processing in animals. Metabolic rates for 15 toads (mean ± SD body mass at start of experiment: 108 ± 31.0 g) were estimated from rates of carbon dioxide ($CO_2$) production and oxygen ($O_2$) consumption at 30 C by open-flow respirometry (flow rate = 100 SCCM) over seven days. After an initial 24 h period to estimate standard resting metabolic rates (SMR, mean ± SD: 4.7 ± 2.86 ml CO$_2$/h), toads were force fed canned dog food (crude protein 8%, fat 3%, water 78%) approximately 10% of body weight and returned to the metabolic chamber for the next 24 h of metabolic recordings. On the third day, toads were randomly assigned to control (air) or $O_3$ (0.8 parts per million, flow rate = 5 liters per min) for 4 h at 30 C, then returned again to metabolic chambers for an additional 5 days of metabolic recordings. Peak $CO_2$ rates increased by a factor of 4.6 in the next 24 h and 6.1 over SMR by 48 h. Individual differences in CO$_2$ production were significantly repeatable ($P < 0.001$); however, we found no significant differences between air and ozone-exposed toads in SDA ($P = 0.129$, split-plot rank ANCOVA). Therefore, acute exposure to $O_3$ had little or no effect on the obligate postprandial increase in metabolism.

Linking organic pollutants to tumor growth in arrow goby, Clevelandia ios, in Morro Bay: Proteomics as a tool for biomarker discovery

Morro Bay is a marine sanctuary on the central coast of California. It is considered a pristine ecosystem; showing little contamination from urban or agricultural inputs. However, our preliminary studies have shown a high incidence of primordial gonadal and liver tumors in arrow goby, Clevelandia ios, collected from the mudflats in Morro Bay. This is indicative of persistent organic pollutants: chemicals that are found in extremely low levels in water and are not easily detected by traditional water quality methods; however, they do harmfully accumulate in organisms. Through chemical analysis we found high levels of 4-nonylphenol in arrow goby tissues, as well as in sediment and water from the bay. Nonylphenol is a persistent end product of the biodegradation of alkylphenol ethoxylates, a group of chemicals that are used as surfactants in household and commercial products. Previous data on persistent organic pollutants in Morro Bay is been limited because detection by existing water testing regimes is deficient, though the biological effect is present. Therefore, new sensitive tools for measuring the biological response to wetland contaminants are urgently needed before detrimental effects such as tumors or reproductive impairments occur. We are developing a tool via proteomics to identify biomarkers of chemical contamination. Through in-lab exposure to nonylphenol, and two-dimensional gel electrophoresis we can track the simultaneous changes in expression of hundreds to thousands of arrow goby liver proteins. We will identify proteins of interest with mass spectrometry; and though the arrow goby is not a model organism, we have already successfully identified several proteins using MALDI-TOF-TOF mass spectrometry. Once developed, such biomarkers can then be used to as an early detection to announce the presence of emerging pollutants.

Does Maternal Stress Alter Egg Composition?

Many studies have shown that treating females with hormones can alter the phenotype of their offspring. These phenotypic effects could be due solely to changes in hormone levels in the eggs. Or, hormonal treatment of females could cause them to alter the composition of their eggs, which could then affect offspring phenotype. These hypotheses are not mutually exclusive, but to date most studies have overlooked the possibility of egg compositional changes. In a previous study, we treated female tree lizards (Urosaurus ornatus) with a pharmacological dose of corticosterone, the primary hormone involved in the stress response, and found that eggs from treated females had less egg mass but were not different in size. In this study, we treated females with a physiological level of corticosterone to determine if it affected egg composition. We found no significant differences in any of the egg compositional aspects measured - average egg mass or size, water content, or amount of lipids, proteins, or salts. These results suggest that offspring phenotypic effects due to maternal treatment with corticosteroids are primarily caused by hormonal changes in the eggs and not changes in egg composition.
A novel cellular marker for temperature stress in marine invertebrates

In the context of global climate change the need to assess the effects of heat stress in marine organisms is increasing. Heat shock proteins (HSP) are frequently used as an indicator for heat stress, but there is often a time lag of several hours between the actual heat stress and detectable up-regulation of HSPs. For identifying an earlier stress indicator, we investigated whether AMP-activated protein kinase (AMPK), a regulator of cellular energy, is activated by temperature in the rock crab, Cancer irroratus. Crabs were exposed to a fast temperature increase (6°C/hour) and heart tissue was sampled every 2°C between 12 and 30°C. Righting reaction times, AMPK activity, total AMPK protein and mRNA, HSP70 protein and mRNA, and lactate accumulation were measured. There was no detectable change in righting response up to 18°C. Above 18°C, reaction time slowed, and AMPK activity increased. At 28°C, there was a loss of righting response, an onset of anaerobiosis, indicated by lactate accumulation, a peak in AMPK activity, and a slight increase in HSP70 mRNA expression. The combination of reduced motor activity, biochemical and molecular markers can be used to characterize temperature thresholds in the context of Sheffords law of tolerance. We propose that the onset of AMPK activity and reduced motor activity at 18°C, coinciding with the average maximum temperature where the animals were collected, indicates the transition from the optimum range, into a range between optimum and pessimum, defined as the pejus range. Therefore, AMPK activity is a cellular marker that can detect temperature stress in a marine invertebrate earlier than HSP70, and may serve as a tool for detecting temperature stress in other invertebrate species as well.

Effects of hyperoxia and intubation of spiracles on oxidative stress in pupae of the moth Antheraea polyphemus.

It has been hypothesized that the air-filled tracheal system of insects has such a high capacity for gas exchange that oxygen supply at rest has to be shut down to prevent excessive oxidative stress. Therefore, insects possess spiracular valves, which control gas exchange between atmosphere and tracheal system. When the spiracles are closed, insects consume oxygen from the tracheal space, reducing intratracheal oxygen partial pressure (PO2) and perhaps oxidative stress. In this study, we tried to assess the antioxidative function of spiracular control in moth pupae. In one group of animals, we intubated the first three pairs of abdominal spiracles, forcing them to remain constantly open. For 24 hours, we exposed untreated and intubated pupae to either 21% O2 (normoxia) or 40% O2 (hyperoxia). We measured CO2 release rate to control for changes in metabolism and spiracular function. Pupae revealed cyclic, but not discontinuous CO2 release. After exposure we separated the pupae in three sections: front (head, pro- and meso-thorax), center (meta-thorax and part of abdomen with intubated spiracles), and rear (mobile part of abdomen with untreated spiracles). We measured H2O2 production (radical production), total antioxidant capacity, and protein carbonyl concentration (oxidative damage) in the three parts. Neither intubation nor exposure to hyperoxia had a significant effect on any of the parameters between treatment groups. There was, however, a significantly smaller concentration of H2O2 and antioxidant capacity in the frontal section compared to the other sections. We suggest that there are either morphological or biochemical differences between frontal section and the rest of the body. We also suggest that 24h blocking of spiracular closure is either not a significant oxidative stressor for with cyclic rather than discontinuous CO2 release or that oxygen supply is reduced by other mechanisms, like water-filled tracheoles.
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IMMUNOFLUORESCENCE LOCALIZATION OF AQUAPORIN DURING SALINITY ADAPTATION

During adaptation to changes in salinity osmoconforming intertidal and estuarine molluscs utilize a comprehensive suite of strategies to maintain osmotic homeostasis. Behavioral methods temporarily delay contact between cells and altered environmental salinities while physiological mechanisms modulate the concentration of intracellular free amino acids to equilibrate the concentration of intracellular and extracellular osmolytes. We are hypothesizing that during the process of physiological salinity adaptation in the ribbed mussel Geukensia demissa, the water permeability of cell membranes is modulated by trafficking aquaporin water channel proteins from the cell membrane to intracellular vesicles, effectively reducing potential water flux between the extracellular and intracellular compartments, allowing more time for adjustment of the intracellular solute concentration. We are developing immunofluorescence microscopy procedures to visualize the subcellular location of aquaporin-2 in mussel gills. Gills from mussels maintained at 15°C and 15%/ooS were excised and incubated at 15°C and 30%/ooS with aeration. Samples were fixed, embedded in paraffin and sectioned (5 microns) at 0, 30, 60, 120 and 180 minutes following salinity transfer. One set of slides was stained with hematoxylin and eosin for brightfield microscopy while a second set was exposed to an anti aquaporin 2 antibody followed by a secondary antibody conjugated to the fluorescent dye Alexa Fluor 568 and examined by fluorescence microscopy at 1000X magnification. Immunofluorescence preparations omitting the primary anti AQP antibody were used as controls, allowing tentative intracellular localization of the aquaporin protein. Supported by CSU AAUP and Student Faculty Research Grants to MAK.

P3.207 KAWARASAKI, Y.*; YI, S.-X.; LEE, ; Miami University, Oxford, Ohio; kawaray@muohio.edu

Rapid Cold-Harding Protects Against Cold-Induced Apoptosis: Role of Bcl-2 Protein

Rapid cold-hardening (RCH) describes an extremely swift acclimation response to low temperature stress. A brief acclimation to a moderately low temperature dramatically increases insect survival to a subsequent cold exposure that would be lethal otherwise. Recently, it was reported that chilling injury induces apoptotic cell death, while the RCH response significantly reduces the number of apoptotic cells. The possible involvement of anti-apoptotic Bcl-2 protein family was proposed since RCH preserved its expression level of these proteins, while it was reduced by cold shock. We investigated the protective role of the Bcl-2 protein, Buffy, against cold-induced apoptosis during RCH, using a mutant strain of Drosophila melanogaster that lacks expression of this Bcl-2 protein. This mutant strain showed significantly lower survival (5.4 +/- 2.1%) after a cold shock treatment of -5.5°C for 2 h, compared to wild type flies (65.7 +/- 4.8%). In addition, the RCH response in the Buffy mutant strain was compromised; in wild type flies, RCH (-6°C for 2 h) significantly increased survival after cold shock from 0% to 81.6 +/- 5.5%, whereas survival rates only increased from 0 to 16.0 +/- 5.2% in the Buffy mutant strain. The TUNEL assay was used to determine whether the reduced capacity for RCH was associated with increased apoptosis in the Buffy mutant strain. In addition, Western-blotting was used to investigate how cold shock and RCH treatment affects the protein expression of this Bcl-2. Our initial results suggest that the anti-apoptotic Bcl-2 protein plays a role during RCH for protection against cold-induced apoptosis. Supported by NSF grant 0917794, IOS-0817911.

P1.15 KELLY, CD.*; JENNIONS, MD; Iowa State University, Australian National University; cdkelly@iastate.edu

Sexually dimorphic immune response in the harem polygynous Wellington tree weta, Hemideina crassident

Adult males are often less immunocompetent than females. One explanation for this is that intense sexual selection causes males to trade-off investment in immunity with traits that increase mating success. We tested this hypothesis in the Wellington tree weta (Hemideina crassident), a large, sexually dimorphic orthopteran insect in which males possess enormous mandibular weaponry that are used to fight for access to female mates. Field-collected males had a significantly greater immune response (greater melanotic encapsulation) than females, suggesting that body condition, longevity or an allied trait is important to male fitness or that females require materials for egg production that would otherwise be used to boost immunity. Although immunity is expected to trade-off against reproductive traits in both sexes, there was no significant relationship between immune response and weapon or testes size in males nor fecundity in females.

P2.111 KAWANO, S.M.*; SCHOENFUS, H.L.; MAE, T.; BRIDGES, W.C.; BLOB, R.W.; Clemson University, St. Cloud State University; skawano@clemson.edu

Comparative Morphological Selection: Waterfall-climbing in Gobid Fishes from Dominica versus Hawaii

When closely related species are exposed to similar selection pressures, will they respond in similar ways? To investigate this question, we subjected juveniles of the amphidromous gobid fish Sigcycium punctatum from the Caribbean island of Dominica to climbing trials up an artificial waterfall (~100 body lengths) to evaluate body shape differences between successful and unsuccessful climbers, and then compared our results to those of previous studies on the closely related species Sicyopterus stimpsoni from Hawaii (Big Island). Failure rates were greater in fish from Dominica (>50%) than in fish from Hawaii (~30%). However, selection did not yield the same patterns between the two species. Although numerous morphological differences were found to be significant between successful and unsuccessful climbers in S. stimpsoni from Hawaii, calculations of selection differentials and gradients showed very few significant patterns of directional selection on morphology induced by climbing in S. punctatum from Dominica. The differing responses of Hawaiian and Dominican gobids may be related to differences in the selective pressures that have acted on these species through their evolutionary history. For example, while the waterfalls scaled by Dominican gobids are typically less severe than those scaled by gobids on the Big Island, Dominican gobids are exposed to in-stream predators that are absent above waterfalls on Hawaii. Our findings suggest that selection need not operate in a uniform manner amongst closely related groups, and that several factors might act to counter expected effects of natural selection on specific aspects of performance. Supported by NSF (IOS-0817794, IOS-0817911).
The 273 species of the Sciuoridae are exceptionally diverse in terms of the habitats they utilize and range from entirely terrestrial to strictly arboreal. These differences are reflected in their hand morphology- in arboreal squirrels the fourth digit is longest, while terrestrial squirrels possess a longer third digit. To test the hypothesis that hand morphology shows similar trends in a smaller, less ecologically diverse clade, we examined various proportions of hand bones within the largely terrestrial tribe Marmotini. We took digital x-rays of over 1,500 specimens representing roughly 50 species and digitized the lengths of all metacarpals and phalangeal bones. The ratio of the length of digit four to digit three varies in a way that is loosely tied to ecology at the intergeneric level. For example, the most terrestrial genus, Cynomys, possesses the smallest fourth to third ratio (0.86 +/- 0.02; N=84) while the semi-arboreal Tamias genus possesses the highest (0.97 +/- 0.03; N=183). However, hand proportions are not a consistently accurate predictor of ecology at the species level. The morphological data also fit well with the current taxonomic breakdown- the genera and super-generic groups are generally morphologically homogenous and distinct from the rest of the sampling. The recent breakdown of Spermophilus, sensu lato, into eight genera is supported by our findings in that the new genera are more morphologically homogenous than the previous grouping. Fluctuating asymmetry between the bones of the right and left hands was also investigated and found to be within the normal biological range. In summary, while hand proportions can be used to predict ecology as low as the generic level, the lower the taxonomic level the less consistent the trends and the less reliable the predictions.

**P3.150 KHAMBATY, M.; ECAY, T.W.*; STEWART, J.R.; East TN State Univ; stewart@etsu.edu**

**Carbonic Anhydrase II Expression in the Chorioallantois of the Corn Snake, Pantherophis guttatus**

The shell of oviparous reptile eggs provides a substantial amount of calcium to the developing embryo. In corn snakes, the eggshell provides 28% of the calcium in hatchlings with the remainder coming from yolk. The chorioallantois contributes to calcium homeostasis during embryogenesis by mediating the transport of shell calcium to the embryo. Shell calcium is in the form of crystallized calcium carbonate deposited primarily on the outer surface. Our objective is to understand how the embryo regulates dissolution and transport. While many studies have looked at the neurobiology, physiology or behavioral ecology associated with female sexual behavior, these different processes have yet to be integrated into a single model system. Using the cichlid fish Astatotilapia burtoni, we examined the endogenous factors that regulate female sexuality on a finer temporal scale by relating circulating hormones levels to changes in oocyte maturation and female affiliative and choice behavior. Even though females overwhelmingly chose to spawn with large males (N=95, p<0.001), their association behavior does not reflect their eventual choice until the day of spawning. In addition to the observed change in association preference, the amount of time spent in a mating bower (p<0.001) and the number of spawning. In our first experiment, we assessed predation among 4 different habitat types, which differed in forest characteristics and bird abundances. Birds were found to be the most common predator. However, there was no difference in predation among the 4 habitats, suggesting that predation on O. pumilo does not differ with forest structure or predator density. In our second experiment, we examined the importance of color and shape, with regard to the aposematic signal of O. pumilo, by examining predation rates between red and brown-colored, frog and ball-shaped plasticine models. Our results demonstrate that bird predators can distinguish between different colored and shaped models, and suggest that both color and shape are important in the aposematic signal of O. pumilo.

**P3.191 KIDD, M.R.*; HOFMANN, H.A.; Univ. of Texas at Austin; mkidd@mail.utexas.edu**

**Hormonal Regulation of Female Sexual Behavior in a Cichlid Fish**

Female sexuality is regulated by levels of circulating hormones mediated by the preoptic-hypothalamic axis. While many studies have looked at the neurobiology, physiology or behavioral ecology associated with female sexual behavior, these different processes have yet to be integrated into a single model system. Using the cichlid fish Astatotilapia burtoni, we examined the endogenous factors that regulate female sexuality on a fine temporal scale by relating circulating hormones levels to changes in oocyte maturation and female affiliative and choice behavior. Even though females overwhelmingly chose to spawn with large males (N=95, p<0.001), their association behavior does not reflect their eventual choice until the day of spawning. In addition to the observed change in association preference, the amount of time spent in a mating bower (p<0.001) and the number of receptive circles performed (p<0.001) by a female increase sharply on the day of spawning. Temporal patterns of circulating hormones 17beta-estradiol (E2), testosterone (T), progesterone (P), and prostaglandin F2 alpha (PGF2) are consistent with those of other vertebrates, yet the occurrence of consecutive hormone peaks within only the last week prior to spawning was surprising. Additionally, while both E2 and T are thought to decrease as levels of circulating P increase, our results suggest that P and T peak at the same time (~4 days pre-spawning). The surge in testosterone precisely coincides with a dramatic increase in female aggression towards unattractive males. Finally, none of the canonical hormones associated with female sexual behavior (E2, T, P, PGF2) are elevated at the time of spawning (rather, they are in a state of marked decline). These results provide novel proximate insights into mate choice behavior.
A technique for measuring multiple hormones from individual water samples using commercial enzyme immunoassays

Understanding the relationship between hormones and behavior requires the concurrent examination of multiple hormones. However, repeated blood sampling can impact the very behavior under study and compromise the subjects overall condition, particularly in small animals. Also, hormones released into the water by teleost fishes can play a role in schooling, migration, alarm reactions, behavioral and physiological responses during reproduction, and parent-offspring interactions. Consequently, the non-invasive analysis of hormone levels in fish holding water using either radioimmunoassay or enzyme immunoassay (EIA) is becoming increasingly common, yet few studies measure more than one hormone at a time. Commercial EIAs for different hormones often rely on different assay buffers, which can make measuring multiple hormones from the same water sample difficult, if not impossible. Using the African cichlid fish *AstrototilaTa burtani*, a major model system for the analysis of the molecular, endocrine and neural mechanisms underlying socially regulated plasticity in brain and behavior, we first introduce a procedure that allows the measurement of 17beta-estradiol (E2), testosterone (T), progesterone (P), and progesterone f alpha (PGE) from a single concentrated water sample using commercial EIAs. We validate this approach by correlating waterborne levels of these hormones with the circulating levels obtained from plasma samples of the same animals. Waterborne hormone levels correlate strongly with plasma values for E2 (r = 0.87), T (r = 0.61), P (r = 0.801) and PGE (r = 0.736). This technique can be applied in any aquatic species and will serve as a powerful tool for elucidating the hormonal regulation of behavior.

Gait diversity in juvenile labroid fishes

Juveniles of a number of labroid fish species, specifically pomacentrids, scarids, and labroids, use pectoral fin-based locomotion during steady swimming. At low speeds they alternate the pectoral fins and they use synchronous pectoral fin movement at high speeds. Above a critical speed they tuck the fins and power swimming with axial bending alone. We examine swimming gaits in juveniles of a related group, the cichlids. Cichlids also belong to the suborder Labroidae, and their morphological diversity provides opportunities to examine locomotor variation across a diverse range of morphologies and ecologies. We hypothesize that juvenile *Labeotropheus* sp. would use the same locomotor modes as juveniles of other members of Labroidae. Young fish were obtained from a local breeder. Fish were filmed at 250Hz in a flow tank at a range of speeds. A ventral view was used to determine fin/axial patterns and a lateral view was used to determine the location of the fish in the water column. Juvenile *Labeotropheus* exhibited an alternating pectoral fin gait at low speeds and transitioned to a synchronous pectoral fin gait at higher speeds. Both gaits were coordinated with axial undulation. In the alternating gait, pectoral fin movement was 180° out of phase with caudal bending. During synchronous pectoral fin movement, each tail beat cycle was associated with two pectoral fin beats so that each pectoral fin was alternately in phase and 180° out of phase with caudal bending. While there are similarities between the pectoral fin gaits of juvenile *Labeotropheus* and other labroid species, coordination of the pectoral fin with the body axis differs markedly indicating that there is considerably more diversity of swim coordination patterns in juvenile labroids than previously described. Supported by NSF grant IBN0238464 to MEH.

Taxonomy and Phylogeography of Hippocampus kuda in Hawaii

The spotted seahorse *Hippocampus kuda* is widely considered a species complex with poor taxonomic resolution. In addition to the biological importance, the entire genus *Hippocampus* is listed on CITES Appendix II, so it is crucial that species are indentified accurately when enacting conservation regulations. Preliminary molecular and morphological data from throughout the range do not support the conclusion that *H. kuda* is a complex, but rather a single morphologically variable species with a deep evolutionary history. In Hawaii, as with other populations throughout the Pacific, there is debate on the taxonomy of *H. kuda*, with a range of opinions being expressed from recent aquarium introduction to distinct species. The purpose of this study was to determine if populations of *H. kuda* in Hawaii are in fact an endemic or not and if not to generate hypotheses for the source and timing of Hawaiian colonization. Seventeen *H. kuda* seahorses were gathered from sites around the island of Oahu, Hawaii and sampled by removing tiny portions of skin from the tail. DNA was extracted and mitochondrial Cytochrome b and 16S genes were sequenced to reveal that, unlike any other location sampled to date, all 17 seahorses were of the identical haplotype. Haplotype diversity (h) of *H. kuda* throughout the Indo-Pacific excluding Hawaii averaged 0.72 compared to a haplotype diversity of 0.0 in Hawaii. Based on a range-wide survey, the Hawaiian haplotype appears unique to Hawaii, but well within the *H. kuda* lineage, and is one mutation removed from a common haplotype found in Japan and the Philippines. These data indicate that the spotted seahorse in Hawaii is *H. kuda* but we cannot infer the age or origin of colonization with these data.
P3.151 KLEIN, T. A.; ROSTAL, D. C.; WILLIAMS, K. L.; FRICK, M. G.; PAIGE, J. I.; Georgia Southern University, Caretta Research Project, Caretta Research Project, U.S. Fish and Wildlife Service; talkelein65@yahoo.com
Seasonal Variation and Maternal Investment of the Loggerhead Sea Turtle Caretta caretta
Female loggerhead sea turtles Caretta caretta were studied on WASAW and Blackbeard Island National Wildlife Refuge and in 2008 nesting season. Nesting activity occurred from May until early August. Nest hatching occurred from July to September. The incubation period for loggerheads in Georgia is typically ~60 days. A total of 30 different nesting females and different aspects of their nests were studied (10 early, 10 mid, 10 late season nests). Nest depth, clutch size, egg size, mean nest temperature, and hatching size were compared. Temperature data loggers were placed in the center of the nests and temperature was recorded every 2 hours until hatching occurred. Twenty eggs were measured from the 30 nests. Six eggs per clutch per clutch were collected for composition analysis from WASAW Island. Nests that were expected to hatch were monitored for hatching emergence. Upon emergence, the straight carapace length, width, and depth for up to 20 hatchlings was recorded from all nests with data loggers. It has been observed that while larger females tend to have larger eggs and clutches, that within females, egg size decreases as season progresses while clutch size remains the same. The measuring of egg and hatching components could shed light on how biological and physical traits of loggerhead nest environments affect embryonic development.

P3.130 KLOHR, RC; KRAJNIAK, KG*; Southern Illinois Univ. Edwardsville; klohr@siue.edu
The Systematic Effects of Neurochemicals on the Alimentary Canal of the Earthworm Lumbricus terrestris
In this study we examined the effects FMRFamide and acetylcholine on each individual segment of the alimentary canal. Each region was carefully dissected, attached to a transducer and suspended in a worm saline tissue bath. A series of applications of these drugs were administered at concentrations (1 pM to 10 M), and the percent change in amplitude and rate were measured and recorded. In the pharynx neither acetylcholine nor FMRFamide caused reproducible data. Treatment of the esophagus with FMRFamide elicited an excitatory response in amplitude with a concentration (0.01 to 1 nM) and a decrease in amplitude at concentration (10 nM to 1 M). The esophagus showed no change in rate except at 100 nM FMRFamide when it was excitatory in each trial. The crop and gizzard, examined separately, each showed a concentration dependant excitatory reaction in both rate and amplitude to increasing concentrations of FMRFamide (1 nM to 10 M). The same peptide applied to the intestine had an inhibitory effect in amplitude (0.01 nM to 1 M) with no change in rate. Acetylcholine applied to the esophagus caused a biphasic response that was excitatory in amplitude at low concentrations (0.01 to 0.1 nM) and an inhibitory at moderate concentrations (1 to 10 nM) followed by another excitatory response at high concentrations (100 nM) before becoming inhibitory again. The rate showed no change throughout the experiments until the neurotransmitter eliciting an excitatory response at higher concentrations (100 nM to 1 M). The response to acetylcholine of the crop and gizzard was excitatory for both amplitude and rate with a threshold of 10 nM. The intestine showed an overall inhibitory effect when acetylcholine was applied.

P3.76 KNUTIE, S.A.*; PEREYRA, M.E.; University of Tulsa; sarah-knutie@utulsa.edu
The relationship between stress hormones and life history strategies during the non-breeding season in three species of cardueline finches
Birds residing in temperate areas during the winter are often confronted with unpredictable weather conditions, reduced resource availability, and shorter days leaving less time to forage. The physiological and behavioral changes necessary to cope with these conditions are mediated in part by glucocorticoids, which enable survival and help increase fitness. Elevated glucocorticoids, which are necessary to cope with these conditions are mediated in part by corticosterone during periods of food deprivation or adverse weather events. Corticosterone during periods of food deprivation or adverse weather events are often associated with increases in foraging and locomotor activity, which may translate into local irruptive movements in some species. Several species of cardueline finches can be found wintering in the south-central Great Plains, a region characterized by highly unpredictable and somewhat extreme conditions. Two of these species, the pine siskin (Carduelis pinus) and purple finch (Carpodacus purpureus) are nomadic, rarely returning to the same wintering areas in successive years. They often partake in sporadic irruptive migrations, which may be related to exogenous cues such as decreased resource availability and adverse weather events. Other species of cardueline finches such as the American goldfinch (Carduelis tristis) are only semi-nomadic during the winter. We investigated the relationship between size, body condition and corticosterone levels (baseline and acute response to stress) in relation to season, annual cycle, and adverse weather events in purple finches, pine siskins, and American goldfinches. In December 2007, Oklahoma experienced a severe ice storm, which destroyed or damaged large numbers of trees. Blood samples were collected the days before, during, and following the storm. Differences in stress physiology between the three species of cardueline finches during the non-breeding season will be discussed.

P1.143 KOBHEY, RL*; HOSHIZAKI, DK; GIBBS, AG; Univ. of Nevada, Las Vegas, NIDDK, National Institutes of Health; kobhey@unlv.nevada.edu
The Effect of Melanization on Desiccation Resistance and Thermotolerance in Drosophila melanogaster
Previous research with the genus, Drosophila, has identified variations in cuticle melanization along gradients of elevation and latitude. Melanization of the cuticle is the result of incorporation of quinones into the cuticle and produces a darker-body phenotype. These quinones react to form cross-links between proteins in the cuticle and may also be polymerized to form melanin. It has been hypothesized that melanization is an adaptation to both low-temperature stress and desiccation stress (water stress). Cross-linking of proteins may make the cuticle more hydrophobic, thus reducing the rate of transpiration through the cuticle. The darker-body phenotype associated with melanization is also hypothesized to increase cold hardiness by allowing the animals to absorb more heat from solar radiation. Evidence in favor of this hypothesis has been obtained for larger insects, such as butterflies and beetles, but the hypothesis has not been tested in insects as small as Drosophila. We are testing mutations that produce lighter or darker body phenotypes to determine if melanization contributes to desiccation resistance and/or cold hardiness in Drosophila melanogaster. Supported by NSF award IOS-0719591 to D.K.H. and A.G.G.
Environmental Proteomics: Acute salinity stress in the marine model organism Ciona savignyi.

The ascidian Ciona savignyi, a model marine invertebrate organism, was exposed to hypoosmotic conditions to analyze tolerance toward hypoosmotic stress. C. savignyi is a species of sea squirt commonly found on pilings of harbors and marinas in the northeast Pacific. Heavy winter rains and subsequent run-offs expose C. savignyi to changing salinity conditions. C. savignyi is an ideal organism for study as its genome has been sequenced and annotated, and as a chordate it is a close relative to vertebrates. Tracking the global changes in protein expression in C. savignyi is a pivotal step in describing the physiological processes that protect animals against cellular damage in response to acute salinity stress. The organisms were exposed to decreasing salinities, 100%, 85% and 70% (sea water), for 6 hours. After exposure to hypoosmotic conditions, specimens were brought back to 100% salinity to recover for 4 hours. Organisms were dissected to remove the tunic, and 2D SDS-polyacrylamide gel electrophoresis was performed on the whole organism to separate proteins and generate protein expression profiles. Gels were scanned and analyzed with a 2D gel image analysis software (Delta2D, DECODON) to compare expression levels of proteins between treatment groups and the control (100% sea water). Comparisons using a 1-way ANOVA with a p-value of 0.05 led to the identification of 19 spots divided among three activity clusters. It is hypothesized that these proteins play a role in the tolerance toward hypoosmotic stress in C. savignyi. Further analysis with MALDI TOF-TOF mass spectrometry will allow for the identification of these proteins and help us determine which role they play in the physiological response to decreasing salinity.

P3.145 KORINE, C; DANIEL, S; PINSHOW, B*: Ben-Gurion University of the Negev, pinshow@bgu.ac.il
Frugal energy use by Hemprich's long-eared bats († Otonycteris hemprichii) during pregnancy and nursing

We hypothesized that the energy balance of breeding female Hemprich's long-eared bats Otonycteris hemprichii bats is shaped by a trade-off between the requirements for embryo or pup growth, and the mothers own need to use torpor to save energy and water. We used indirect calorimetry to measure metabolic rates (MR) of pregnant and nursing bats over a range of ambient temperatures. Mass specific MR of euthermic bats decreased from 22.95 mWg⁻¹ to 5.04 mWg⁻¹ as ambient temperature increased from 15 C to 33 C, and was not different from that of non-reproductive female bats. We estimated daily energy expenditure (DEE), taking into account the costs of foraging and roosting in pregnant and nursing bats. DEE increased by 54%, from late pregnancy (54.74 kJ/day⁻¹) to peak lactation (84.23 kJ/day⁻¹). This increase was smaller than the 78% - 182% increase measured with doubly labeled water in other insectivorous bat species. The proportion of DEE invested in maternal care by mother bats was about 30%, in the range found in other insectivorous bat species (28% - 32%). Our data indicate that the increase in DEE of female O. hemprichii during reproduction is relatively small compared to other insectivorous bats, which may be advantageous in desert habitats.

P3.167 KOSTELANETZ, Sophia A.*; DICKENS, Molly J.; BUTLER, Luke K.; ROMERO, L. Michael; Tufts University; sophia.kostelanetz@tufts.edu
Effects of chronic stress during molt on the heart rate and heart rate variability of European starlings

Chronic stress (CS) is the physiological condition of over-stimulation of coping mechanisms to chronically repeated noxious stimuli. Previous studies have looked at glucocorticoid levels during molt and stress. This is the first study to investigate the effect of chronic stress during molt on heart rate (HR) and heart rate variability (HRV) in captive European Starlings (Sturnus vulgaris). Each of 16 birds was implanted with a heart rate monitor to collect electrocardiograms. Three weeks after molt began, all birds were exposed to 18-days of chronic stress. Changes in HR and HRV were analyzed during two daily time periods: daytime and nighttime. Preliminary data show that during the daytime, there were no statistical changes in HR. However, HRV decreased with the onset of a molt, with no subsequent change during CS. The decrease in HRV indicates a shift from parasympathetic to sympathetic control of HR with the onset of molt, with the same balance remaining throughout CS. In contrast, during the nighttime HR goes up with the onset of molt, with no subsequent change during CS. HRV did not change both with the onset of molt and throughout CS. Because there was no decrease in HRV, the data suggests that the increase in HR is being driven by changes in parasympathetic not sympathetic input. Previous data have shown that CS has a dramatic impact on HR and HRV of non-molting birds, but here we show that molting birds have an attenuated response to CS.
**Hysteresis in Force Production of Bodywall Muscle of Larval Diptera**

We describe neuromuscular hysteresis - a strong dependence of muscle force production on recent motoneuron activity - in the bodywall muscles of larval Diptera, including Sarcophaga and Drosophila. In semi-isolated nerve-muscle preparations, we show that force produced by a train of nerve impulses at a singular rate is significantly different than that produced by the same train of stimuli when preceded by a brief (< 200 ms) high frequency burst of impulses. The increased force could not be explained by a change in electrical junction potentials (EJPs) between the two impulse trains; EJPs were not statistically different before or immediately after the high frequency burst. Both single muscle and semi-intact preparations exhibited hysteresis similarly, suggesting that the mechanics of non-contractile tissue is not central to the mechanism of hysteresis. Hysteresis was most dramatic at low impulse rates - yielding ~100% increase in force predictions based on constant-rate impulse trains - and decreased in a consistent manner as impulse rate increased. The frequencies at which hysteresis was greatest correspond well to the range observed under normal physiological conditions. In an attempt to more closely model physiological activation, we modulated nerve frequency in a sinusoidal fashion across rates close to those during normal, rhythmic behavior. Each successive cycle of these modulations yielded a slightly decreased, but still notably positive hysteretic force loop. These force loops illustrate the difference between force produced while frequency was increasing and that produced while it decreased. Our hope is that this initial characterization provides a foundation upon which the underlying mechanism of this non-linearity can be investigated.

**Evidence of senescence in a branchiopod crustacean, Branchinecta lindahl, living in a highly unpredictable environment**

The longevity of ephemeral aquatic environments can be highly unpredictable due to variations in precipitation, temperature, and humidity. Small pools are especially sensitive to environmental conditions and are typically colonized by animals adapted for rapid maturity and reproduction. Selection for early reproduction can have negative effects on other traits such as late reproduction and longevity, resulting in senescence. *Branchinecta lindahl* is a species of fairy shrimp that commonly colonizes small disturbed pools, such as roadside ditches. These pools are known to dry unpredictably, occasionally killing actively reproducing populations of *B. lindahl*. It is unknown if *B. lindahl* females exhibit reproductive senescence. Daily egg production in female *B. lindahl* was measured in the laboratory to determine if senescence occurs, and if females display a trade-off between early reproduction and late reproduction and survival. Preliminary results indicate that egg production decreases towards the end of the lifespan in a subset of female *B. lindahl*.

**Decreased phenotypic plasticity in a trait undergoing extreme selection**

Directional selection can cause the mean value of a trait averaged across environments to change. However, the effect of such selection on phenotypic plasticity of the trait is not clear because plasticity and mean trait values may be controlled by different mechanisms. The spadefoot toad Scaphiopus couchii has evolved extremely short larval periods to survive highly ephemeral desert pools from ancestors using long lasting pools. To examine evolutionary change in plasticity in age and size at metamorphosis in response to pond duration, we reared individual tadpoles of *S. couchii* and its relatives *Spea multiplicata* and *Pelobates cultripes* in the lab at two water volumes and two temperatures starting at three developmental stages. All species accelerated development in the low water level treatment, but at the expense of reduced growth in *Sp. multiplicata* and *Pb. cultripes*, but not *Sc. couchii*. The percent increase in development rate and percent decrease in growth rate due to low water volume were greater in *Spes* and *Pelobates* compared to Scaphiopus at all stages and temperatures. Our results indicate that *Sc. couchii* has lower plasticity in age and size at metamorphosis in response to small water volumes compared to other two species. Nevertheless, *Sc. couchii* has remarkable habitat tracking in nature to achieve the largest body size possible for a given short duration pond, often leaving the pond the day before pond drying. Thus, our results do not favor the idea that ephemeral breeding ponds of *Sc. couchii* are predictably short thereby favoring reduced plasticity. Rather, our results support the hypothesis of a mechanistic connection between regulation of larval period trait values and plastic responses to the environment.
P3.20 KULLEPERUMA, Kethika*; JIMENEZ, Lizandra; DOOLEY, James K.; Adephi University, Mt. Sinai Cytogenetics Lab; dooley@adephi.edu  
Malacanthidae and Branchiostegidae, based on the mitochondrial genes 16S and cyt.b genes  
Two hypotheses exist: 1. tilefishes are monophyletic and belong to a single family (Malacanthidae) and two subfamilies Malacanthinae and Branchiosteginae and 2. the fishes are polyphyletic and warrant being assigned to the two families Malacanthidae and Branchiostegidae as a former morphological revision proposed. Fossil records date the group to the mid-Eocene 45 Ma. Tilefishes are a primitive benthic percoid group of fishes found world-wide in tropical to subtropical waters. They consist of five genera and 42 nominal species. These fishes are dimorphic, with one group, the elongate sandtilefishes, found in shallow to moderate sandy bottom depths (20-117m) while the other robust-bodied tilefishes are found in mud-sand bottom at greater depths (150-500m). Thus far, partial 16S (600 bp) and cyt.b (1000 bp) genes of 22 species have been sequenced for the first time and analyzed using PAUP, and MrBayes to generate a maximum parsimony (MP) and Baysian trees, respectively, PAUP maximum likelihood (ML) and neighbor-joining (NJ) analyses produced similar trees. The beryciform fish Beryx splendens was used as the outgroup. Bayesian analysis produced five clades with all but Lopholatilus and Hoplolatilus forming as generic specific clades. Hoplolatilus (12 extant species) was shown to consist of 2 clades somewhat supporting , the present Hoplolatilus sub generic arrangement. MP analysis also produced a five clade tree with all but Malacanthus and Hoplolatilus forming generic specific clades. Preliminary conclusions based upon molecular data support the hypothesis that the tilefishes are polyphyletic.

P3.26 KUROCKIN, IO*; IVANINA, AV; EILERS, S; SOKOLOVA, IM; University of North Carolina at Charlotte, Charlotte, USA, Hochschule Bremen, Bremen, Germany; iroklov@unc Charlotte.edu  
Effects of cadmium exposure on mitochondrial response to environmental anoxia and re-oxygenation in eastern oysters (Crassostrea virginica).  
Intertidal organisms are periodically exposed to limited oxygen availability followed by reoxygenation during tidal cycles, often in the presence of other stressors such as metal pollution, but the effects of these stressors on their metabolism are not well understood. We have studied the effects of anoxia caused by air exposure (1-6 days) with subsequent reoxygenation on mitochondrial function and nitric oxide (NO) levels in control oysters and in oysters exposed to 50 ug L^-1 of cadmium (Cd) for 30 days. Oxygen consumption of isolated mitochondria respiring on pyruvate, succinate, and TMPD decreased during air exposure but increased well above the normoxic levels during the first 6h of re-oxygenation in control (not exposed to Cd) oysters. Respiratory control ratios (RCR) decreased during anoxia and recovery in control oysters indicating a decrease in mitochondrial efficiency. In Cd-exposed oysters, a decrease in mitochondrial respiration or RCR during hypoxia was not significant, and the respiration burst in first hours of reoxygenation was completely abolished. NO content was significantly decreased and remained stable after 3 days of air exposure returning to the initial levels after 6 h of normoxic recovery in control oysters. NO level recovery was significantly delayed in Cd exposed oysters during recovery which correlated with the significantly lower activity of nitric oxide synthase in Cd-exposed oysters. These data suggest that cadmium may have an important effect on mitochondrial metabolism and on metabolic adaptations to periodic anoxia and reoxygenation during the tidal cycle in marine bivalves. Supported by NSF CAREER (IBN-0347238).

P1.41 KUMBUREGAMA, S*; WIKRAMANAYAKE, A; University of Hawaii at Manoa, University of Miami; shalika@bio.miami.edu  
Evolution of germ layers: insight from early Wnt signaling in a cnidarian  
The animal-vegetal (AV) axis, a character seen in most bilaterian eggs is crucial for germ layer segregation and gastrulation. This axis most likely played an important role in evolution of pattern formation in animal embryos, but its evolutionary origins are unknown. We use cnidarians, a sister group to bilaterians, to gain insight into evolution of the AV axis. In Nematostella vectensis, the AV axis is specified by localization of the Wnt pathway regulator Dishevelled (Dsh) to the animal pole of unfertilized eggs. Dsh activates Wnt/catenin signaling segregating endoderm from ectoderm. Additionally, Dsh signaling in the Wnt/PCP pathway regulates morphogenesis during gastrulation in Nematostella. We will discuss mechanisms that localize Dsh protein to the animal pole and how this protein selectively regulates cell fate specification and morphogenesis in Nematostella. Our results support the hypothesis that Wnt signaling played a critical role in germ layer segregation and gastrulation during animal evolution.

P3.25 KUSHNER, S.A*; GIBB, A.C; ARENA, A; FERRY-GRAHAM, L.A; Mansfield University of Pennsylvania, Northern Arizona University, Moss Landing Marine Laboratory; kushners@mounties.mansfield.edu  
Four-eyed fish (Anableps anableps) use the same jaw-opening movements to produce a distinct prey-capture behavior across environments  
Four-eyed fish, Anableps anableps, are native to northern South America and inhabit mangrove swamps. They swim at the water's surface so that their eye is bisected by the air-water interface, which allows a simultaneous view of both aerial and aquatic environments. A. anableps feed both in the water on aquatic organisms, and out of water on intertidal, terrestrial and even low-flying aerial organisms. In the laboratory, A. anableps were offered prey items (crickets) held on forceps both above (aerial) and below the surface of the water (aquatic). Using high-speed digital-imaging, we recorded and quantified five displacement variables and five timing variables associated with the head and jaw movements during the mouth-opening phase of prey capture in both environments (e.g. maximum gape, time to maximum jaw depression, etc.). Surprisingly, the relative timing and magnitude of these movements were statistically indistinguishable across environments. However, the time between mouth opening and prey contact was longer and strike velocity was more rapid when A. anableps were feeding on prey held above the surface. These results suggest that a single set of cranial movements is used to produce mouth opening in both environments, but the predator is physically closer to the prey-item when these movements occur underwater. The ram-suction-index (RSI) indicates that the movements of the neurocranium and jaws produce effective suction during aquatic feedings, but the same movements result in a ram-based prey capture during aerial feedings.

P1.55 KUSHNER, S.A*; GIBB, A.C; ARENA, A; FERRY-GRAHAM, L.A; Mansfield University of Pennsylvania, Northern Arizona University, Moss Landing Marine Laboratory; kushners@mounties.mansfield.edu  
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P1.132 LANGSTON, Jennifer; PIRES, Anthony*; Dickinson College; llangston28@yahoo.com

Regulation of Metamorphosis by Catecholamines in Larvae of the Polychaete Capitella sp. I

Recent work has indicated that catecholamines regulate the induction of metamorphosis in primitive and derived gastropods. We have begun to investigate the distribution of this developmental control mechanism in other lophotrochozoan taxa, by studying the effects of endogenous catecholamines on metamorphosis of the polychaete, Capitella sp. I. Immunolabeling for the catecholamine-generating enzyme, tyrosine hydroxylase (TH), revealed TH-immunopositive cells in apical regions of the prostomium, in the circumesophageal nerve ring, underlying the prototroch prostomium, and in the far posterior portion of the palatoquadrate. Given the close association of these structures with anatomical elements critical to feeding and respiration (e.g., mandibular and hyoid arch muscles, jaw cartilages), all of these areas represent functionally important regions of the chondrocranium. Primary areas of variation include the width of the muscular cartilaginous chondrocranium, the distance between the upper jaw articulation sites (= gape width), and the anatomy of the posterior portion of the palatoquadrate. Given the close association of these structures with anatomical elements critical to feeding and respiration (e.g., mandibular and hyoid arch muscles, jaw cartilages), all of these areas represent functionally important regions of the chondrocranium. Although little is known about the potential selective advantages (if any) of any of these anatomical variations, or their heritabilities, the existence of discrete, presumably genetically based intraspecific variation at this small scale satisfies one of the major requirements necessary for natural selection to act as an agent driving interspecific changes in tadpole morphology.

P2.102 LAKE, D.T.*; FRICK, M.G.; RAWSON, P.D.; ZARDUS, J.D.; The Citadel, Charleston, SC; Caretta Research Project, Savannah, GA; University of Maine, Orono; laked1@citadel.edu

Host-specific morphological plasticity obscures species boundaries in a commensal barnacle

Barnacles are familiar shoreline animals; however, less well known are the many species that live attached to other animals as obligate commensals. The four recent species of barnacles in the genus Chelonibia as adults are only found attached to marine vertebrates, crustaceans and molluscs: C. testudinaris and C. caretta attaching to sea turtles, C. manati to manatees, and C. patula to crabs and snails. Sharing similarities in form but varying in size and growth habits, these taxa have been deemed separate species at least since Darwin 1854 monograph on the Cirripedia. However, despite morphological differences these barnacles may in fact constitute a single species that exhibits different forms depending on host affiliation. To test this hypothesis, we compared genetic variation between specimens of Chelonibia collected from sea turtles, crabs, and manatees. DNA was extracted using commercially available kits and a portion of the mitochondrial gene cytochrome oxidase I (COI) was amplified through the Polymerase Chain Reaction (PCR). Resulting sequences were compared and analyzed phylogenetically. The results support our hypothesis in part, showing low or no genetic variation among C. testudinaris, C. manati, and C. patula but significant species-level divergence with C. caretta.

P2.49 LANGSTON, Jennifer; PIRES, Anthony*; Dickinson College; pires@dickinson.edu

Regulation of Metamorphosis by Catecholamines in Larvae of the Polychaete Capitella sp. I

Recent work has indicated that catecholamines regulate the induction of metamorphosis in primitive and derived gastropods. We have begun to investigate the distribution of this developmental control mechanism in other lophotrochozoan taxa, by studying the effects of endogenous catecholamines on metamorphosis of the polychaete, Capitella sp. I. Immunolabeling for the catecholamine-generating enzyme, tyrosine hydroxylase (TH), revealed TH-immunopositive cells in apical regions of the prostomium, in the circumesophageal nerve ring, underlying the prototroch prostomium, and in the far posterior portion of the palatoquadrate. Given the close association of these structures with anatomical elements critical to feeding and respiration (e.g., mandibular and hyoid arch muscles, jaw cartilages), all of these areas represent functionally important regions of the chondrocranium. Primary areas of variation include the width of the muscular cartilaginous chondrocranium, the distance between the upper jaw articulation sites (= gape width), and the anatomy of the posterior portion of the palatoquadrate. Given the close association of these structures with anatomical elements critical to feeding and respiration (e.g., mandibular and hyoid arch muscles, jaw cartilages), all of these areas represent functionally important regions of the chondrocranium. Although little is known about the potential selective advantages (if any) of any of these anatomical variations, or their heritabilities, the existence of discrete, presumably genetically based intraspecific variation at this small scale satisfies one of the major requirements necessary for natural selection to act as an agent driving interspecific changes in tadpole morphology.

P2.103 LARSON, PM*; RAABIS, S; BRICK, A; CORRIVEAU, J; HALL, H; LENIHAN, P; MAY, S; St. Anselm College; plarson@anselmedu

Intraspecific variation in chondrocranial morphology of wood frog tadpoles (Rana sylvatica)

This study investigates intraspecific variation in chondrocranial morphology among tadpoles derived from three wood frog (Rana sylvatica) egg masses collected from a single vernal pool. Results indicate that chondrocranial shape differs significantly among samples of tadpoles derived from the three egg masses, even when reared under identical laboratory conditions and matched for size and developmental stage. Thus, these results suggest that the variation observed is genetic in origin, and not simply due to environmental influences on the development of the tadpole chondrocranium. Primary areas of variation include the width of the muscular process of the palatoquadrate, the size of the palatoquadrate articular process, the distance between the upper jaw articulation sites (= gape width), and the anatomy of the posterior portion of the palatoquadrate. Given the close association of these structures with anatomical elements critical to feeding and respiration (e.g., mandibular and hyoid arch muscles, jaw cartilages), all of these areas represent functionally important regions of the chondrocranium. Although little is known about the potential selective advantages (if any) of any of these anatomical variations, or their heritabilities, the existence of discrete, presumably genetically based intraspecific variation at this small scale satisfies one of the major requirements necessary for natural selection to act as an agent driving interspecific changes in tadpole morphology.

January 3-7, 2009, Boston, MA
In this study, we employ two separate analyses in order to understand how population growth rate \((pgr)\) responds to changes in the population’s vital rates (rates of survival, growth, and fertility). Prospective analyses are commonly used to inform management decisions and ask the question: how would \(pgr\) change, given a change in one or more of the vital rates? Retrospective analyses examine how variation in \(pgr\) is expressed as a function of the (co)variation of the vital rates. This type of analysis can reveal how year-to-year variation in growth, survival, and fertility contributes to variation in \(pgr\). Our prospective analysis was achieved by developing a time-invariant, five-stage matrix model using 17 years of data collected on a wild population of Verreaux’s sifaka. Using this matrix model, we calculated sensitivity and elasticity values that capture the prospective dependency of how \(pgr\) would change, given a change in a vital rate. Our retrospective analysis draws from matrix models developed from the first half and last half of the 17-year dataset. From these matrices, we decompose variation in \(pgr\) into contributions from the variation in the vital rates. Our results show that \(pgr\) is most sensitive to transitions into maternity, and less dependent on survival and growth of reproductively immature animals. We also find that variation in survivorship of mothers contributes the largest amount to variation in \(pgr\). Our results suggest that the long-term viability of the sifaka population depends on recruitment of females into motherhood and is less dependent on the survival of pre-reproductive females.
**P2.43** LEE, E.M.; MCCAULEY, D.W.; University of Oklahoma, Norman; emcmaie@ou.edu

**Cartilage rescue in a zebrafish mutant following heterospecific expression of a lamprey SoxE gene**

Gene duplication is thought to be a driving force for generating novel evolutionary traits that have led to increased vertebrate diversity and complexity. The appearance of neural crest cells in the ancestral vertebrate has also been proposed to be a characteristic key to the evolution of vertebrates. Some vertebrate cartilages are derived from migrating chondrogenic neural crest cells. Expression of Sox9 in these cells regulates expression of Type II collagen, the major matrix protein in vertebrate cartilage. Sox9 is one of three SoxE transcription factors that arose as a result of gene duplication in the vertebrate lineage. Lampreys, the basal-most extant vertebrates also possess three duplicate SoxE genes, SoxE1, SoxE2, and SoxE3 whose expression patterns have previously been described by our group. Here we investigate the functional role of the lamprey (*Petromyzon marinus*) gene SoxE1 within the context of zebrafish (*Danio rerio*) cartilage development. The chondrogenic function of a SoxE gene might have been acquired in early vertebrates following duplication of the ancestral SoxE gene at the base of vertebrates. Here we show that the Jef110*zebrafish mutant missing a functional Sox9a gene and lacking cartilage, shows partial rescue of cartilage development following heterotopic expression of lamprey SoxE1 mRNA. Our data suggest that neural crest and chondrogenic functions of SoxE genes may have arisen prior to SoxE duplication at the base of vertebrates, but that the chondrogenic role was likely acquired by different SoxE paralogs present in agnathan and gnathostome vertebrates.

**P2.4** LEININGER, E.C.; KITAYAMA, K.; KELLEY, D.B.; Columbia University, New York, NY; eco2107@columbia.edu

**The evolution of neuromuscular systems for vocal behavior in the African clawed frog (Xenopus)**

African clawed frogs (*Xenopus*) vocalize to attract females and mediate male/male antagonistic interactions. Individual frogs rely on the temporal characteristics of calls to distinguish sex and reproductive state; these characteristics (particularly click rate) are also species-specific. To explore the origins of species differences in vocal signaling, we examined physiological properties of muscles in the vocal organ of *X. borealis* (a species with a slow, biphasic advertisement call) relative to *X. laevis* (a species with a fast, biphasic advertisement call). In *X. laevis*, female calls are slow and monotonous relative to male calls, and laryngeal muscle is sexually differentiated with respect to contractile speed, fiber number, fiber twitch type, and fiber recruitment. In *X. borealis*, a species where female calls can be as rapid as those of males, we report that while larynx weight and laryngeal muscle fiber size is sexually dimorphic, other characteristics such as fiber type, fiber recruitment, and the rates at which discrete tension transients can be produced do not differ between the sexes. This reduced sexual dimorphism is consistent with the greater overlap in click rate of calls from male and female *X. borealis*, compared to *X. laevis*. One mechanism that may contribute to reduced sexual dimorphism in *X. borealis* is reduced sensitivity to the masculinizing effects of androgen.

**P1.140** LEMA, S.C.; Univ. of North Carolina, Wilmington; lemas@uncw.edu

**Isolation and expression patterns of cDNAs for three vasotocin receptors and an isotocin receptor from a teleost, the Amargosa pupfish**

Arginine vasopressin regulates hydromineral balance, vasoconstriction and sociosexual behaviors in mammals, and the related hormone arginine vasotocin has been implicated to play similar roles in birds, amphibians and teleost fish. While three distinct receptors for vasopressin (V1a, V1b and V2) have been identified in mammals, only a single receptor has been found in teleosts. Here, cDNAs for vasotocin receptors were isolated and sequenced from the Amargosa pupfish (*Cyprinodon nevadensis amargosae*) - a species studied previously for vasotocin’s role in regulating aggression. Using degenerate primer PCR and 5’- and 3’-rapid amplification of cDNA ends (RACE), two full-length cDNAs encoding deduced sequences of 497 and 385 amino acid residues, and a third cDNA encoding a 325 residue partial open reading frame, were identified. The 497 residue cDNA exhibited highest identity (49.0-57.4%) to V2-type vasopressin/vasotocin receptors of mammals and amphibians, and lower identity to V1a (37.8-39.6%) and V1b (41.1-41.9%) receptors. The cDNA encoding 385 amino acids had greater identity to V1a-type receptors from mammals and amphibians (58.6-62.6%) than to V1b (51.5-53.5%) and V2 (38.6-45.0%) receptors. Similarly, the partial cDNA for 325 residues also showed greater identity to V1a receptors from mammals (56.7-58.5%) and amphibians (59.5-61.5%), than to either mammalian V1b (54.7-55.4%) or V2 (40.9-42.1%) receptors. A fourth full-length cDNA encoding an isotocin receptor of 395 amino acids has also been identified from this pupfish. Future characterization of the function and expression regulation of these receptors will provide new insights into the evolutionary and functional diversity of the vasotocin/vasopressin and isotocin/mesotocin/oxytocin receptor families in vertebrates.

**P2.14** LEMASTER, MP*; UHRIG, E; MASON, RT; Western Oregon University, Oregon State University; lenamastm@wou.edu

**Temporal Variation in the Female Sexual Attractiveness Pheromone of the Red-sided Garter Snake, Thamnophis sirtalis parietalis**

Female garter snakes produce and express a sexual attractiveness pheromone during the breeding season that elicits male courtship behavior. Composed of a homologous series of saturated and mono-unsaturated methyl ketones, this pheromone is expressed in the skin lipids of females. It has been observed that female snakes lose their attractiveness to males as the breeding season progresses. Here we present a study designed to determine whether temporal changes in the quantity and/or quality of the female sexual attractiveness pheromone are responsible for the observed loss of attractiveness utilizing the red-sided garter snake, *Thamnophis sirtalis parietalis*, as a model system. Female red-sided garter snakes were collected immediately following spring emergence and held under natural conditions (outdoor arenas) for the duration of the breeding season. Behavioral experiments demonstrated that females are significantly less attractive to males within two weeks of emergence from winter hibernacula. Subsequent chemical analyses revealed a significant qualitative difference in the relative concentrations of individual methyl ketones comprising the pheromone profiles between newly emerged females and females two weeks post-emergence. Together, these results support the hypothesis that changes in the female sexual attractiveness pheromone are responsible for diminishing post-emergence female attractiveness in garter snakes.
P3.195 LIEBL, Andrea L.; ALAM, Jennifer L.; MARTIN, Lynn B.; University of South Florida; liebl@mail.usf.edu
Rapid Quantification of the Bactericidal Capacity of Avian Plasma
Ecological immunology is an emerging field of biology, but progress has been slowed due to the availability of techniques. Bactericidal assays, which measure the capacity of blood and/or plasma samples to kill microorganisms, have been used extensively in the past several years because they are simple small sample of blood and minimal equipment is required to perform the assay. Our goal in the present study was to improve current techniques by reducing the amount of processing time, necessary blood/plasma volume, and the need to culture test samples overnight through the use of spectrophotometry (using a Nanodrop). Preliminary data indicate that the bactericidal capacity of house sparrow (Passer domesticus) plasma against E. coli using our approach is comparable to current methods. Ongoing studies are i) validating this approach for other microorganisms (e.g., gram-positive bacteria and fungi), ii) comparing whole blood versus plasma capacity, iii) assessing repeatability, and iv) ascertaining the effects of long-term storage on sample viability.

P3.143 LIN-YE, A; PANTAZATOS, S; GEDDIS, MS; AMBRON, RT; GOODMAN, RM; Columbia University, BMCC-CUNY, Columbia University; rmg5@columbia.edu
ELECTROMAGNETIC FIELDS PROMOTE REGENERATION FOLLOWING INJURY: INDUCTION OF INCREASED hsp70 LEVELS AND BINDING OF INJURY-SPESIFIC FACTORS IN THE MAPK CASCADE
Electromagnetic fields (EMFs) are used medically to promote tissue repair, but the molecular pathways by which this occurs are only beginning to be understood. EMFs are known to up-regulate the heat shock gene HSP70 but the molecular pathways by which this occurs are only beginning to be understood. EMFs are known to up-regulate the heat shock gene HSP70 and to induce elevated levels of hsp70 protein. The activation of HSP70 occurs through the binding of heat shock factor 1 (HSF 1) to a heat shock element (HSE) in the region of the HSP70 promoter that contains three nCTCTn consensus sequences. These sequences are distinct from the sequences involved in thermal response and do not respond to elevated temperature. In this set of experiments Planaria were transected equidistant between the head and the tail. Individual head and tail portions were exposed to a 60 Hertz 80 milliGauss EMF for one hour, 2x a day for 15 days post-transsection. The regenerating heads and tails were photographed and lengths were measured at 3-day intervals. In some experiments protein lysates were analyzed for hsp70 levels, doubly phosphorylated (pp)-ERK, Elk-1 kinase activity, and SRF-SRE binding, using either Western blot or EMSA. During the initial 3 days post-transsection, EMF exposure caused a significant increase in regeneration for both heads and tails -- more so for tails. Concurrently, EMF-exposed heads and tails exhibited an elevation in the level of hsp70 protein, activation of an ERK cascade and an increase in SRF-SRE binding. Our results indicate that a well-defined EMF promotes regeneration in Planaria accompanied by an increase in hsp70 levels and the activation of kinases and transcription factors that are typically associated with repair mechanisms. These findings provide insight into the clinical application of EMFs. Support provided by the Robert I. Goodman Fund.

P3.137 LIN, H.*; TRIMMER, B.A.; Tufts University; hua-li.lin@tufts.edu
Soft dynamics --- ground reaction forces in a crawling caterpillar
Most terrestrial soft bodied animals move by pressing against the substrate in carefully controlled sequences. However, lepidopteran larvae have well-developed limbs (the prolegs) that can be used for climbing in complex branched structures and on a variety of surfaces. The tobacco hornworm, Manduca sexta is therefore an excellent animal to study how limbed locomotion in soft-bodied animals compares to that of legged animals with rigid skeletons. In this study, we devised a method to measure the ground reaction forces (GRFs) in fifth instar Manduca at all contact points during crawling. A multi-sensor array was built to match the step pattern of the caterpillar and to measure the GRF exerted by each proleg with ±mN accuracy. By tracking individual proleg movements a GRF profile could be determined for each segment. During horizontal crawling different prolegs were found to have their own characteristic ground contact pattern with stereotypic crochet protraction. Remarkably, the crochets release their grip with negligible upward force. Simultaneous measurement of all proleg GRFs normal to the direction of travel revealed a rhythmic redistribution of body weight corresponding to the ground thrust during stepping. The work done by different prolegs could be estimated by following the moving center of mass and, by integrating the GRF data, we were able to deduce the effective momentum during various phases of locomotion. Similarly, from GRF loading rates, we obtained invaluable information about force propagation. These findings could help to understand how soft-bodied animals exploit internal dynamics to exert forces on their environment.

P3.135 LEYSEN, H.*; DUMONT, E.R.; ADRIAENS, D.; Ghent University, Belgium, Univ. of Massachusetts, Amherst; helen.leySEN@UGent.be
Stress distribution and morphological specializations in the feeding apparatus of a seahorse (Syngnathidae: Hippocampus reidi)
The family Syngnathidae (Gasterosteiformes) encompasses the pipefishes and seahorses. Syngnathid fishes are characterized by an elongated snout with small terminal jaws. They are extremely fast suction feeders, with a feeding strike characterized by a rapid neurocranial elevation accompanied by an equally rapid retraction of the hyoid. This results in prey capture times of even less than 6 ms. However, the long, tubular snout with small diameter also has its disadvantages, including a limitation on prey size and an increase in the moment of inertia of the head during dorso-rotation. Our longterm goal is to investigate the degree to which the extreme morphological specialization of the feeding system in syngnaths constrains its functional versatility. One of the limitations that the feeding apparatus may experience is that of mechanical overloading during the extreme accelerations of skeletal elements and the production of high suction forces. Since expansion of the buccal cavity generates a large negative pressure, this implies that a great amount of mechanical force is exerted onto the head. We completed a finite element analysis of the skull of Hippocampus reidi to determine where stress accumulates under the strong pressure generated during suction feeding. We hypothesized that structural adaptations would be present in regions of high loading, in order to dissipate stress and avoid skeletal damage. A thorough histological and morphological study of the regions and bones that are experiencing the largest mechanical stress during suction feeding, allowed us to test this hypothesis.
Further study is needed to determine the causal role that corticosteroids play in mediating the trade-offs we observed. Our correlative findings provide evidence that corticosteroids, often considered an accurate measure of response to environmental stress in animals and known to play a role in immune system function, body condition, and response to environmental challenges, for example. However, we do not know how all of these functions are allocated, particularly when an organism is confronted with environmental challenges. We examined the relationships between endoparasitism and the free-ranging population of tree swallows (Tachycineta bicolor) and three species of spionid polychaetes collected from False Bay, WA and Lowes Cove, ME. Traditional visual inspection underestimated the frequency of injury/regeneration by approximately 5-20% depending on the species. The utility and limitations of MG staining as an assay for faunal injury will be discussed.

The relationship between parasitemia and resource allocation in Tachycineta bicolor
Within-individual trade-offs in resource allocation exist because of constraints and limitations on those resources. Because of these constraints, an individual may be forced to trade off between investment in immune system function, body condition, and response to environmental challenges. For example, however, we do not know how all of these functions are linked and what mediates the trade-offs that occur between them. Addressing this question will provide insight into how resources are allocated, particularly when an organism is confronted with environmental challenges. We examined the relationships between endoparasitism and the free-ranging population of tree swallows (Tachycineta bicolor) and three measures of their resource allocation: white blood cell count, body condition, and corticosteroid levels. Results show that tree swallows with high parasitemia levels also had low body condition, a low heterophil:lymphocyte ratio, and high corticosteroid levels. These results suggest that in order to fight off parasite infection, tree swallows directed more energy toward their immune response and less energy toward maintaining body condition. Corticosteroid hormones, often considered an accurate measure of response to environmental stress in animals and known to play a role in immune responses, were elevated in birds with high parasitemia, and thus may play a role in mediating the trade-offs we observed. Our correlative findings provide evidence of the trade-offs that occur in organisms under stressful conditions. Further study is needed to determine the causal role that corticosteroids might play in mediating resource allocation.
P3.74  LOUDONVILLE, R.L.*; HEMLEPP, I.; COPELAND, C.; SCARBOROUGH, J.; University of Akron; londronville@uakron.edu
Response of leptin I and II to cold acclimation in carp.

Leptin is a small (16 kDa) peptide hormone that influences fat deposition, metabolic rate, satiety, reproduction, angiogenesis, bone density and immune function in mammals. Its study in basal vertebrates has been hampered by difficulty cloning the cDNA; however recent labs have had success for fish, including Fugu (Kurokawa and Suzuki, Peptides 26:745, 2005) and Cyprinus carpio (Huising et al., Endocrin. 147: 5786, 2006). Carp are the only vertebrates reported to date that express multiple isoforms of leptin. As temperate-zone fishes typically accumulate body lipid as they acclimate to temperatures, we acclimated carp to 5°C and 25°C for 8 weeks to measure the response of each leptin isofrm to leptin exposure. Semiquantitative PCR indicates that cold exposure significantly increases mRNA expression of both leptin isoforms. Currently we are confirming these results with quantitative (real-time) PCR. These data indicate that the leptin signal in ectotherms remains coupled to adipose stores (both increase with cold exposure) as opposed to endotherms, where adipose stores increase while leptin decreases.

P3.159  LOUNSBERRY, Zachary*; SOARES, Daphne; University of Maryland, University of maryland; daph@umd.edu
Female choice of Betta splendens using a socially complex paradigm

What are the parameters used by females when choosing a mate? I chose to study the behavior of the siamese fighting fish (Betta splendens) to examine the underlying mechanisms that dictate female choice. Males of this species are known for their elaborated displays and violent fights, presumably investing their resources to influence mating success. Former studies have tested parameters such as fin length, body size, coloration, visual displays, and nest size. While it is likely a combination of these characteristics that ultimately causes the female to choose a mate, it has been shown that a female that eavesdrops on a fight between two males will almost certainly choose the winner over the loser. However, it is still unknown what other social parameters will influence B. splendens females, and here we ask whether familiarity is a factor. Is a female more apt to choose a male that she has lived with in a larger social group or one she has never seen before? Moreover, how does the importance of familiarity compare to the importance of fighting outcome? To help answer these questions, females from two socially raised clutches of B. splendens were given a choice between the males from their respective clutches or a completely novel male. The results strongly suggest a preference for an unknown male. This preference is checked against the importance of eavesdropping and other possible traits that influence female mate choices.

P1.93  LOUDON, S. J.*; ALDWORTH, Z. N.; DANIEL, T. L.; University of Washington; sloudon@u.washington.edu
Perturbing flight paths in Lepidoptera by inducing abdominal flexion

Insects use rapid body rotations during flight control. These rotations are generally considered to be initiated by the wings. Insects can also use the movement of other body parts, such as the head, legs or abdomen, to influence their flight path. A recent study in the crepuscular hawkmoth, Manduca sexta, has suggested that abdominal movements are used during tracking flight to cancel pitching and yawing motions initiated by the wings. However, it is unknown to what extent abdominal movements themselves can be used to initiate changes in the flight path. To address this issue we elicited abdominal movement in Manduca through electrical stimulation during loosely tethered flight in order to determine the extent of association between abdominal movement and changes in flight trajectory. We used multiple high-speed cameras to film the animals flight in a closed chamber under low-light conditions. Stimulation current was delivered using tungsten electrodes inserted through the ventral cuticle of the thorax. Four stereotyped body points were digitized from the flight sequences, and used to extract 3-dimensional flight parameters such as yaw and pitch, as well as the dorsal-ventral and lateral flexion rates of the abdomen. We then used correlation analysis to determine the relationship between the abdominal movement and the observed changes to the flight path. We consistently found abdominal movements and changes in flight posture following stimulation, and flexion data were correlated with the attitude changes at delays of between 500-750 ms. These results demonstrate that abdominal movements can be used in insect flight control.

P2.24  LONGORIA, A.*; AGUIERRE, P; FREDENSBORG, BL; University of Texas, Pan American; blfredenbor@utpa.edu
Living on the edge: A field study on the effect of salinity and parasitism on an intertidal gastropod

Physiological stress and parasitism are both important stressors affecting the abundance, diversity and composition of intertidal animal communities. However, rarely have the two stressors been studied in concert. This study investigated the effect of a naturally occurring rapid decrease in salinity on the density of plicate horn snails, Cerithidea pliculosa, and the prevalence (%) of larval trematodes (flukes) using the snails as hosts. Random collections of C. pliculosa were conducted on two separate occasions on three intertidal flats in Laguna Madre, South Texas. The density of snails was determined and >100 snails were dissected per site to determine the infection status of the snails. The first collection was conducted five days prior to the arrival of a category two hurricane (Hurricane Dolly). The second sampling event took place three weeks later. A drop in salinity was recorded in the study area due to substantial rainfall during the storm. No difference in the density of snails was observed for any of the three sites indicating that C. pliculosa is tolerant to variations in salinity. In one of the three sites, the prevalence of infection by larval trematodes decreased significantly (P = 0.012) suggesting that infected snails disproportionately were lost from the population. No difference in prevalence could be detected for any of the two other sites (P = 0.10 and P = 0.99), but the proportions of trematode species significantly differed between the two sampling events for all three snail populations (P = .025). In conclusion, occasional events of stressful conditions can influence host-parasite interactions but the outcome seems to be species specific. More studies are needed on the effect of physiological stress on host-parasite interactions.
Melatonin alters arginine vasotocin immunoreactivity in green treefrogs (Hyla cinerea).

The arginine vasopressin/vasotocin (AVP/AVT) system plays an important role in regulating sexual behavior, including mediating responses to socioeconomic stimuli. Although reproduction is regulated seasonally in many animals, few studies have investigated whether seasonal changes in reproductive behavior are concurrent with seasonal changes in AVP/AVT. Previous work in our laboratory demonstrated a seasonal increase in AVT-immunoreactive cell number in green treefrogs (Hyla cinerea). In the present study, we investigated whether melatonin mediates this seasonal change in AVT immunoreactivity. Treatment of green treefrogs with melatonin-filled silastic capsule implants for 4 weeks significantly altered AVT immunoreactivity, although these differences depended significantly upon sex. In male treefrogs melatonin treatment significantly increased AVT-immunoreactive cell number in the suprachiasmatic nucleus and caudal hypothalamus, while in female frogs melatonin did not significantly influence AVT immunoreactivity. Similar to previous studies, we also observed a significant sex difference in the number of AVT-immunoreactive cells in frogs treated with a blank implant, with female frogs having more immunoreactive cells in the suprachiasmatic nucleus and caudal hypothalamus than male frogs. These results indicate that the AVP/AVT system is an important target for melatonin in facilitating seasonal changes in reproductive physiology and behavior.

Flexural stiffness and composition of the propterygia of punting and non-punting batoids.

Benthic batoids perform a mode of locomotion termed punting, during which the pelvic fins are depressed into the substrate and then extended caudally to propel the body forward, while keeping the rest of the body still. Skates, which possess muscular and skeletal specializations for punting, and the lesser electric ray, Narcine brasiliensis, exhibit this true punting pattern. However, some benthic batoids, such as the Atlantic stingray, Dasyatis sabina, and the yellow-spotted stingray, Urolophus jamaicensis, have demonstrated an augmented punt, which also includes pectoral fin movements. In this study, our goal was to determine if these differing kinematic patterns relate to structural and compositional differences within the main punting skeletal element, the pelvic propterygium. In addition to the species listed above, the pelagic stingray, Pteroplatytrygon violacea, was also tested, as its life history suggests that the pelvic fins are not used for this benthic locomotion. We performed morphometric analyses, three-point bending tests, and compositional analyses. Our results show that the skate possesses propterygia with significantly higher second moments of area when compared to the other species tested. Propterygia of the true punters have approximately 80% greater flexural stiffness than the augmented punters (p<0.05). Moreover, propterygia of the augmented punters have almost twice the flexural stiffness compared to the non-punting pelagic stingray (p<0.05). For all species, we found that neither water nor mineral content are good predictors of flexural stiffness. This study demonstrates that the flexural stiffness of propterygium in benthic batoids may have evolved in order to resist the bending forces experienced during punting.
Estimating the cost of ventilation in zebra finches by increasing mechanical work

The cost of ventilation may be high in birds due to the large mass of the ventilatory system, which must be moved with every breath. To measure this cost we developed a mechanical method to increase the work of breathing in small, readily available zebra finches. Birds were surgically outfitted with velcro sutured to the distal end of the sternum, around the sternal ribs, and to the skin covering the synsacrum (back). A custom built mask with a screen pneumotach was used to measure ventilation, and oxygen consumption ($V_o_2$) was measured via flow-through respirometry. Weights of approximately 7.9 and 13% of body mass were added alternately to the sternum and back. The mass of the sternum and associated flight muscles in zebra finches is 14% of body mass. Mean oxygen consumption values for 3 minute periods were used to calculate minute ventilation, frequency, $V_o_2$. Preliminary results indicate that changing the location of these masses from the back to the sternum produced no change in $V_o_2$. Birds may have been forced to change their mode of breathing or their perching posture when faced with these loads. The actual cost of ventilation remains equivocal, nevertheless, this result potentially reveals plasticity in ventilatory mechanics of passerines, which allows birds to mitigate the cost of added sternal mass.

Net joint work as a function of speed in a small running bird, the chukar.

Little information is available on the mechanical work done at individual joints in small running animals. We calculated the net work done at the joints of chukars running over a force plate at approximately constant speeds ranging from 0.7 to 2.7 m/s. Using simultaneous high-speed video to measure joint kinematics and measures of segment properties, we calculated net joint work using 2-D inverse dynamics. As expected for constant-speed runs the positive and negative work summed across all joints were approximately equal. However, the individual joints showed large differences in the amount and sign of the work done. Positive joint work showed the highest values at the hip and the ankle, but, whereas the ankle showed an almost equal amount of negative work, very little negative work was done at the hip. Negative work predominates to varying degrees at the tarsometatarsal-phalangeal, and inter-phalangeal joints. Although, these values cannot be interpreted directly in terms of muscle work, they provide valuable guidelines regarding which muscles likely provide positive work and which are involved energy storage, and braking. Supported by NIH AR47337 and NSF I0B-0542795.

The sublethal effects of multiple acute cold exposure: lessons from Drosophila

Changes in snow cover and temperature with projected climate change will influence not only the mean temperatures that overwintering insects are exposed to, but also the frequency of freeze-thaw cycles. However, the majority of insect cold tolerance studies have focused on the effects of a single cold exposure, and the consequences of multiple cold exposure in insects have remained poorly elucidated. Two competing hypotheses are proposed: either chill injury is cumulative with increasing cold exposure regardless of intervals between exposures, or individuals are able to repair damage incurred during exposure allowing greater survival with repeated versus sustained cold exposure. We employed a Drosophila model system to gain a better understanding of the impacts of multiple cold exposure on metabolic fuels and fecundity. Adult virgin female flies were exposed to either a sustained (single ten hour) or multiple (five exposures, two hours each separated by 24 h) cold treatment at -0.5 degrees Celsius. Controls included treatments that examined the interaction between age and cold tolerance. Treated flies were assayed for total lipid, protein, and carbohydrate content. Total male and female offspring from treated females were also counted, allowing examination of sex ratio, fecundity, generation time, and intrinsic rate of increase. Initial results support the hypothesis that multiple cold is less deleterious than sustained cold.
P2.131 MARSHALL, S.L.;* WEIGAND, K.L.; DEAROLF, J.L.; Hendrix College, Conway, AR; marshall@hendrix.edu

Influence of betamethasone on the fast-twitch fibers of the external abdominal oblique in fetal guinea pigs (Cavia porcellus)

Glucocorticoid steroids are used to accelerate the development of various organs in fetuses before premature delivery. In the present study, the possible negative ramifications of the use of betamethasone, a glucocorticoid, on the expiratory external abdominal oblique muscle were considered. We hypothesize that exposure to betamethasone will result in a significant amount of muscle atrophy and significant decrease in the percentage of fast-twitch fibers in the external abdominal oblique. To test these hypotheses, pregnant guinea pigs were injected with betamethasone (0.5 mg/kg) or sterile water at 65%, 75%, and 85% gestation. Samples of the external abdominal oblique were then collected from all fetuses, cut using a cryostat, and stained for myosin ATPase activity. Images of the stained muscle sections were taken and fiber percentages were calculated. Scion Image was used to measure fiber diameter as well. The external abdominal oblique aids in a fetus’s ability to exhale carbon dioxide. In periods of stress, the fast-twitch fibers are recruited to exhale at a faster pace than normal conditions. A decrease in number or atrophy of the fast-twitch fibers would impair these muscles ability to contract with the same speed as a normal non-treated muscle. These side effects would hinder a preterm infant’s ability to cope with periods of respiratory distress. This inability to adapt could prove damaging or life threatening to the infant.

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Comparative Metabolic Biochemistry Of Shark Myocardial Tissue

Work on lamnid sharks (Family Lamnidae) has revealed their ability to undergo broad high-latitude migrations and rapid and repeated sojourns into depths below the thermocline. Both scenarios expose these fishes to cold temperatures. Lamnids have the ability to maintain their swimming muscles at temperatures above ambient (regional endothermy), and this quality may allow these sharks to sustain elevated muscle metabolic biochemical capacities when exposed to cold water. However, the lamnid heart does not benefit from regional endothermy and all myocardial tissues are at thermal equilibrium with ambient temperatures. Proper cardiac function is essential for providing lamnids with adequate supplies of oxygenated blood for maintained swimming muscle function. Thus, a heart that is exposed to prolonged cold or rapidly fluctuating ambient temperatures should be capable of maintaining elevated metabolic biochemical capabilities. The objective of this study was to compare the activities of citrate synthase (CS) and lactate dehydrogenase (LDH) in the myocardial tissue of lamnid and non-lamnid sharks at various temperatures in order to determine how enzyme activities are affected. Analysis shows that CS activity is significantly higher at 20°C for lamnid sharks (24.2+/-3.4 IU g⁻¹) relative to non-lamnids (12.6+/-1.5 IU g⁻¹). LDH activity is also significantly higher in lamnids (169.8+/-52.2 IU g⁻¹) relative to non-lamnids (109.6+/-19.6 IU g⁻¹). There was no significant difference in the thermal rate coefficients (Q₁₀) at 10-30°C between lamnids (1.58+/-0.4) and non-lamnids (1.56+/-0.2) for CS. The Q₁₀ values at 10-30°C for LDH also showed no differences between lamnids (1.71+/-0.3) and non-lamnids (2.22+/-0.4). It appears that lamnids have higher cardiac enzyme activities than non-lamnids, but are similarly affected by temperature changes.

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Responses of Blue Crabs to Hypoxia in Fresh Water

Previous work demonstrated that blue crabs (Callinectes sapidus) in saline waters respond to long term hypoxia by increasing hemocyanin concentration and oxygen transport properties. Additionally, researchers reported that under field conditions and lab simulations, hypoxia is accompanied by hypercapnia and low pH, affecting hemolymph pH. The present research examined responses of blue crabs to long term hypercapnic hypoxia in freshwater at 23°C. Hypoxic conditions (50-60 mmHg O₂) were induced by allowing the crabs to consume oxygen supply, resulting in a hypercapnic induced decrease in pH from 7.88 to 7.18. Post-branchial hemolymph oxygen and pH were measured in normoxia, after 24 hours of hypoxia and several days later. Within 24 hours, postbranchial hemolymph oxygen declined 46% to 79%, but post-branchial pH changes varied from -0.167 to +0.171 The initial responses to hypoxia demonstrates that blue crabs prevent extreme postbranchial hemolymph pH changes under acidic stress as well as maintain postbranchial oxygen tension. Despite the variation in postbranchial hemolymph among individual crabs, 86% mortality occurred during three days of hypoxia. The high mortality rate suggests the blue crabs are not able to survive the multiple stress of hypoxia/hypercapnia along with the stress of living in freshwater. It is not clear if the elevated mortality results from a failure of oxygen transport, acid-base balance or ion regulation. Supported by a Rice Center Graduate Student support grant to JTM.

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Reproductive demographics of syngnathid fishes inhabiting a human-altered landscape

Syngnathid fishes (pipefish and seahorses) are distinguished by their unusual brooding and mating systems. Due to their low mobility and high site fidelity, human alteration of the landscape may have dramatic impacts on their biology. This two year study investigated seasonal reproductive patterns of two syngnathid species, the gulf pipefish (Syngnathus scovelli) and the dwarf seahorse (Hippocampus zosterae) using a modified mark-recapture technique. Every 2-4 weeks, fish were collected via pushnet from 3 adjacent sites in Tampa Bay (FL), varying in their distance to open water within the system. This location was selected because of a nearby marina/housing construction project, which began six months into our study. Fish were marked, photographed, and released the same day to their collection sites. Our results indicate a large, flexible population with data for 5300 individuals. Reproductive demographics varied markedly across season in both S. scovelli and H. zosterae, with sex ratio cycling predictably in S. scovelli, but fluctuating dramatically in H. zosterae with season. Other sexual variables analyzed included habitat use by males and females (H. zosterae and S. scovelli), degree of sexual ornamentation in females (S. scovelli), and frequency of partial pregnancies in males (S. scovelli), all of which were found to vary across season. These results suggest the potential for environmental effects on the sexual selection landscape that may affect the availability of mates across season. Our results also indicate that population size and sexual ornamentation decreased and the frequency of partial male pregnancies increased across the study period, suggesting the possibility that degradation of environmental quality due to construction could have also impacted reproduction.
Effects of Hypoxia on the Development of the Digestive System and Metabolism of the Zebrafish

Hypoxia slows growth and development, and limits the survival of many fish species. Many studies in fish have shown a significant decrease in metabolic rate when exposed to hypoxia; a mechanism which permits fish to survive but may come at a cost. Whether a cost or benefit, data show that many fish species including zebrafish are smaller to their normoxic counterparts when reared in hypoxic water. Smaller body size could be directly related to the decrease in the metabolic rate, which may or may not be related to a decreased amount of food consumption. The development of the digestive system itself may also be delayed by hypoxia. Decreased blood flow to the gut, could easily lower caloric assimilation. The effects of hypoxia on the digestive system were studied in larval and juvenile zebrafish. Yolk volume, blood flow to yolk, gut and cloacal area, and heart rate were compared between normoxic and hypoxic zebrafish larvae. The larval experiments show that there is a lag in development of the digestive system and decrease in blood flow in hypoxic zebrafish. In juvenile zebrafish, metabolic rates were lower in hypoxic zebrafish. It is yet undetermined if food consumption and assimilation differ between the two groups.

Mucilage Antigenicity and Composition in Different Zooxanthella Strains

Zooxanthellae (genus: Symbiodinium) are brown, unicellular algae that reside intracellularly in most cnidarians and comprise at least 8 clades, each consisting of several strains. In this mutualism the endosymbiotic algae are within a symbiosome membrane (host and symbiont-derived) and donate photosynthetic products to their host in exchange for shelter and nutrients. Symbiodinium produce mucilage that surrounds the cells while within the symbiosome or as free-living algae. The specificity of this association is beginning to be understood; however, the importance of mucilage production has not been examined. The symbiosome membrane is the area of interface in this symbiosis and is presumably important in recognition and transfer of nutrients. Cultured Symbiodinium were labeled with a previously developed primary antibody that binds to symbiont mucilage (PC3) and visualized with a fluorescent secondary antibody on a confocal microscope to identify labeling. Mucilage contained PC3 antigen in cultured fluorescent secondary antibody on a confocal microscope to identify labeling. Mucilage contained PC3 antigen in cultured Symbiodinium were labeled with a previously developed primary antibody that binds to symbiont mucilage (PC3) and visualized with a fluorescent secondary antibody on a confocal microscope to identify labeling. Mucilage contained PC3 antigen in cultured

Effects of an experimental immune enhancement, rather than an immune challenge, in a wild bird

Experimental manipulations of the immune systems of wild birds most commonly take the shape of immune challenges. These challenges are intended to induce immune responses and to force tradeoffs among limited resources (e.g. energy). Instead of challenging birds, however, we endeavored to enhance immune function in nesting Eastern bluebirds (Sialia sialis). Immune enhancement was attempted by orally supplementing young birds with a lysozyme solution throughout the nestling period. Lysozyme, a natural antibacterial protein, functions by hydrolyzing cell-wall peptidoglycan, making Gram-positive bacteria particularly susceptible to its effects. This protein, produced by many animals, has been identified in avian blood and egg albumin. Furthermore, lysozyme concentrations are known to vary among individuals (in adults, nestlings, and eggs). We hypothesized that by providing nestlings with extra lysozyme we could increase this line of immunological defense without increasing the costs associated with its production. Furthermore, we hypothesized that the relative importance of lysozyme to nestling bluebird physiology will be reflected in concomitant effects on chick immune function, growth and development, and parental care. We collected and analyzed plasma samples to establish the degree to which lysozyme treatment impacts indices of immune function, we recorded body and feather measurements to determine the effects of treatment on nestling growth and development, and we quantified feeding rates to identify any compensatory adjustments in parental behavior in response to nestling condition. Preliminary results suggest immune enhancement affects some aspects of nestling physiology, while seemingly not others.

Effects of a clay cap on contaminants in water, sediments and macroinvertebrates of Kearny Marsh

Sediments contaminated by organic compounds, heavy metals, and other potentially toxic chemicals have accumulated in many of the worlds deepwater and wetland environments. This project investigated a new in situ capping technology that could be used to remediate and/or manage contaminated sediments. AquaBlok™ (AB) is a patented, composite-aggregate technology comprised of a solid core, an outer layer of clay material, and polymers. When placed in water and over sediment, AB hydrates forming a layer between contaminants in sediment and the overlying water. AB was placed in a marsh between July 25th and August 3rd of 2005. For water quality in May of 2006 the controls were lowest in temperature, DO, pH, and ORP. In August of 2006 the controls were highest in temperature and duplicate plots were split between the highest and lowest in DO, pH, and ORP. In October of 2006 a control was almost always lower in all parameters and AB was highest in all water quality parameters. In November of 2006 control temperatures, DO, and pH were the lowest whereas depth was highest. Total suspended solids were always similar in all plots as was number of benthic macroinvertebrates from cores which were low. The numbers were higher on the Hester-Dendys. For contaminants of concern (COC) in water, Cd was highest in the AB plots. Fe was highest in AB, and Pb was lowest in control plots and highest in the AB plots. Organic contaminants were lowest and highest in AB. COC in the sediment, metals and organic contaminants were highest in the control plots. These results suggest that AB is more effective in the removal of COC in sediment than it is in decreasing TSS, increasing diversity and abundance of macroinvertebrates, and removing Cd, Fe, Pb, and organic contaminants from the water column.
P1.32 MCCLINTOCK, James B.*; ANGUS, Robert A.; MCDONALD, Michelle R.; AMSLER, Charles D.; Univ. of Alabama at Birmingham; mcclintok@uab.edu

Ocean acidification and calcified Antarctic seafloor macroorganisms: The perfect storm

An important consequence of anthropogenic production of atmospheric CO₂ is the acidification of the worlds oceans. Antarctic seas are perhaps the most vulnerable anywhere due to: 1) an inverse relationship between dissolution rates of calcium carbonate and temperature, and 2) a preponderance of generally weakly calcified macroorganisms due to either the high cost of calcium carbonate production at low temperature and/or a lack of evolutionary selection for robust calcification due to the absence of shell-crushing invertebrate (crabs) or heavily jawed fish predators. Employing shells of the common Antarctic bivalves *Laternula elliptica* and *Yoldia eightsi*, the limpet *Nacella concinna* (with and without an encrusting coralline alga), as well as the brachiopterid *Loiothrya uva*, we measured rates of dissolution under conditions of ambient (pH 8.2) and acidified (pH 7.4) seawater (current models predict pH 7.4 in the world's oceans by the year 2200). Shells were cut lengthwise, weighed, and placed into 1-liter glass beakers with seawater that was aerated with different concentrations of CO₂ so as to regulate pH. Within 14 days shells in acidified sea water had lost their luster. After 5 weeks the shells and thallus of the coralline alga had suffered significant dissolution when compared to controls. Moreover, one of the shells of the bivalve *L. elliptica* in acidified seawater became so fragile it fragmented into multiple pieces. Our findings indicate that Antarctic calcified seafloor macroorganisms, and the communities they comprise, are likely to be the first to experience the cascading impacts of ocean acidification. Supported by NSF OPP#0442769 to JBM and CDA.

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Investigating the Species Boundaries Between *Platanthera zothecina* and *Platanthera sparsiflora*

The rare alpine bog orchid, *Platanthera zothecina*, has been recognized as a separate species from the widespread montane *P. sparsiflora* because *P. zothecina* has a larger column size, spur length, and larger, thicker leaves. We sequenced two different regions of DNA to test whether *P. zothecina* is, in fact, a distinct species from *P. sparsiflora*. Both regions showed little variation and grouped some populations of *P. zothecina* with populations of *P. sparsiflora*. The DNA data suggests that *P. sparsiflora* has adapted to low elevation springs in the desert multiple times and thus *P. zothecina* should more appropriately be treated as a low elevation subspecies instead of a distinct species.

P1.146 MCCORKICK, Stephen D.*; CHRISTENSEN, Arne K.; REGISH, Amy; USGS, Conte Anadromous Fish Research Center, Turners Falls, MA, Univ. of Massachusetts, Amherst; mccorkick@umext.umass.edu

Presence of a freshwater and a seawater isoform of Na⁺,K⁺-ATPase in the gills of a teleost fish

The sodium pump, Na⁺,K⁺-ATPase (NKA) in the gills of teleost fish is involved in ion regulation in both fresh water and seawater. The main catalytic subunit of NKA is the α subunit, and recent molecular studies indicate isoforms of this subunit may be differentially regulated by environmental salinity. We have developed and validated antibodies specific to the NKA -α1a and NKA -α1b isoforms of Atlantic salmon, and used Western blots and immunohistochemistry to characterize their size, abundance and localization. The abundance of gill NKA -α1a was higher in fresh water than in seawater, whereas NKA -α1b was more abundant after seawater acclimation. NKA -α1a was present in most chloride cells in fresh water on both the filament and lamellae, but largely absent in seawater chloride cells. NKA -α1b was present in a small number of filamental chloride cells in fresh water (that were distinct from cells with NKA -α1a), but was found in all of the large filamental chloride cells in seawater. The results provide evidence for salinity-specific isoforms of Na⁺,K⁺-ATPase that may have distinct functions for ion uptake and secretion. Preliminary data on the regulation of these subunits by cortisol will also be presented.
Effects of ocean acidification on larval development and settlement of the common intertidal barnacle Amphibalanus amphitrite

Increased levels of anthropogenic CO$_2$ released into the atmosphere are anticipated to result in the increased acidification of the world’s oceans. Marine invertebrates that produce calcified body parts may be particularly vulnerable. Barnacles are an ecologically important group of calcified marine invertebrates that are potentially vulnerable to acidification. We examined aspects of larval development (nauplii and cyprids) and juvenile settlement in the common intertidal barnacle Amphibalanus (=Balanus) amphitrite reared in ambient seawater (pH = 8.4) and acidified seawater (pH = 7.4) conditions. pH levels were regulated by bubbling air containing different concentrations of CO$_2$ into experimental and control beakers containing groups of 800 naupliar larvae each and fed diatoms (Skelotosema costatum). Development of nauplii and cyprids was significantly delayed in the 7.4 pH treatment. Moreover, fewer cyprids settled and metamorphosed into juvenile barnacles at pH 7.4. Our findings indicate that early development and juvenile settlement in A. amphitrite are negatively impacted by exposure to pH 7.4, a level of ocean acidification expected to occur in the next two hundred years.

Limb morphology and ground reaction forces in lizards: forelimbs vs. hindlimbs

Quadrupeds typically exhibit forelimbs and hindlimbs with different morphologies. These morphological differences are expected to be related to the demands of supporting and propelling the body. For example, running animals exhibit a period of braking force followed by accelerative force which is related to the differential function of fore vs. hind limbs. However, the morphological basis for differential function remains poorly understood. This study explores how morphological differences in the fore- vs. hindlimb are related to differences in individual limb ground reaction forces using a comparative approach. Musculoskeletal limb morphology was quantified for seven species of lizards. In addition, individual limb three-dimensional ground reaction forces (fore- or hindlimb) were quantified for each species as they sprinted down a 3-meter racetrack. Forelimbs exhibited net braking forces whereas hindlimbs exhibited net accelerative force. Surprisingly, lateral forces showed a phylogenetic signal: the four iguanian had hindlimb-dominated lateral forces whereas lateral forces were roughly equally distributed between fore vs. hindlimbs in the other species. These differences in fore-aft and lateral forces can be explained by the relatively greater length and mass of the hindlimbs in all species, with the greatest difference in the Iguana. Only some species showed differences in vertical forces between the fore- and hindlimbs and these differences were not related to limb morphology, suggesting that other aspects of morphology may influence differences in vertical force (e.g. head vs. tail size).

Comparative analysis of NOS signaling in the crustacean molting gland

Molting in crustaceans is regulated by ecdysteroids produced in the Y-organs (YO) located in the lateral cephalothorax. Ecdysteroid secretion by the YO is suppressed in the presence of molt-inhibiting hormone (MIH), a neuropeptide produced in the X-organ of the eyestalk ganglia (EG). The binding of MIH to its cell surface receptor in the YO activates a signal transduction cascade, resulting in decreased production of ecdysteroids. Recent research indicates that the pathway may involve nitric oxide synthase (NOS), an enzyme which catalyzes the production of nitric oxide from oxygen and arginine and is known to be expressed in the YO. Additional research shows that the sensitivity of the YO to MIH varies over the molting cycle. Increases in expression of signaling proteins such as NOS could increase sensitivity of the MIH pathway. To illuminate the role of NOS, we eyestalk ablated (ESA) two species of decapod crustaceans, the land crab Geocarcinus lateralis and green crab, Carcinus maenas. Eyestalk ablation removes the endogenous source of MIH and activates the YO. Expression of NOS is quantified with real-time PCR. Preliminary results indicate that ESA increases expression of NOS mRNA in the land crab. Supported by National Science Foundation. (IBN-0342982 and IOS-0745224)

Anthropogenic Chemicals Adversely Affect Predator Avoidance Behavior of Larval Fish

When aquatic organisms are exposed to common anthropogenic chemicals, how will that exposure affect innate survival behaviors? To investigate this question, short-term exposures (12 days) subjected larval fathead minnows Pimephales promelas to environmentally relevant concentrations of chemicals, singular or in mixture, from the following two classes: (1) estrogens or (2) anti-depressant pharmaceuticals. Following exposure, larvae were introduced to a simulated threat stimulus (standardized vibration). Under normal circumstances during a predator-prey confrontation, larval fish use an escape response, the C-start, to rapidly move away from an approaching threat. The C-start has been extensively studied and a neuro-anatomical axis of sensor-Mauthner cell (neuron; CNS)-effector has been identified. This behavior is also conserved across teleost lineages, and the inability to effectively execute a C-start has direct adversary consequences. High-speed (1,000 Hz) video recordings of larval C-start performances were collected for frame-by-frame analysis of latency periods, escape velocities, and total escape response. Both chemical classes adversely affected larval total escape response; however, they exhibited different modes of action. Estrogen exposure significantly affected larval latency periods (up to 60% longer to react); antidepressant exposure affected larval escape velocity (up to 63% slower). Our findings suggest that anthropogenic chemicals have the ability to influence larval escape performance through multiple modes-of-action. Further studies will explore the molecular alterations on the Mauthner cell axis caused by these chemical exposures. EPA STAR (R832741-01-0).
P3.153 MCGINN, N.A.*; CHERR, G.N.; University of California, Davis; namcginn@ucdavis.edu
Comparative physiology of multidrug resistance in marine invertebrate oocytes and embryos
Multidrug resistance (MDR) - discovered in cancer cells resistant to multiple chemotherapeutic agents - is important in normal cell function and in the protective mechanisms of tissues such as the blood-brain barrier and placentas. The efflux of target compounds that characterizes MDR is found in a taxonomically wide range of organisms where MDR performs functions similar to those in mammalian tissues. In marine invertebrates, MDR activity is found in adult tissues, notably gill, but MDR is also a functional protective mechanism in the early developmental stages of broadcast spawners. In the sea urchin Strongylocentrotus purpuratus, MDR activity was low in unfertilized eggs, but dramatically increased after fertilization. In sea stars, no such increase after fertilization was observed, however, MDR activity did increase after germline vesicle oocytes underwent maturation in vitro. In this study, we have taken a comparative approach to better understand how MDR activity varies in oocytes and embryos from different phyla of broadcast-spawning marine invertebrates. As in S. purpuratus, MDR activity in the eggs of the sea urchin Lytechinus pictus was significantly greater after fertilization, although the level of MDR activity was lower overall. In contrast, there was no increase in MDR activity post-fertilization in either the mussel Mytilus galloprovincialis or the echiuran worm Urechis caupo. While the overall level of MDR activity in M. galloprovincialis approaches that of L. pictus, U. caupo activity was consistently lower. These differences may be a result of the maturational state of the oocytes/eggs or, perhaps, the exposure of adults to MDR substrates. We continue to investigate species with different reproductive strategies with a focus on oocyte maturation.

P2.164 MCGUIRE, N.L.*; UBUKA, T.; PERFITO, N.; BENTLEY, G.E.; University of California, Berkeley; Helen Wills Neuroscience Institute and University of California, Berkeley; nicolette@berkeley.edu
A novel neuropeptide system within the gonads: GnIH and GniH-R in passerine songbirds
Many hormones that are classified as neuropeptides are synthesized in vertebrate gonads in addition to the brain. Receptors for these hormones are also expressed in gonadal tissue; thus there is potential for a highly localized autocrine or paracrine effect of these hormones on a variety of gonadal functions. In the present study we focused on gonadotropin-inhibitory hormone (GnIH), a neuropeptide that was first characterized as a hypothalamic regulator of pituitary function in birds. Here we present molecular, histological and physiological evidence for the presence and functional significance of a GnIH system in avian gonadal tissues. The presence of GnIH and its receptor, GniH-R, in gonadal cells of passerine birds suggests a role for this system in the local regulation of sex steroid synthesis. Data from gonadal culture support this conclusion. Thus gonadal GnIH may fine-tune reproductive physiology and behavior via local regulation of steroid synthesis and its subsequent release into the periphery.

P2.48 MCHUGH, D.; SCHULT, N.; PERNET, B.; Colgate University, Long Beach; dmchugh@mail.colgate.edu
Poecilology as a window on larval evolution: Comparative analyses of gut development in Streblospio benedicti (Spionidae, Annelida)
As a poecilogenous species, Streblospio benedicti (Spionidae, Annelida) provides an excellent opportunity to explore evolutionary transitions in larval developmental modes in marine invertebrates. Within a single population, females of S. benedicti produce either larvae that develop from large, yolky eggs (100-200 um) and spend only a few hours or days in the plankton without any need to feed, or larvae that develop from small eggs (60-70 um) and spend days to weeks feeding in the plankton before metamorphosis. In comparative analyses of morphogenesis and gene expression patterns, we are assessing similarities and differences between the two contrasting larval developmental modes. Because one of the key traits that differs between the two larval types is the timing of formation of a functional gut, we are focusing on gut development. Using phalloidin labeling and immunohistochemical techniques, we identify comparable developmental stages in the two larval types and reconstruct gut development for these stages. For genes involved in gut patterning (foxA, hedgehog, Tbox6), we use quantitative PCR to record transcript levels and in situ hybridization to document the patterns of expression at specific developmental stages in both larval types. This work is bringing us closer to explaining the evolution of larval diversity in marine invertebrates.

P2.185 MINTYRE, Alyssa*; MCGEE-MOORE, Alana; COOPER, W. James; ALBERTSON, R. Craig; Syracuse University; ammcinty@syr.edu
The Evolution of Skull Form and Trophic Ecology Among the Cichlid Fishes of Lake Malawi
An organism's unique skeletal and muscular structures form a biological machine capable of interacting with its environment. When an animal's anatomical form changes, the resulting modification in biomechanical function can allow it to occupy a new ecological niche. The cichlid fishes of Lake Malawi are an extraordinary example of rapid evolutionary divergence. In a very short span of evolutionary time (1-2 million years), one species has diversified into several hundred species that inhabit an extremely wide variety of feeding niches. This ecological divergence was produced by a massive radiation in skull form and function. We studied the anatomical diversity of this incredible lineage by dissecting and photographing the skulls and jaws of 102 fishes from 47 of the 53 cichlid genera found in Lake Malawi. The genera examined contain 93% of the cichlid species that are native to the lake. We examined anatomical landmarks that are of biomechanical importance for fish feeding using geometric morphometric analyses, which are coordinate based mathematical analyses of anatomical form. Our results provide a nearly comprehensive measurement of the anatomical diversity of Lake Malawi cichlid skulls, and provide a quantitative description of a classic example of an adaptive radiation. The results confirmed a significant degree of variation among cichlid genera, and indicate that the two major lineages of Lake Malawi cichlids, the "rock dwellers" (mbuna) and the "sand dwellers", have each evolved skull shapes that are not possessed by the other, and these morphologies have allowed each of them to exploit unique ecological opportunities.
Neoblasts in Catenulida
Our current understanding of the stem-cell (neoblast) system in Platyhelminthes comes primarily from a wealth of experiments on regeneration in members of the Triclaidida, supplemented by studies of members of other groups. To date, there are relatively few studies of the neoblasts in the potentially-primitive Catenulida. Accordingly, we have carried out M-phase (anti-phosphoH3) and putative S-phase (anti-PCNA) labeling experiments in Stenostomum virginianum and Catenula lemmae, supplementing these light-microscopic histological studies with electron microscopy. We have also studied neoblast dynamics in starved and fed S. virginianum. Neoblasts were observed in the gastrodermis and parenchyma of both species by both light-microscopic immunohistochemistry and by electron microscopy. In addition, S. virginianum was found to possess neoblasts in the epidermis, consistent with previous light- and electron-microscopic observations of dividing cells in the epidermis of various catenulid species. Following prolonged starvation, neoblast mitoses in S. virginianum recovered in a biphasic fashion, with mitoses peaking at 3 hours and 24 hours post-feeding, in a pattern reminiscent of that in triclad flatworms. Collectively, these data support the hypothesis that the neoblast stem-cell system may be a synapomorphy for the Platyhelminthes. (Supported by a Grant from the Winthrop University Research Council)
As the primary component of the avian aerodynamic lift generating surface, feather anatomy has been shaped by tradeoffs between mechanical and energetic constraints. Characteristics that would favor increased rigidity and resistance to buckling, stiffer material components and larger cross-sectional areas or second moments of inertia, are energetically more costly as these materials must be oscillated many times per second during flight. We studied variation in cross-sectional geometry of the rachis in both primary and secondary feathers of the Barn Owl (Tyto alba). Feathers were sectioned at five different locations along the length of the rachis either with a low-speed saw after embedding in epoxy or with a scalpel. Cross-sections were photographed under a dissecting microscope, and cross-sectional areas (XSA) and second moments of inertia (I) were calculated. Using published values for Young’s modulus (E) of feather keratin, we estimated flexural stiffness (E * I) at each location. All feathers exhibited a strong proximodistal gradient in both XSA and I, with commensurate decreases in flexural stiffness, with rachis tips approximately two orders of magnitude smaller than proximal ends. Between-feather variation correlated well with published stiffness, with rachis tips approximately two orders of magnitude smaller than proximal ends. Between-feather variation correlated well with published stiffness, with rachis tips approximately two orders of magnitude smaller than proximal ends.
The scaling of growth, nutrient assimilation and metabolism in larval hawkmoths raised on natural and artificial diets

Recent theory attempts to explain metabolic scaling based on the evolutionary optimization of the structure and function of resource supply networks and exchange surfaces. However, we know of no studies that have simultaneously examined the scaling of both metabolism and resource exchange between animals and their environment. We use the larvae of tobacco hawkmoths (Manduca sexta), which grow ca. 10,000-fold in mass in 18 days, to investigate whether metabolic scaling is related to developmental changes in nitrogen (N) and carbon (C) assimilation and excretion. To examine the effects of diet quality (C:N), we also imposed a diet treatment, raising caterpillars on either a stock laboratory diet or on the leaves of tobacco (Nicotiana tabacum) a natural hostplant. Animals fed tobacco grew more slowly, and though they grew for a longer period, they reached a smaller asymptotic size. Tobacco fed animals also displayed metabolic scaling exponents shallower than those of animals fed the standard laboratory diet, which is consistent with other studies documenting the effect of food quality on metabolic scaling. The scaling of excretion (frass production) was similar to the scaling of metabolism, while the scaling of ingestion was shallower. Together, these results lead to a relatively simple model of ontogenetic growth and point to the potential importance of the stoichiometry (C:N balance) of nutrient uptake for understanding metabolic scaling and growth. This study is part of a larger NSF-funded undergraduate interdisciplinary research and training project (Manduca InSTaRs) assessing the role of midgut morphology and function in metabolic scaling.

The diversity of visual perception in sympatric Lake Victoria cichlids

Lake Victoria harbors hundreds of endemic species of cichlids which have experienced explosively adaptive radiation during a very short period. They are ecologically and morphologically highly diverse whereas genetic differentiations among species are extremely low. Lake Victoria cichlids are one of the well-studied organisms at the genetic mechanisms of sensory drive speciation. In allometric and parapatric distribution cases, the adaptation of visual systems and the evolution of nuptial color might cause reproductive isolation that lead to speciation. We studied the diversity of visual system in sympatric cichlids that has not been reported. We determined the sequences of opsin genes, which code photoreceptor proteins, from seven sympatric species. The LWS and RH1 genes showed the species-specific amino acid replacements, and showed higher degree of diversification between each species than those in neutral regions. Especially in two species, the divergent natural selection has acted on LWS gene regions detected by population genetic analysis using LWS and its flanking regions. The LWS pigments reconstituted from LWS of those two species absorbed different spectra suggesting functional diversification. These results suggest that even in sympatric cichlids had species-specific visual perception. The visual systems of sympatric cichlid species might have adapted not only to light environments but also to species-specific microhabitats including ecological features such as feeding and mating behaviors.

Water availability is not a bottle-neck to rebuilding fat stores in insect-eating, migrating blackcaps

Migrating birds stopover to rebuild lost tissue, and access to drinking water positively affects fat accumulation. Before fat is accreted, birds must rebuild their digestive tracts (GIT). We used 30 freshly caught, migrating blackcaps (Sylvia atricapilla) to test the prediction that after a simulated in-flight starvation period the rebuilding of the GIT is faster in birds with access to drinking water than without. Ten birds were randomly assigned to each of three groups receiving: water ad libitum, 30 min access to water per day, or no water. All three groups were fed mealworms ad libitum for the 6-day experiment. Mean daily water intake was significantly different among the groups (F(2,28)=0.23, NS). Furthermore, in all groups, mean food intake almost doubled from day 1 to day 2, remained high until day 4, and declined on days 5 and 6. Body mass in all groups increased continuously from day 1 to day 6 (F(5,140)=190.76, p<0.0001) and did not change on day 7 (F(1,14)=0.28, NS), suggesting that tissue replacement was complete. Visual fat score increased similarly in all three groups (F(2,28)=0.47, NS). The data did not support our prediction in that there were no apparent differences in body mass and fat score between the groups. Although preformed and metabolic water gained through eating mealworms is apparently sufficient for blackcaps to rebuild their digestive organs and fat stores, given access to water the birds drink prodigiously, perhaps allowing more time for activity.

Phosphorylation state of Na-K-Cl cotransporter in the intestine of euryhaline teleosts in response to varying osmolality

The Na-K-Cl cotransporter (NKCC) couples the movement of Na, K, and Cl across polarized cell membranes. Two NKCC isoforms have been cloned: NKCC1, a ubiquitously expressed secretory isoform with an important role in the regulation of intracellular Cl and cell volume, and NKCC2, a kidney-specific absorptive isoform expressed in the thick ascending limb of the loop of Henle. In teleosts, NKCC2 is present in the apical membrane of the kidney-specific absorptive isoform expressed in the thick ascending limb of the loop of Henle. In teleosts, NKCC2 is present in the apical membrane of the intestine where it functions in osmo- and iono-regulation. Estuarine teleosts, experience rapid salinity changes and must be able to regulate plasma ion concentrations. To cope with hyperosmotic stress, teleosts drink seawater, absorb Na and Cl via apical NKCC2 in the intestine, and secrete excess ions via the gill. It is hypothesized that rapid activation of NKCC2 is achieved in part by protein phosphorylation, as has been demonstrated for NKCC1. This study examined the in vitro and in vivo phosphorylation state of NKCC in the intestine of killifish and flounder in response to varying osmolality using immunological techniques and detection with NKCC antibodies, R5 (phospho-specific) and T4. Phosphorylated NKCC was highly expressed in the intestine of killifish and flounder. Exposure of killifish and flounder intestine to high osmolality in vitro resulted in a reduction in R5 signal, whereas no effect on T4 signal was observed. Loss in R5 signal after incubation in high osmolality was almost fully reversible after a subsequent incubation in low osmolarity. These data demonstrate changes in the phosphorylation state of NKCC in the intestine of euryhaline teleosts upon exposure to varying osmolality, supporting the hypothesis that phosphorylation plays a role in regulating NKCC during acute salinity changes.
Muscle architecture and spring properties during active shortening

Active cross-striated muscle recoils elastically during rapid unloading. Previous analyses show that this spring-like property of actively shortening muscle is remarkably similar in vertebrate muscles (mouse soleus, EDL; frog depressor mandibulae, sartorius). Here, we expand our studies to invertebrate cross- and obliquely striated muscles. The cross-striated abdominal extensors and flexors of crayfish are used in rapid locomotory tail flips. The rigidly parallel sarcomere organization that produces the cross-striated muscle pattern suggests functionality similar to vertebrate skeletal muscle. The obliquely striated longitudinal muscle fibers of the earthworm body wall are used in peristaltic locomotion. Here, the sarcomeres are offset, which allows thick filaments to shear relative to each other and generate force over a large range of lengths. If the sarcomere arrangement plays a role in muscle elasticity, we would expect that muscle stiffness and the mechanism(s) for generating elasticity to differ between cross- and obliquely striated muscles. We used load-clamp experiments to measure the displacement of isolated muscles during recoil following sudden drops in load. We then calculated muscle stiffness across a range of muscle forces and lengths. Our results show that, regardless of sarcomere arrangement, all muscles tested respond similarly to changes in load. Muscle displacement increases exponentially as the change in force increases, resulting in non-linear increases in muscle stiffness with load. Thus, the ability to recoil elastically during rapid unloading appears to be a general feature of cross- and obliquely striated muscle in animals. The mechanism of muscle elasticity does not appear to be affected by differences in sarcomere organization. Supported by NSF IOS-0623791, IOS-0732949.

P1.90 MONSON, Emilee*; GERKEN, Sarah; University of Alaska Anchorage; emilee.monson@gmail.com

The presence of penial lobes in two new Lampropid species (Crustacea; Cumacea), Lampropenis sp. A and Lampropenis sp. B, from the shores of the Pribilof Islands, Alaska.

A new genus and two new species of lampropid cumaceans (Lampropenis sp. A, Lampropenis sp. B) are described from specimens from the collections of the Smithsonian National Museum of Natural History. The samples were collected in 1917 from the Pribilof Islands, St George and St. Paul, Alaska. Cumaceans are small marine crustaceans. Their length can range from 1mm-30mm, with the larger specimens generally residing in deeper, colder environments as well as in arid conditions. To do our work we field collected rough-skinned newts (Taricha granulosa) and harvested immediately ventral skin, kidney, and intestine. Standard procedures were used in performing western blots to demonstrate the presence of AQPs in these tissues. Western Blot showed AQP 1 and AQP2 to be relatively abundant in the bladder, kidney, and intestine and have lower levels of expression in the ventral skin relative to ERK 1 and ERK 2. However, they appeared to be present in all tissues examined. AQP1 localization in the ventral skin appeared in the epithelia along with AQP2 and AQP4. Newt kidney showed clear localization of AQP1 and AQP2 around the proximal and distal convoluted tubules. Localization of AQPs 1 and 2 appeared lining the lumen of the intestine along with AQP4 in the smooth muscle of the cross section. The knowledge of the urodele model can only broaden our scope and understanding of AQPs in amphibians and the physiology of animals in general.

P3.125 MOOI, R.; California Academy of Sciences; mmooi@calacademy.org

The Summer Systematics Institute: Hands-on, collections-based undergraduate research at the California Academy of Sciences

With world-wide threats to biodiversity and growing interest in the origins and diversification of life, phylogenetic systematics and evolutionary biology have become critical components of undergraduate education. More than 12 years ago, to help address these issues, the California Academy of Sciences launched the Summer Systematics Institute (SSI) with support from NSF’s Research Experiences for Undergraduates (REU) initiative and the Academy’s Wallace endowment. The SSI is an 8-week internship at the California Academy of Sciences in San Francisco. The SSI has brought to the Academy more than 100 undergraduates from almost 40 different states to work on research with an advisor of their choice on a project relating to the discipline of that advisor. Participants also receive instruction while taking part in a museum-based curriculum that includes tours, lectures, and lab exercises on phylogenetic systematics, molecular techniques, biodiversity, evolutionary biology, global change, and other contemporary issues in the natural sciences. In the past 4 years, 9 of the undergrads attended the SICB meeting that followed their summer internship and presented their findings in the form of talks and posters. Among the 28 participants of the past 4 years, 26 different universities and colleges are represented from 15 different states. The Academy has just opened its state-of-the-art new museum in Golden Gate Park, and this exciting REU Site will continue to offer undergraduates, particularly those from groups under-represented in the sciences, important insights into the contributions that museum-based research can make to issues facing society today.

January 3-7, 2009, Boston, MA
P2.133 MOON, Brad R.; HAMPTON, Paul M.; Univ. Louisiana, Lafayette; BradMoon@louisiana.edu

The Effects of Long Tendons on the Energetic Cost of Muscle Contraction

Muscles that have long tendons often shorten less than muscles with short tendons, which suggests that muscles with long tendons have a lower cost of contraction. However, in most muscles it is difficult to separate the effects of fiber type and tendon length on contractile cost. The shaker muscles in the tails of rattlesnakes are good models for studying how tendon length affects contractile energetics because they vary along the tail in tendon length but have a single dominant fiber type, which provides a natural control that is lacking in typical muscles. Shaker muscle segments with long tendons were found previously to shorten significantly less than segments lacking tendons. We are now testing the hypothesis that muscles with long tendons have a lower contractile cost than segments without tendons. We are using denervation and selective paralysis to block the contraction of muscles segments while measuring oxygen consumption in western diamond-backed rattlesnakes (Crotalus atrox). By carefully measuring and subtracting the metabolic rates under different conditions (resting, all shaker muscles active, only muscles with long tendons active, and all muscles blocked), we can partition the cost of contraction between muscles that have long tendons and no tendons. Our early results indicate that (1) shaker muscles have metabolic rates that are high enough to allow selective paralysis without loss of metabolic signal strength, (2) denervation of the distal-most muscles segments does not alter the activation or contractile strains of more proximal, intact segments, and (3) the cost of contraction in segments with long tendons is lower than in segments without tendons. The results on a larger sample are likely to be representative of other fast muscles, which appear to be relatively common in diverse lineages of animals.

P3.99 MOORE, M.S.*; BUCKLES, E.L.; KUNZ, T.H.; Boston University, Boston, Cornell University, Ithaca; mmoore@bu.edu

Are Hibernating Bats Capable of Mounting an Effective Immune Response? Histological Evaluation of a Cellular Response to Phytohemagglutinin (PHA) Injections in the Little Brown Myotis (Myotis lucifugus) and the Big Brown Bat (Eptesicus fuscus)

White Nose Syndrome (WNS) is a recently observed condition affecting bats in the northeastern United States that has caused up to 95% mortality in some hibernacula. First reported in the winter of 2006-2007, bats affected with WNS exhibit unusual behaviors, develop a fungal growth on their faces, ears, and wing membranes, are depleted of fat reserves, and exhibit extensive wing necrosis and scarring. It is not known whether the fungus, for which this syndrome is named, is the cause of death or an opportunistic condition of immuno-compromised individuals. However, bats that have the visible fungal colonies on their noses and wings have fungal hyphae within the dermis and epidermis and are absent of local inflammation. To test the hypothesis that hibernating bats are unable to mount an effective inflammatory response to the fungus because of physiological constraints associated with deep torpor, we collected biopsies of swellings developed in response to subcutaneously injected phytohemagglutinin (PHA) in active and hibernating little brown myotis, Myotis lucifugus, and big brown bats, Eptesicus fuscus. Biopsies were collected at 6, 12, and 24 hours post-injection and analyzed histologically for variation in immune function cells. In active bats, the response to injection is mild, but does vary depending on time post-injection. These results will be used to describe potential differences in inflammatory response between active and hibernating bats, investigate possible variables associated with WNS, and establish whether or not hibernating bats can respond to a potentially infectious fungal condition.

P4.1 MOORE, JR; WALTERS, JR; MOORE, IT; Virginia Tech; a2jmoor@vt.edu

Breeding behavior in Prothonotary Warblers: Is food availability the key?

Global climate change has resulted in the advancement of many phenological events in the spring such as budburst, insect emergence, and reproductive behavior of many birds. A long-term study of the Prothonotary Warbler (Protonotaria citrea) reveals that, over the past twenty years, males have advanced their arrival date by approximately three weeks however clutch initiation dates have remained unchanged. This appears to have resulted in a mismatch between timing of breeding and peaks in food availability. We examined whether experimentally supplementing food upon arrival would advance breeding and associated behaviors at two different sites in the James River Virginia watershed. Experimental pairs were supplemented with waxworms upon arrival and nest boxes were visited 3-4 times a week to determine clutch initiation dates. In addition we measured male aggression and testosterone levels in response to the food supplementation. Clutch initiation dates and male plasma testosterone levels did not differ between experimentally supplemented and control pairs. Thus it appears that while birds are arriving earlier a lack of available food is not the cue preventing them from advancing breeding.

P4.74 MOORE, A.M.*; BARRY, B.D.; MENAKER, M.; University of Virginia; atm4z@virginia.edu

Photic Niche and Photosensitivity of the Pineal Oscillator in Anolis Species

Circadian clocks coordinate behavior and physiology such that events occur at the appropriate time of day or night. Light is the most salient cue by which the clock is entrained to the 24-hr day, yet the influence of environmental light on clock evolution remains largely unexplored. To investigate the relationship between photic niche and the physiology of a circadian pacemaker, we have focused on the lizard pineal gland because a) it is intrinsically photosensitive and entrains to light directly, b) its role as a circadian pacemaker varies widely across species, and c) its rhythmic output, melatonin, is readily quantifiable. We cultured individual pineal glands from several species of Anolis lizards and measured melatonin output under lighting regimes designed to reveal period, amplitude, and photosensitivity of the pineal oscillator. We show that light suppresses nighttime melatonin levels in all species except A. carolinensis, with considerable variation among species in the magnitude and duration of suppression. Preliminary analyses suggest that shade-dwelling species are more sensitive to light-induced melatonin suppression than are sun-dwelling species, providing initial support for the hypothesis that photic niche is correlated with circadian photosensitivity. Future work will incorporate additional species in an attempt to characterize the contributions of phylogenetic lineage, structural niche, photic niche, and light history effects towards phenotypic variation in circadian physiology.

January 3-7, 2009, Boston, MA
Visual Latency and Sexual Asymmetry of Signal Detection in *Sceloporus undulatus* lizards

Visual signal properties often vary greatly between and within individuals in a variety of social contexts. For example, in many species of lizards, males produce different complex motion displays used in territorial and courtship contexts. While it is widely known that visual signals emitted by senders can exhibit great variation in efficacy and design, far less is understood whether and how receivers vary in the ability to detect and respond to different complex signals. We tested for variation of signal detection within and between receivers. Specifically, we tested whether *Sceloporus undulatus* lizards exhibit differential signal detection between the left and right visual fields, a phenomenon known as visual laterality. Additionally, we tested whether male and female *S. undulatus* lizards differ in their ability to detect two types of motion signals displayed by males: courtship and territorial. Using a robotic lizard model, we assayed visual performance from each visual field and each sex by measuring the latency to detect the two male display types. While signal efficacy can greatly depend on the receivers ability to detect and respond to a senders signals, variation both within and between different receivers can affect the direction of signal evolution. We found that the left and right visual fields of both males and females differ in detection performance for both display types. Detailed results and data will be presented. Our findings suggest that sexual asymmetry and laterality of visual ability may play an important role in the evolution of visual communication systems and should be taken into consideration when studying signal design and efficacy.

Visual Laterality and Sexual Asymmetry of Signal Detection in *Sceloporus undulatus* lizards

Performance has been shown to be strongly correlated with fitness in reptiles, including garter snakes, and performance measures early in life reflect later trends. Anti-predator behavior and pattern morphology have been shown to be strongly correlated with each other and with fitness. We measured performance, anti-predator behaviors, and dorsal patterning in lab-reared juveniles from closely-related populations of western terrestrial garter snake, *T. elegans*, representing two life history ecotypes. High elevation, meadow (M-slow) snakes grow slow, mature late, and live long (median lifespan 8 yrs), and low elevation, lakeshore (L-fast) snakes grow fast, mature early, and die young (median lifespan = 4). In addition, the two ecotypes have been shown to differ across a suite of other traits. The purpose of this study was to determine if the two ecotypes differed in traits related to predator avoidance to ask what are the ecological forces underpinning the evolution of anti-predator characters. Dorsal pattern was strongly correlated to ecotype with L-fast snakes being more patterned (i.e. checkered or spotted) and M-slow snakes being generally solid. Both performance and reversal behaviors were influenced by ecotype: L-fast snakes were faster and reversed less than M-slow snakes. Stopping behavior (coiling) was not influenced by ecotype, pattern, or sex. We discuss these results in the context of the ecology and evolutionary history of lakeshore and meadow populations.

The evolution of the human hand: making a fist

Anatomical features that distinguish human hands from the hands of other apes undoubtedly facilitate our ability to make and use tools. However, the high proliﬁcity of our species for aggression led us to suspect that the anatomical conﬁguration of our hands may also protect the hand from injury when striking an opponent. Relative to other apes, humans have shorter fingers (digits 2-5) and a thumb (digit 1) that is much larger, more mobile and muscular. These changes allow humans to form a ﬁst in which digits 2-4 are ﬁrmly buttressed by contact of the fingertips against the palm and by the wrapping of the thumb around the distal phalanges of digits 2, 3 and 4. We suggest that this buttressing provides greater stiffness at the metacarpal-phalangeal and phalangeal-phalangeal joints, and thereby protects the ﬁst from injury when delivering a blow. The importance of buttressing may be found in a common injury called the Brawlers Fracture, which is characterized by fractures of the necks of the relatively un-buttressed 4th and/or 5th metacarpals. To test the hypothesis, that the proportions of the human hand provides protection against injury during ﬁghting, we measured the stiffness of the 2nd metacarpal-phalangeal joint in a closed ﬁst using a force transducer and a linear transducer. Subjects used three different ﬁst postures: full buttressing, no thumb buttressing, and no buttressing. Results conﬁrm that the buttressing inherent in a formed ﬁst increases the stiffness of the metacarpal-phalangeal joints. On average, the no thumb posture exhibited approximately 1/2 the stiffness of a fully buttressed ﬁst and the no buttressing posture exhibited 1/3 the stiffness of a fully buttressed ﬁst. These results are consistent with the idea that the selection for aggressive behavior played a role the evolution of the human hand.

Conservation ecology and social organization of the White-breasted Thrasher on St. Lucia

The White-breasted Thrasher *Ramphocinclus brachyurus* is an endangered songbird endemic to the islands of St. Lucia and Martinique. Research in 2002-2004 established that the population comprises ca. 800 breeding pairs, 80% of which inhabit dry forest along the east coast of St. Lucia in two subpopulations. This work also revealed that the thrasher is a facultative cooperative breeder. The Praslin subpopulation is now facing an immediate threat: a resort under construction will destroy or fragment habitat containing up to 35% of the global thrasher population. Here we examine the effects of habitat loss associated with resort construction on White-breasted Thrasher reproductive success and social ecology. Mayfield nest success estimates did not differ between the pre (2002-04) and post-disturbance (2006-07) periods. From 2006 to 2007, nest success remained the same within fragments (27 fragments, 0.02-20 ha) and decreased in the resort nature reserve (26 ha plot bordering contiguous forest); edge nests were more successful than those in the interior. Group size and the proportion of groups cooperatively breeding increased significantly from 2002-04 to 2006-07, though we did not see any evidence of displaced birds joining previously established territories, as was predicted. This research advances understanding of how indirect mechanisms may magnify overall impacts of habitat loss, determines the degree of site fidelity of thrashers living in fragments on the development site and the effects of fragments on their tendency to maintain territories and group stability, and will influence future decisions about habitat protection on St. Lucia.

P3.101 MORENO, L*; NAVA, S.S.; WANG, D.; MARTINS, E.P.; Indiana University and the Center for the Integrative Study of Animal Behavior, Bloomington; lorna.moreno@gmail.com

P1.107 MORGAN, M*; CARRIER, D; University of Utah, Salt Lake City; mhmorgan@mac.com

Evolution of Life Histories in Garter Snakes: Correlations among Performance, Morphology, and Behavior

Performance has been shown to be strongly correlated with fitness in reptiles, including garter snakes, and performance measures early in life reflect later trends. Anti-predator behavior and pattern morphology have been shown to be strongly correlated with each other and with fitness. We measured performance, anti-predator behaviors, and dorsal patterning in lab-reared juveniles from closely-related populations of western terrestrial garter snake, *T. elegans*, representing two life history ecotypes. High elevation, meadow (M-slow) snakes grow slow, mature late, and live long (median lifespan 8 yrs), and low elevation, lakeshore (L-fast) snakes grow fast, mature early, and die young (median lifespan = 4). In addition, the two ecotypes have been shown to differ across a suite of other traits. The purpose of this study was to determine if the two ecotypes differed in traits related to predator avoidance to ask what are the ecological forces underpinning the evolution of anti-predator characters. Dorsal pattern was strongly correlated to ecotype with L-fast snakes being more patterned (i.e. checkered or spotted) and M-slow snakes being generally solid. Both performance and reversal behaviors were influenced by ecotype: L-fast snakes were faster and reversed less than M-slow snakes. Stopping behavior (coiling) was not influenced by ecotype, pattern, or sex. We discuss these results in the context of the ecology and evolutionary history of lakeshore and meadow populations.

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Visual Laterality and Sexual Asymmetry of Signal Detection in *Sceloporus undulatus* lizards

Evolution of Life Histories in Garter Snakes: Correlations among Performance, Morphology, and Behavior

Performance has been shown to be strongly correlated with fitness in reptiles, including garter snakes, and performance measures early in life reflect later trends. Anti-predator behavior and pattern morphology have been shown to be strongly correlated with each other and with fitness. We measured performance, anti-predator behaviors, and dorsal patterning in lab-reared juveniles from closely-related populations of western terrestrial garter snake, *T. elegans*, representing two life history ecotypes. High elevation, meadow (M-slow) snakes grow slow, mature late, and live long (median lifespan 8 yrs), and low elevation, lakeshore (L-fast) snakes grow fast, mature early, and die young (median lifespan = 4). In addition, the two ecotypes have been shown to differ across a suite of other traits. The purpose of this study was to determine if the two ecotypes differed in traits related to predator avoidance to ask what are the ecological forces underpinning the evolution of anti-predator characters. Dorsal pattern was strongly correlated to ecotype with L-fast snakes being more patterned (i.e. checkered or spotted) and M-slow snakes being generally solid. Both performance and reversal behaviors were influenced by ecotype: L-fast snakes were faster and reversed less than M-slow snakes. Stopping behavior (coiling) was not influenced by ecotype, pattern, or sex. We discuss these results in the context of the ecology and evolutionary history of lakeshore and meadow populations.

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Conservation ecology and social organization of the White-breasted Thrasher on St. Lucia

The White-breasted Thrasher *Ramphocinclus brachyurus* is an endangered songbird endemic to the islands of St. Lucia and Martinique. Research in 2002-2004 established that the population comprises ca. 600 breeding pairs, 80% of which inhabit dry forest along the east coast of St. Lucia in two subpopulations. This work also revealed that the thrasher is a facultative cooperative breeder. The Praslin subpopulation is now facing an immediate threat: a resort under construction will destroy or fragment habitat containing up to 35% of the global thrasher population. Here we examine the effects of habitat loss associated with resort construction on White-breasted Thrasher reproductive success and social ecology. Mayfield nest success estimates did not differ between the pre (2002-04) and post-disturbance (2006-07) periods. From 2006 to 2007, nest success remained the same within fragments (27 fragments, 0.02-20 ha) and decreased in the resort nature reserve (26 ha plot bordering contiguous forest); edge nests were more successful than those in the interior. Group size and the proportion of groups cooperatively breeding increased significantly from 2002-04 to 2006-07, though we did not see any evidence of displaced birds joining previously established territories, as was predicted. This research advances understanding of how indirect mechanisms may magnify overall impacts of habitat loss, determines the degree of site fidelity of thrashers living in fragments on the development site and the effects of fragments on their tendency to maintain territories and group stability, and will influence future decisions about habitat protection on St. Lucia.
**A Comparative Study of Urea-Induced Hypometabolism in Ectothermic Animals**

Many organisms endure extended periods of dormancy by depressing their metabolism, effectively prolonging their endogenous energy-stores. Though the mechanisms of hypometabolism are incompletely understood, recent evidence suggests that urea accumulation in autumn and early winter during extended dormancy and may benefit from its putative hypometabolic effect. To investigate the phylogenetic breadth of the hypometabolic response to urea, we studied four animals that accumulate urea during amphibian development as well as mechanistic insights toward understanding organ/tissue-sensitivity to TH in vertebrate development.

**Increased body-axial stiffness reduces escape performance in larval zebrafish**

Fish larvae swim by undulating their body. The shape of their body wave depends on the interaction between their body and the surrounding water. Fish larvae swim by undulating their body. The shape of their body wave depends on the interaction between their body and the surrounding water. This study focuses on zebrafish, in particular the comparison between wild-type and a mutant called stocksteif. This mutant shows severe over-ossification of the entire notochord, causing the vertebrae to fuse into a stiff rod over the first 15 days of larval development. By comparing wild-type and a mutant called stocksteif, we studied how stiffening the vertebral column affects the shape of the body wave, and how this change in body wave kinematics in turn affects escape performance in zebrafish larvae. We recorded escape responses from a top view with a high-speed camera at 1500 frames per second to determine swimming kinematics. At age 5 days, that is before the vertebral column shows significant ossification, the two morphs body wave kinematics and escape performance are not significantly different. At age 15 days, the vertebral column of the stocksteif/mutant is largely fused. We found that as ossification of the axial skeleton progresses, body wave speed and peak curvature decrease in the stocksteif/mutant, but not the wildtype with unfused vertebral body. Both body wave parameters affect the larvae escape performance: stocksteif larvae achieve lower translational accelerations. The increasing stiffness of the vertebral column seems to seriously limit the axial muscles ability to bend and undulate the fish body.
Hormones and life-history trade-offs: how do parental corticosteroid levels correlate with changes in offspring sex ratio in tree swallows (Tachycineta bicolor)?

Species face many trade-offs as a result of resource availability, time, and physical constraints. These trade-offs often manifest themselves in modifications of life-history traits that may be mediated by hormonal signals. Corticosterone (cort), a hormone involved in metabolic function as well as response to stress, may influence these trade offs. Offspring sex ratio biasing in many avian species, including tree swallows (Tachycineta bicolor), has received attention in past years. While occurrence of sex ratio biasing is well documented, the mechanisms underlying this phenomenon remain unknown. Previous studies have suggested a causal relationship between cort and sex ratio biasing. We looked at the relationship between offspring sex ratio in tree swallows and parental baseline cort levels in a box-nesting population at Queens University Biological Station in Ontario, Canada. We will relate both social male and female cort levels to sex ratio of their offspring. We expect that parents with higher cort levels will have female-biased clutches while parents with lower cort levels will have male-biased clutches. A finding of a natural correlation between parental cort levels and offspring sex ratio will provide further support of the potential causal link between cort and sex ratio biasing in birds.

Effects of Chelating Agents on Manganese Accumulations in Gill of the Eastern Oyster, Crassostrea virginica

Manganese (Mn) is needed in small amounts for normal physiological functions, but high amounts are toxic and causes Manganism. Manganism has been misdiagnosed as Parkinsons disease. The two are similar and due to disruptions in dopamine neurons in the brain. Recently, p-aminosalicylic acid (PAS) has been used to alleviate symptoms of Manganism. PAS has anti-inflammatory and chelating properties. The ability of PAS to ameliorate symptoms of Manganism is postulated to be related to its chelating actions. Crassostrea virginica, possesses a dopaminergic system innervating its gill. Our lab showed manganese disrupts this dopaminergic innervation. We also found PAS caused a dose dependant decrease in Mn accumulations in oyster gill. This study sought to determine if other chelating agents caused similar reductions in Mn accumulations as PAS. We incubated gills of C. virginica, for 10 hour with 500 µM of Mn, followed by 3 day treatments with up to 2 mM of the metal chelators, diaminocyclohexanetetraacetic acid (DACH), sodium EDTA (EDTAa) or calcium EDTA (EDTAc). Mn levels were measured using a Perkin Elmer AA 800 Atomic Absorption spectrophotometer with a THGA graphite furnace. All 3 chelating agents reduced Mn accumulations compared to controls. DACH was the most effective, followed by EDTAc and EDTAa. The study shows the chelating agents are effective in reducing Mn accumulations and supports the hypothesis that the mechanism of action of PAS in treatment of Manganism is related to its chelating abilities. This work was supported in part by the Louis Stokes Alliance for Minority Participation (LSAMP) in Science, and by grants 2R25GM06003-05 of the Bridge Program of NIGMS, 0516041071 of NYSDOE, 0622197 of the DUE Program of NSF, and 0420359 of the MRI Program of NSF.
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In animal communication, the sensory drive model predicts that visual signals evolve to match the visual abilities of receivers, which in turn are shaped by the physical conditions of the environment. Thus, when populations of animals live in habitats that differ in visual conditions, the visual systems of individuals from those populations may diverge, and in turn guide the coevolution of signals and visual performance. This coevolution may also depend on the strength of directional selection on the sexes, e.g., if sexual selection acts strongly and independently on both sexes, phenotypic evolution can be accelerated. When the sexes have been subjected to different selective pressures, they may not only be sexually-dimorphic in phenotype, but also in the underlying genetic, morphological, and physiological mechanisms that produce those phenotypes. Different mechanisms are likely to yield different adaptive responses to subsequent selective pressures and hence slow or accelerate the sensory drive process and its effect on population divergence and evolution. Here, I tested for population and sex differences in visual performance in the sexually dimorphic Sceloporus undulatus lizards that have evolved adaptive dorsal coloration in three extremely divergent habitat types (white sand dunes, black lava rocks, and desert scrub). I show that morphs from the three habitats differ in spectral sensitivity to the blue color exhibited by males. I also find that males and females differ in their ability to detect the blue color. Specific data and results will be presented. These findings suggest that visual performance may evolve quickly and diverge between the sexes and that the sensory drive process may be best described as the repeated co-evolution between signals and receiver sensory systems.

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What works best? Classroom undergraduate research experiences with different levels of inquiry

Financial constraints and increasing numbers of undergraduates interested in research impact opportunities for one-on-one work with faculty mentors. To increase access to undergraduate research (UR) opportunities, three traditional lecture courses were selected for integration of different approaches to UR: 1) Class-Guided Research Experience in which students are required to develop testable hypotheses and carry-out research on any topic that fits within the scope of the course; 2) Faculty-Guided Research Experience in which faculty embeds students into their on-going research; and 3) Mixed Faculty-Class Research Experience in which students select from a list of testable hypotheses compiled by faculty who also provides the basics, but not the details, for experimental design. Funded by the UCF CASTL Program, we assessed student perceptions of their class UR experiences. While comparison of our three classes was complicated by course objectives, sample size, and location (one was study-abroad), overall the data showed all students involved in classroom UR felt it was a good way to learn science and positively impacted their interest in science. Student responses to the three approaches however differed significantly, with the perceived greatest gains in learning detected in those involved in a class-guided research experience (ANOVA: p < 0.01).

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In animal communication, the sensory drive model predicts that visual signals evolve to match the visual abilities of receivers, which in turn are shaped by the physical conditions of the environment. Thus, when populations of animals live in habitats that differ in visual conditions, the visual systems of individuals from those populations may diverge, and in turn guide the coevolution of signals and visual performance. This coevolution may also depend on the strength of directional selection on the sexes, e.g., if sexual selection acts strongly and independently on both sexes, phenotypic evolution can be accelerated. When the sexes have been subjected to different selective pressures, they may not only be sexually-dimorphic in phenotype, but also in the underlying genetic, morphological, and physiological mechanisms that produce those phenotypes. Different mechanisms are likely to yield different adaptive responses to subsequent selective pressures and hence slow or accelerate the sensory drive process and its effect on population divergence and evolution. Here, I tested for population and sex differences in visual performance in the sexually dimorphic Sceloporus undulatus lizards that have evolved adaptive dorsal coloration in three extremely divergent habitat types (white sand dunes, black lava rocks, and desert scrub). I show that morphs from the three habitats differ in spectral sensitivity to the blue color exhibited by males. I also find that males and females differ in their ability to detect the blue color. Specific data and results will be presented. These findings suggest that visual performance may evolve quickly and diverge between the sexes and that the sensory drive process may be best described as the repeated co-evolution between signals and receiver sensory systems.

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Development of postural stability in horses from newborn to one month old.

Motor control development is the sequential, continuous age-related process whereby neurocontrol of skills and coordinated movements changes. The process involves changes in coordination of locomotion, development of strength, posture control, balance, and perceptual skills. Young horses are able to stand within hours after birth despite their relatively small muscle mass and immature motor control. This study analyzes the development of motor control in foals using Postural Sway Analysis (PSA). When a horse is standing stationary, gravity is counter-acted by the net ground reaction forces under each hoof. The location of the net upward force, the center of pressure (COP), can be measured using a force plate. PSA tracks movements of the COP over a period of time. In this study, PSA was performed immediately after newborn foals nursed for the first time (approximately 2 hours after birth), daily for a week, and once weekly until the foals reached one month of age. Three measurements of postural sway were used: amplitude of sway in both cranio-caudal and mediolateral directions, mean sway velocities, and mean frequency after fast fourier transformation. Static balance improved rapidly. Static instability was greater in the cranio-caudal direction than in the mediolateral direction, which is the opposite of what is observed in adults. Sway amplitudes decreased during the first 5-7 days after birth. Velocities and frequencies continued to decrease during the first 3 weeks post-partum. There was considerable inter-individual variation between foals that could partly be linked to differences in conformation and morphology. This study is part of a larger project that will look at development of both static and dynamic stability. We will continue to follow the foals through one year of age.

P3.185 NEBEKER, CA*; SKOPEC, MM; HALEY, S; DEARING, MD; Weber State University, University of Utah, University of Utah; cneb45@yahoo.com

Quantification of biotransformation enzymes implicated in Neotoma lepida’s ability to consume creosote

Two populations of the desert woodrat (Neotoma lepida) have different tolerances for creosote bush (Larrea tridentata). Very few animals consume creosote bush since the leaves are coated with a toxic phenolic resin deterring herbivory. However, a population of the desert woodrat from the Mojave Desert consumes creosote as a large part of its diet; leading us to believe it has evolved a superior ability to biotransform the resin present on creosote bush when compared to a population of the desert woodrat from the Great Basin desert where creosote bush is absent. A previous study in the lab showed that the Mojave woodrats have higher activity of two detoxification enzymes glutathione s-transferase (GST) and cytochrome P450 2B (CYP2B) compared to Great Basin woodrats when fed a diet containing creosote resin as well as a control diet. We quantified the amount of enzyme present using western blots and found that similar to enzyme activity, there was a trend for GST protein levels to be higher in the Mojave woodrats than the Great Basin woodrats when fed a diet containing creosote resin as well as a control diet. For CYP2B however, their was no difference in the amount of protein between the two populations (F<sub>1,30</sub>=0.225 p=0.878). This leads us to assume the Mojave population has evolved a new isoform of CYP2B that is more effective and therefore has higher activity per unit protein. Our next step is to compare the gene sequences for CYP2B in both populations to determine if they differ in a manner that could lead to functional differences.
Effects of \( p \)-Aminosalicylic Acid on the Neurotoxic Effects of Manganese on the Dopaminergic Innervation of the Gill of the Bivalve Mollusc, Crassostrea virginica

Lateral cilia of the gill of Crassostrea virginica are controlled by a reciprocal serotonergic-dopaminergic innervation from their ganglia. Serotonin is an excitatory neurotransmitter at the ganglia and gill, causing cilia-excitation. Dopamine is an excitatory neurotransmitter in the ganglia, but an inhibitory neurotransmitter at the gill, causing cilia-inhibition. Manganese (Mn) is a neurotoxin causing Manganism in people chronically exposed to elevated levels in their environment. Clinical interventions for Manganism have not been successful. Recently, \( p \)-aminosalicylic acid (PAS) is providing effective treatment of severe Manganism in humans. PAS has anti-inflammatory and chelating properties. The mechanism of action is unknown and further studies of PAS in the treatment of Manganese is necessary. Previously, we showed short-term treatments of C. virginica with Mn disrupts the dopaminergic innervation of the gill. In this study we examined acute effects of PAS, EDTA and the anti-inflammatory agent, salicylic acid (SA) on the effects of Mn on gill innervation. Beating rates of lateral cilia in gill epithelial cells were measured by stroboscopic microscopy of gill preparations which had the ipsilateral visceral ganglia (Vg) attached. The cerebrovisceral connective innervating the Vg were stimulated using suction electrodes, before and after additions of PAS, EDTA and SA to the gill. PAS and EDTA effectively blocked the neurotoxic effects of Mn, while SA did not. The study demonstrates that the mechanism of action of PAS in alleviating Manganism in humans may be more related to its chelating abilities as opposed to its anti-inflammatory actions. This work was supported in part by grants 2R25GM06003-05 of the Bridge Program of NIGMS, 0516041071 of NYSDOE, and 0622197 of the DUE Program of NSF.

Surf and turf: foraging choices of an island sparrow population

Foraging choices of parents feeding nestlings play an important role in offspring survival and quality. Different prey items can affect nestling growth and development. Savannah Sparrows (Passerculus sandwichensis) breeding on Kent Island, New Brunswick, Canada forage in both terrestrial (field and forest) and intertidal habitats during the breeding season. Analysis of \(^{13}C\), a stable isotope of carbon, can quantitatively describe differences in foraging choice within and between populations. Differential uptake of \(^{13}C\) between terrestrial and aquatic photosynthesis allows for the determination of the percentage of an organisms diet that comes from terrestrial or aquatic sources. We used stable isotope analysis of blood and feather samples of adults and nestlings, visual observations of nests, and monitoring of nestling weight to determine whether different foraging choices by parents affected offspring growth. We observed 26 nests for an average of 2 hours each during which time identity of parent, direction of approach, food size and type, and habitat where foraging occurred was recorded for each visit to the nest. Preliminary analysis of the observational data suggests that at some nests parents forage preferentially from one direction while other parents forage randomly in relation to direction. Once stable isotope samples are analyzed, we will test how foraging behavior and diet choice influence offspring quality in P. sandwichensis in an island ecosystem.
Effects of testosterone on bite force and locomotor performance in the six-lined racerunner

Numerous studies have examined the effects of testosterone on behavior in territorial lizards, but few have explored the role of testosterone (T) in non-territorial species. Here, we experimentally manipulated T levels in Aspidoscelis sexlineatus, a common non-territorial lizard. During the breeding season, males exhibit mate guarding, and will follow a female for several days after copulation. Male-to-male interactions during the breeding season involve chasing and occasionally escalate into fights with biting. Therefore, high bite force and high endurance capacity should be advantageous to retain exclusive access to females and ensure paternity. In territorial lizards, T levels peak with the breeding season and several studies have cited T as a possible mediator of the seasonal increases in performance (e.g. bite force and locomotor performance). Fluctuating T levels have been observed in A. sexlineatus; however, the role that T plays in the performance of A. sexlineatus or other male guarding species remains unknown. For this study, male racerunners were captured and blood samples were drawn immediately to quantify T levels. Lizards were then returned to the lab where locomotor performance (endurance), bite force, and morphological data were collected. Following performance trials, lizards received silastic T implants. Lizards were housed in the lab for four weeks where locomotor endurance and bite force performance were measured biweekly. Additionally, a blood sample was collected every two weeks to monitor T levels. This research will quantify the morphological and physiological factors affecting performance in A. sexlineatus and provide valuable data concerning how T affects alternative mating systems.

Male field crickets discriminate between pheromones of adult and juvenile females

The field cricket, Gryllus texensis, uses pheromones for short range communication. Previous work indicates male crickets show preference for pheromones from females that had no previous contact with males. In this study we examined the ability of male crickets to discriminate between male and female pheromones and adult female and juvenile female pheromones. Male field crickets were isolated at least 3 days prior to testing. Half the males were isolated after reaching full molt, so these males may have had sexual encounters prior to testing. We collected pheromones on filter paper by isolating the stimulus individuals in Petri dishes for 30 minutes. For each trial, we placed a focal male in the test arena for 2 minutes of acclimation and then presented him with two filter papers. Each male was presented with a contrasting pair of pheromones, either male and adult female, or adult female and juvenile female. For 10 minutes we recorded the time spent by the male on the filter paper with active antennae or maxillary palpi movement. We tested for differences in duration of time spent investigating the two pairs of pheromones presented. We found no significant difference in the behavior of virgin males and males that had been exposed to mature females as adults and therefore grouped all males together for further analysis. Males overall showed no significant difference in time spent investigating male and female pheromones. However, when presented with juvenile and adult female pheromones, males spent significantly more time investigating the juvenile female pheromones. Male Gryllus texensis may be sensitive to pheromonal cues of maturity since these may indicate how much previous male contact the female has had, thus enabling males to allocate sperm to virgin females and minimize sperm competition.
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Scraping and sucking: Does morphology determine performance in two species of suckers?

The co-occurring desert and Sonora suckers show distinct morphological and behavioral traits that yield predictions for feeding behavior. Desert suckers have a broad mouth and a cartilaginous plate that appears specialized for scraping attached algae, and Sonora suckers have a smaller gape that may produce effective suction when capturing small invertebrates. Gut content studies suggest that Sonora suckers feed more on insect prey and desert suckers feed more on algae, and this is further supported by stable isotope analysis, where Sonora suckers have a higher nitrogen signal -- which indicates a higher proportion of animal tissue in the diet -- but both species feed on algae and invertebrates. This raises the question: are aspects of feeding behavior in each species modified to enhance performance on particular prey items, perhaps reducing competition or partitioning food resources? In the laboratory, we examine the performance of each species on a variety of elusive and non-elusive prey types to answer the following specific questions: (1) Are Sonora and desert suckers able to capture the same prey items? (2) Are desert suckers more effective at scraping algae? (3) Do Sonora suckers use suction when capturing insect prey? Preliminary data for both species suggest that they will take prey on the bottom, but not in the water column -- which suggests that only benthic insects are likely to be included in the diet in the wild. Ongoing experiments will examine the ability of each species to remove encrusting material from the substrate by scraping and procure food from the substrate by suction.

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Untangling the palatal organ: Investigating the embryological origin of a novel structure

Exploiting the conserved developmental mechanisms seen in vertebrates, the zebrafish has become a popular model organism within the field of biomedical research. Yet, by ignoring what makes this cypriniform fish unique we are overlooking a powerful model organism for investigating the origin and development of morphological novelty. The trophic diversity that characterizes cypriniform fishes includes a unique feeding mechanism whereby small food particles often encountered in benthic feeding are extracted. The structure that plays a key role in separating edible from inedible prey items during benthic feeding is the palatal organ. Located in the anterior pharyngeal roof, the palatal organ is a muscular cushion composed of a highly disorganized tangle of differently sized muscle fibers covered by an epithelium studded with mucous cells. During feeding the palatal organ secretes mucus to entrap food and the muscles work to entrap and move the food along to the pharyngeal teeth. Functionally, and indeed even in histological sections the palatal organ strongly resembles a small mammalian tongue. There is little, if any, data addressing either the embryological origin of this muscular organ or the ontogenetic stage at which it first develops. Here we describe the ontogeny of the palatal organ in several ontogenetic stages of the zebrafish. The palatal organ, while less well-developed in zebrafish than in other cypriniforms, is apparent from very early larval stages. Moreover, the combination of muscle fiber types seen in the adult may reflect the complex embryological origin of this organ, identifying the developmental mechanisms responsible for the origin of this feeding adaptation may enhance our understanding of how functional novelties arise and evolve.

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Modification of limb inertial properties leads to persistent changes in neural control of walking in humans

Animals with distally heavy limbs, such as primates and felids, have been proposed to use longer, slower strides to decrease leg-swing costs and minimize locomotor energy use. In this study, we investigated whether such cost-saving kinematic changes can be seen within a species when limb inertial properties are altered, and whether long-term changes in limb inertial properties produce persistent gait changes. Ten healthy human subjects walked and ran on a treadmill under both a Control condition, subjects wore a small weighted backpack, and a Leg Weights condition, subjects wore ankle weights. Kinematics and oxygen consumption were measured in both conditions; subjects then wore ankle weights for 6 hours, and oxygen use and kinematics were measured again. For walking trials, results from morning sessions indicated that subjects adapted immediately to a more distally located limb center of mass by using lower stride frequencies. Notably, results from afternoon walking sessions indicate that this change in gait persisted once ankle weights were removed and subjects returned to a normal, more proximally located limb center of mass. This persistence suggests a change in the neural control of rhythmic locomotor patterns brought about by experiencing a more distal hindlimb center of mass. There was no reduction in stride frequency while running in response to wearing ankle weights, suggesting that running is more resistant to kinematic adjustment. For all trials, locomotor cost was similar between Control and Leg Weights conditions. This results support the hypothesis that animals with distally heavy limbs can maintain low walking costs through kinematic adjustment, and suggest a feedback system in which locomotor control is influenced by limb inertial properties.

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Effect of diet on periovulatory levels of steroid hormones and primary sex ratio in zebra finches

Recently, a number of studies on birds have indicated that females (the heterogametic sex) are capable of using pre-ovulatory mechanisms to skew primary offspring sex ratios; however, no one has conclusively identified the mechanism responsible for this phenomenon. Sex is determined in the first meiotic division when one sex chromosome is retained in the oocyte and the other segregates to the polar body. During this time, follicular steroid production is limited primarily to progesterone (P4) and it has been suggested that maternal steroids, which are sensitive to environmental perturbations, could influence sex chromosome segregation. Experimental studies exploring the relationship of maternal steroids on sex ratio have primarily administered various exogenous hormones but, to date, no one has examined endogenous hormones at ovulation. We manipulated both diet quality and perceived food availability in breeding female zebra finches to examine the effects on natural levels of maternal steroids circulating during meiosis I, the critical time in sex determination and primary offspring sex ratio. We found that females on the low quality diet had significantly lower body condition, but higher P4 and lower CORT levels when compared to females on a higher quality diet. Levels of maternal testosterone do not differ between diet quality or perceived availability. Though we do show an effect of diet on body condition and levels of P4and CORT, factors which have been shown to bias sex ratios, to date, this change in hormone profile at the periovulatory period did not result in a change in the primary sex ratio in clutches produced by females on the different diets.
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**Metabolic performance and latitudinal distribution of Black-capped and Carolina Chickadees**

In endotherms, metabolic performance affects a wide array of ecological traits, including species distribution, and researchers have suggested that the northern boundaries of North American passerines are limited by birds ability to sustain high metabolic rates required for thermoregulation. Black-capped chickadees (Poecile atricapillus, BC) are year-round residents in most of Canada and the northern United States, while Carolina chickadees (Poecile carolinensis, CA) inhabit the southeastern United States. These species hybridize along a narrow contact zone that is moving north at approximately 1.6 km per decade, movement possibly facilitated by global climate change. There is strong evidence that the chickadee hybrid zone is correlated with temperature, as the east-west orientation closely matches temperature isotherms. We measured basal (BMR) and peak metabolic rates (PMR) for BC and CA in multiple states and also obtained metabolic rates for additional populations in previously published studies. We noted a general correlation between colder temperatures and higher metabolic rates among populations of BC, although this trend was not robust between all locations. Metabolic rates of CA did not differ between populations. Within Ohio, BMR and PMR were significantly greater in BC than CA. However, metabolic rates did not differ between the two species after controlling for the effect of mass. Hybrids had a significantly higher mass-specific BMR than either parental species. We suggest that the mtDNA-nDNA mismatch in hybrids may produce defective mitochondrial proteins, increasing metabolic rate because individuals rely on a greater rate of oxygen consumption to meet ATP demands.

P3.29 OLIVER, Christopher E.; POLLOUX, Bart J.A.; BANET, Amanda I.; ARNOLD, Stephanie; GARLAND, JR, Theodore; Univ. of California, Riverside; cou601@student.ucr.edu

**Does a primary sex character vary with the degree of female-biased sexual size dimorphism: a test in the Poeciliidae.**

Sexual selection has been recognized as a factor that shapes the evolution of secondary sex characters, including aspects of morphology and behavior. However, can sexual selection operate on primary sex characters? We examined the relationship between female-biased sexual size dimorphism (SSD, measured as male/female standard length) and length of the gonopodium, a primary sexual character found in male poeciliid fish that is used to inseminate the females. The Poeciliidae includes over 200 species of freshwater, livebearing fish. Two main mating strategies occur in this family, gonopodial thrusting and courtship. Species that exhibit gonopodial thrusting exhibit few if any secondary sexual characters and a high degree of SSD; whereas species that exhibit courtship tend to have secondary sexual characters and a low degree of SSD. Therefore, it has been predicted that species with a high degree of female-biased SSD should exhibit larger gonopodia to aid in copulation. We tested this by examining SSD and proportional gonopodium length (gonopodium length/male standard length) in ~45 species of poeciliid fish in a phylogenetic context. We also examined other relationships with SSD and gonopodia, such as allometry of the traits. Preliminary non-phylogenetic results favor the prediction that species with a high degree of SSD have proportionally longer gonopodia than those with a low degree of SSD. Phylogenetically informed and additional results will also be discussed. Supported by NSF DDIG IOS-0709798 to T.G. and C.E.O, and NSF grant DEB-0416085.

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**Differences in escape behavior between a cryptic and an aposematic litter frog**

Clay models have been used to investigate the relative anti-predator effectiveness of cryptic and of aposematic coloration in litter frogs, but such studies fail to account for possible differences in prey escape behavior. We examined the escape behaviors of two litter frogs, the cryptic Craugastor (=Eleutherodactylus) transfordii and the brightly colored and toxic Oophaga (=Dendrobates) pumilio, in response to a human predator. For all individuals, we measured the distance between the frog and the observer at the instant of flight (approach distance), and the distance between frogs initial and final positions (retreat distance), in the field. The cryptic C. transfordii had a shorter approach distance than did non-calling individuals of the brightly colored O. pumilio. In addition, we noted that calling O. pumilio males had a shorter approach distance than did either non-calling male or female O. pumilio. These findings demonstrate that a cryptic and an aposematic litter frog differ in their escape response to a predator. These results also suggest that, at least in male O. pumilio, a tradeoff may exist between predator avoidance and reproductive success via territorial defense and mate attraction.

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**Embryonic modulation of yolk steroids in European starlings (Sturnus vulgaris)**

Sex steroids influence sexual differentiation during critical stages of vertebrate embryonic development. In birds, steroids of maternal origin are present in the yolk at oviposition and affect various aspects of offspring development, but do not influence sexual differentiation. Steroids in bird egg yolks decline markedly during early incubation via unknown mechanisms. Our goal was to determine if embryos actively modulate yolk steroid signals during early incubation. First, testosterone (T) and estradiol (E2) levels in yolk and albumen of European starling eggs were characterized at oviposition. Next, other eggs were incubated and yolk/albumen (YA) and whole embryo homogenates on E6). Results indicate that at oviposition, T and E2 occur in yolk but not albumen, and yolk T concentration varies significantly among clutches. Across development, E2 remains low or undetectable, PROG and T concentrations decline in YA homogenates, and are negatively correlated with embryo mass. Presence of radioactivity in aqueous fractions of both YA and embryo homogenates on E6 suggests that some tritiated T was converted to a water-soluble form, the amount of which positively correlates with embryo mass. Collectively, the results indicate that starlings actively metabolize yolk testosterone during early development via metabolism of lipid-soluble steroid into a water-soluble metabolite. This steroid shunt likely buffers embryos from the influence of yolk steroids during periods when sexual differentiation could otherwise be influenced.
Role of Matrix metalloproteinases in activating myostatin in the skeletal muscle in response to high fat diet induced diabetes

High fat diet-induced obesity (HFDIO) is associated with type 2 diabetes and metabolic dysfunction. Skeletal muscle and adipose tissue are the main sites of energy utilization and play an important role in the regulation of energy homeostasis. Obesity is also known to be a pro-inflammatory disease with increased systemic cytokine release, potentially triggering local immune responses. The intent of this project is to evaluate the relationship between muscle growth, metabolism, and the immune system, specifically targeting how matrix metalloproteinases (MMPs) and myostatin (MSTN) might interact in skeletal muscle tissue. Myostatin is a negative regulator of skeletal muscle mass and impacts body fat accumulation, and it has recently been demonstrated that MSTN plays an important role in high-fat diet induced obesity (HFDIO). Removal of MSTN results in resistance to HFDIO. In addition, we have demonstrated that different strains of mice exhibiting differential susceptibility to a high fat diet exhibit significant differential MSTN gene expression. Also, MSTN appears to bind decorin in the ECM, which is a target of MMP activity. Matrix metalloproteinases are zinc-dependent endopeptidases and have been implicated in the pathiology of dystrophin-related muscle disorders and inflammatory myopathies. Activated MMP-2 and -9 are present in muscle from obese mice, and MMP-2 gene expression is highly upregulated in obese spleen tissue. MMP-9 gene expression is elevated to a greater degree than MMP-2 in muscle tissue of obese mice, suggesting a role of MMP-9 in muscle responses to inflammation and possibly MSTN activation regulation. By comparing different inbred strains of mice, we can better understand the genetic components regulating diabesity, which may lead to a better understanding of the interaction between the immune system and metabolism.

Acclimation to Hypoxia Alters Gene Expression and \( K_{aM} \) Channel Response to Acute Low Oxygen in the Hearts of Goldfish

Goldfish (Carassius auratus) are extremely tolerant of environmental hypoxia and may retain normal cardiac function for several days in the complete absence of oxygen. Previous results suggest that the hypoxia-induced activation of cardiac ATP-sensitive potassium (\( K_{ATP} \)) channels, whether in sarcolemmal or mitochondrial membranes, serves to increase tolerance of low oxygen. We have characterized a nitric oxide (NO)- and cGMP-dependent signaling pathway by which this \( K_{ATP} \) channel activation occurs in acute hypoxia. The purpose of the present study was to resolve alterations in cardiac cell viability, \( K_{ATP} \) channel activity and gene expression in response to hypoxia acclimation. Goldfish were exposed to moderately hypoxic conditions (2.6 mg O2/l) for seven days at 22°C. Isolated cardiac myocytes from animals acclimated to hypoxia were significantly more tolerant of subsequent exposure to acute hypoxia in vitro than were cells from non-acclimated fish. The viability of cells from both groups was decreased by the NO-synthase (NOS) inhibitor L-NAME and enhanced by analogs of cGMP, although to different degrees. Quantitative real-time RT-PCR data indicated that KCNJ11, a gene coding for the pore-forming subunit of sarcolemmal \( K_{ATP} \) channels, was downregulated in response to hypoxia acclimation, while the expression of HF1 (hypoxia inducible factor) was unchanged. These data indicate that prior whole-animal acclimation to chronic environmental hypoxia enhances cellular tolerance of subsequent low oxygen in this species, and suggest a role for the altered regulation of cardiac \( K_{ATP} \) channels in this response. (Supported by the Brachman Hoffman Fund and by an HHMI grant to Wellesley College)

Heterospecific Vocal Mimicry in Cassin's Finch (Carpodacus cassinii)

Heterospecific vocal mimicry (HVM) is widespread among oscine songbirds. In some cases songbirds mimic entire elements from other species repertoires and use signals in the same social contexts. For example, studies have established that HVM can function for deception of hosts by brood parasites or predator evasion by eliciting mobbing behavior among heterospecifics. In other cases, songbirds include mimicked elements in their songs. It has been asserted that HVM in song is the outcome of passive processes like the accumulation of learning mistakes to generate large repertoires that include imitations. Alternatively, in other mimicking species, HVM may be under sexual selection because females assess song complexity as a cue for male quality. I investigated song complexity and expression of HVM in Cassins finch (Carpodacus cassinii), a North American mimicking species.

Cassins finch is an excellent model to test the sexual selection hypothesis because males mimic many different species and insert those imitations in songs used to attract females. My analysis of Cassins finch song reveals that within a bout, males generate the greatest variation through manipulation of heterospecific imitations in a single song theme. Further, these imitations are placed at the end of songs, where the type and syntax of these elements generate variation on the theme. These data suggest that Cassins finch males control song complexity largely through appropriation of elements from other species. Thus it is possible that sexual selection through female choice is driving males to produce complex songs achieved through expression of heterospecific imitations. This interpretation is consistent with the observation that males seldom sing during aggressive encounters with other males, but frequently do so when interacting with females.

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Turning performance of batoid rays: Limitations of a rigid body

The ability to maneuver is critical to the locomotor performance of batoid rays, but can be constrained by the inflexibility of the body. Turning motions are therefore affected by the motions of the expanded and mobile pectoral fins. Turning radius (maneuverability) and turning rate (agility) were measured from overhead video recordings of rays in a large pool during unrestricted swimming. The rays were characterized as swimming by oscillatory movements of the pectoral fins (Aetobatus narinari, Myliobatis freminvilli and Rhinoptera bonasus) or by undulations of the fins (Dasyatis americana and Dasyatis centroura). Oscillatory rays maneuvered by either powered or unpowered gliding turns, whereas undulatory rays turned using asymmetrical undulations of both pectoral fins. Underwater observations showed that both rays used banking while turning, which ranged from 15-70°. No statistical differences were found between mean turning parameters between the two locomotor types. However, minimum turn radius and maximum turning rate were respectively smaller and larger for oscillatory rays (0.7 m; 44.4°/s) compared to undulatory rays (1.0 m; 30.4°/s). Rays can reduce the rotational inertia of the body by banking and bending the fins dorsally to change the distribution of mass, thereby overcoming the mechanical constraints on turning that are imposed by the structure of their rigid bodies. Despite compensation by possessing flexible appendages, rays still have lower agility compared to flexible-bodied swimmers.

Detection and Localization of a Possible Photoreceptive Pigment in Temperate Holothurians (Echinodermata)

Many echinoderms have the ability to detect light, either by primitive eyes or through a diffuse dermal detection called extraocular photoreception. Johnson (1997) showed that an asteroid and an ophiuroid possibly contain a rhodopsin-like protein that is likely used for photoreception. Many holothurians have been shown to be photosensitive, but the cellular mechanism and components used have not been described. The current study was designed to determine if photosensitive temperate holothurians have a rhodopsin-like protein that may be used for photoreception. Photopigment protein was detected by western blotting using two monoclonal antibodies raised against bovine rhodopsin (MW=39 kDa). Pharyngeal retractor muscle taken from Cucumaria miniata during both winter and summer show a solitary band at about 40 kDa. Tube feet (with skin) and respiratory tree from C. miniata in summer also show a solitary band at about 40 kDa. Oral tentacle and tube feet from Parastichopus californicus have also shown solitary banding at about 40 kDa. Continuing research is investigating two more species, Eupentacta quinquememita and Psaolus chitonoides and determining the effect of light on photopigment protein levels. The protein in question, which binds rhodopsin antibodies, is in the molecular weight range of rhodopsins, and is found in photosensitive holothurians, will be isolated and sequenced to determine if it is a photoreceptive pigment.

Arrest of aerobic metabolism in Artemia franciscana embryos during diapause

Diapause embryos of the brine shrimp, Artemia franciscana, are characterized by a low metabolic rate. Based on our previous data, we hypothesized that metabolic arrest is due to a combination of at least two mechanisms, namely substrate limitation to the mitochondrion and reversible inhibition of oxidative phosphorylation. We measured metabolic intermediates in metabolically-active embryos and in diapause embryos. A significant reduction in glucose-6-phosphate was evident in diapause (0.22 +/- 0.02 nmol/mg; mean SE, n = 3) versus active (1.85 +/- 0.53 nmol/mg) embryos. Values for glucose in diapause (5.98 +/- 1.8 nmol/mg) and active (3.58 +/- 2.09 nmol/mg) embryos allow the calculation of mass action ratios (0.04 diapause vs. 0.52 active), which indicate inhibition at the hexokinase (HK) step and suggest a reduced glycolytic flux and substrate limitation to the mitochondrion in diapause. Pyruvate is lower in diapause (0.24 +/- 0.04 nmol/mg) than in active (0.46 +/- 0.08 nmol/mg) embryos, but not as low as anticipated, despite being downstream of the glycolytic inhibition at HK. This observation could be explained by an inhibition of pyruvate dehydrogenase (PDH). Measurement of acetyl CoA levels and kinetic characterization of PDH are underway to evaluate this possibility. To further infer sites of respiratory inhibition, we measured the apparent K_m of Complex IV (cytochrome c oxidase) for cytochrome c (cyt c). The value in diapause embryos (30.3 +/- 3.5 M; mean SE, n = 3) was significantly higher than in active embryos (12.6 +/- 3.9 M). Whether or not this reduction in apparent affinity has any impact on flux through Complex IV depends on estimates of cyt c level in the intermembrane space. [Supported by NIH grant 2 RO1 DK04670-14A1]
A novel peritrich (Ciliophora) from the symbiotic community of freshwater pulmonate snails (Mollusca, Gastropoda) in Massachusetts Freshwater pulmonates are host to numerous symbiotic communities including mutualistic, commensalistic and parasitic protozoans and metazoans. In our investigation of the symbiotic community of two species of freshwater snails, Menetia dilatata and Physa sp., we discovered a previously undescribed species of peritrich that lives inside the snails pulmonary cavity (lung). We use a combination of brightfield, fluorescence and electron microscopy to describe this new species. This ciliate, a member of the genus Scyphidia, forms colonies on the mantle tissue of small snails with transparent shells. The ciliate is host to endosymbiotic algae (presumably Chlorella) that occupies a large proportion of the ciliates volume and forms a mixotrophic relationship with it. As host snails age, their shells become less transparent, and the colonial ciliate declines in abundance, indicating a potential obligate relationship between the symbiont. Binary fission of the ciliates leads to the production of swarmer that also contain endosymbiotic algae. This report constitutes the first description of mixotrophy in Scyphidia, which comprises both marine and freshwater symbiotic ciliates.

Gape and bite force in the northern grasshopper mouse (Onychomys leucogaster) and the deer mouse (Peromyscus maniculatus)

Previous studies on the masticatory apparatus of the northern grasshopper mouse (O. leucogaster) and the deer mouse (P. maniculatus) suggest that there are architectural differences in the jaw muscles relating to feeding behavior and diet. For example, for some of the jaw-closing muscles, O. leucogaster may have a smaller physiological cross-sectional area (PCSA) but a more favorable lever advantage for producing bite force at the incisors than P. maniculatus. This configuration is thought to help maintain or increase bite force capabilities at large gapes in O. leucogaster, which may be required to facilitate their carnivorous diet consisting of similar-sized vertebrates. To determine the relationship between gape and bite force in both species, we collected bite forces at different gapes from 8 individuals of P. maniculatus and 11 individuals of O. leucogaster using an adjustable bite force transducer instrumented with strain gauges. Despite the fact that O. leucogaster weighs almost twice as much as P. maniculatus, both species prefer to bite at a similar range of gapes, from 4.0 mm to 8.0 mm, significantly lower than their maximum gapes. Moreover, absolute and relative maximum bite forces in both species peak at 5.0 mm of gape. However, as expected O. leucogaster has absolutely and relatively higher maximum bite forces at each gape. Any structural differences in the jaw musculature appear to have a negligible influence on producing significantly larger bites, but may facilitate the larger bite forces in O. leucogaster.

Distinguishing the validity of subspecies of the endangered Hawaiian tree snail Achatinella mustelina using a principal component analysis of shell characters

The endangered Hawaiian tree snail species Achatinella mustelina was divided into 25 subspecies based on traditional shell characters (Welch 1938). A recent molecular genetic analysis of 21 populations through the species range yielded no support for the subspecies distinctions. In the present study 11 shell characters were measured on photos of 50 shells of each of 19 nominal subspecies using image-analysis software; the shells are in the collections of the B. P. Bishop Museum, Honolulu. The characters included both traditional linear measurements (5), plus perimeter (3) and surface-area (3) measurements. The resultant data were subjected to principal component analyses to determine the most important discriminating characters and to answer the question, do the shell characters support assignment to the nominal subspecies? The principal components (PCs) explained 95.5% of the variance among measurements, and two, PC1 and PC2, provided most of the information. Pair-wise comparisons of the subspecies, based on PC1 and PC2, plus examination of the subspecies ranges on a map, provided support for 11 of the subspecies (i.e., they were distinct from all subspecies with overlapping ranges), but not for the remaining 8 (i.e., they were not distinguished from sympatric subspecies). It remains for these results to be resolved with the results of molecular genetic analyses of snails from the same populations.
Differential allocation of carotenoids and testosterone into egg yolks affects the immune performance of Japanese quail chicks

In birds, females can influence variation in offspring performance by differentially transferring resources such as nutrients and hormones to eggs. In this study we assigned 48 female Japanese quail (Coturnix coturnix japonica) to one of the following treatments: a carotenoid supplemented diet, an injection of GnRH, a carotenoid supplemented diet combined with GnRH challenges, and control, over a period of seven weeks. On a weekly basis we measured carotenoid and testosterone levels in yolks for each female, and incubated and hatched eggs from these females. After two weeks of growth, we examined the ability of the chicks plasma to fight off bacteria, and we measured the dimensions of the bursa of Fabricius on all chicks. Testosterone levels were higher in eggs from the GnRH challenged females relative to eggs from carotenoid supplemented or control females, and testosterone levels were even higher in eggs from females receiving carotenoid supplemented diets and GnRH challenges. Chicks from females receiving carotenoid supplemented diets only had considerably enhanced immune responses. Those chicks had larger bursa than chicks from other treatments and female chicks had significantly larger bursa than males. Moreover, bacteria killing ability of their plasma was higher than in chicks from other treatments. We provide evidence that female allocation of carotenoids in eggs can influence immune performance of chicks, and discuss the extent to which increased levels of testosterone in the yolk may compromise chick immune function.

Daphnia pulex (Crustacea) chemical senses

Can you smell that? Using genomics to demystify Daphnia's (Crustacea) chemical senses

For years the debate of if, how and which chemical signals can be detected by Daphnia has plagued freshwater biologists. Daphnia pulex, a sentinel and keystone species of freshwater systems, thought to be the sister group to the terrestrial insects, is the first aquatic invertebrate to have its genome sequenced. Using representative Grs and Ors from all available insect species as queries, we present the chemoreceptor superfamily of D. pulex, finding six distinct gustatory-like receptors (Grs) clusters, for a total of 58 genes. These 58 Grs form a major species-specific cluster of 49 genes, a smaller cluster of 5 genes, as well as a highly divergent singleton (GrS8). The final three genes, Grs55-57, share distinctive amino acid motifs and cluster with the sugar receptors of insects, and may illuminate the origin of this distinctive subfamily and the potential for Daphnia to detect sugars. This chemoreceptor gene repertoire presumably mediates the many taste and smell functions of this crustacean. Consistent with the prediction of Robertson et al. (2003), we find no evidence of Olfactory receptors (Ors), in particular, no homolog of the otherwise highly conserved DmOr83b protein, which has orthologs in all available insect genomes, was found. While it is always possible that this entire Or gene lineage was lost at some point in the history of Daphnia pulex, we think it more likely that the insect Or lineage is indeed a relatively recently expanded lineage concomitant with the evolution of terrestiality in insects or their hexapod ancestors. We present ESTs and tiling array support for the predicted gene models, and expression data comparing expression between the sexes.

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Eat and run: Predator preference for and escape responses by potential hosts of the snail Crepidula adunca (Mollusca, Gastropoda)

When a species strictly associates with only one host, despite the presence of many similar alternatives, the question arises as to what selection pressures are driving the specificity of this symbiosis. The suspension-feeding, epibiotic, marine snail Crepidula adunca is found almost exclusively on the host snail Calliostoma ligatum in the San Juan Islands, Washington. This fidelity is especially surprising considering that other potential hosts, including the similarly-shaped, commensal snail Margarites pupillus, exist in the same habitat. We investigated whether predator preference for hosts other than C. ligatum may have contributed to the evolution of C. adunca's specialization on C. ligatum. The sea stars Pisaster ochraceus and Leptasterias hexactis, the crabs Cancer productus and Cancer oregonensis, and the snail Liracuncinum dira are the dominant predators that co-occur with Crepidula adunca. Of these, Leptasterias hexactis is the most voracious predator of both C. ligatum and M. pupillus, and contact with L. hexactis causes a violent reaction in individuals of these species of snails. Leptasterias hexactis prefers to consume Margarites pupillus, the snail not utilized by Crepidula adunca, rather than the host Calliostoma ligatum. This preference is not just due to differences in escape behaviors between the snails, because the sea star consumes more individuals of M. pupillus than C. ligatum when the snails are prevented from moving. Other anti-predatory behaviors, such as running speed and defensive tactics may also contribute to higher rates of predation for M. pupillus compared with C. ligatum. Thus, host choice by Crepidula adunca is likely due, at least in part, to relative risks of predation for the various host species.

Aquaporin-3 expression correlates with seasonal acquisition of freeze tolerance in the goldenrod gall fly, Eurosta solidaginis

Some invertebrates have evolved adaptations to survive freezing of their body fluids during subzero temperature exposure. The accumulation of cryoprotectants, such as glycerol, and the redistribution of water between body compartments play central roles in their capacity to survive freezing. The movement of glycerol and water into and out of the cell is facilitated by aquaporins, which are pore-forming transmembrane proteins. Recent studies demonstrated that there is a significant decrease in freeze tolerance when molecular movements through aquaporins are blocked. Larvae of the goldenrod gall fly, Eurosta solidaginis, are freeze-intolerant during the summer, but develop their capacity for freeze tolerance through the autumn. To determine whether aquaporin expression is correlated with their acquisition of freeze tolerance, Eurosta solidaginis larvae were collected monthly, from July through January. As expected, larvae developed progressively greater levels of freeze tolerance through the autumn. Also, glycerol concentration increased in the larvae as the plant gall tissues around them senesced and dried. Following each field collection, membrane- and soluble-protein fractions were isolated from larval homogenates. Immunoblots using rat anti-AQP3, a water- and glycerol-permeable aquaporin, showed a gradual increase in membrane-bound AQP3 from July through January. In contrast, AQP3 proteins in the soluble fraction peaked in September and gradually decreased through December. These results support the hypothesis that AQP3 expression increases concomitantly with increasing freeze tolerance in E. solidaginis. Supported in part by NSF grant #OB-0416720.
Three generations of captive-bred axolotls (*Ambystoma mexicanum*) reveal a new, non-lethal phenotype that results in the sustained inflation of the lungs for weeks to months. Affected animals inhale but rarely exhale. Animals expressing this phenotype float inverted or listing for two or more consecutive weeks, with trunks breaking the water surface. The new phenotype, designated the Blackburn College Floater (BC-Floater), was first documented in crosses raised in Blackburn College laboratories. Over three years, crosses were raised under similar laboratory conditions (20-25°C with local photoperiods). A repeated cross produced 29% and 25% BC-Floaters in successive years. That same male crossed with a different female produced only 2% offspring that matched the floater phenotype. Subsequent crosses of BC-Floaters that had recovered to normal body posture exhibited an unclear pattern of incomplete penetrance. Two crosses of F₁ BC-Floaters produced 20% and 21% BC-Floater offspring. Two crosses of F₂ BC-Floaters produced 8% and 10% BC-Floater offspring. Axolotls first exhibited the floating phenotype at 21-80mm total length and 3-15 weeks post-hatching (mean=43mm and 8 weeks, N=55 representing animals from 3 crosses). By one year of age, most BC-Floaters either recovered to a normal body posture and ventilation of their lungs or died from the apparent stress of the continued inverted condition. In still, shallow water (5cm), recovery was slow and irregular; 8 of 29 (28%) BC-Floaters recovered by nine months. In 25cm deep water (with turbulence generated by a hanging power filter) 42 of 44 (93%) six-month-old BC-Floaters reverted to a normal body posture within 10 days.

Several studies have indicated that the whelk *Nucella lamellosa* displays phenotypic plasticity in response to predation threat from the predatory crab *Cancer productus*. Less research has been performed on the phenotypic plasticity of *N. lamellosa* in response to another major predator, *Pisaster ochraceus*. This study looked to expand upon this body of research. It was found that the presence of waterborne cues from *P. ochraceus* induces changes in the retractability of *N. lamellosa*. *N. lamellosa* held in the presence of sea stars had greater retractability than those held without sea stars. Further, *N. lamellosa* exposed to sea star cue were less likely to be preyed upon by *P. ochraceus* than those not previously exposed to cue. Greater retractability in *N. lamellosa* was correlated with less mortality in the predation experiment, suggesting that retractability is an inducible defense against sea stars.

A New, Non-Lethal Phenotype, the Blackburn College Floater (BC-Floater), in the Axolotl (*Ambystoma mexicanum*)

Should I stay or should I go? Optimal decisions for attack and flight during predator-prey interactions

One of the most important decisions that a prey makes during its lifetime is if and when to flee from a predator. To date, all theoretical treatments of flight initiation predict that a prey should flee when it detects a predator in the environment. However, prey might gain considerably by not fleeing if they are successfully cryptic or if predators fail to attack. Previous models of flight initiation make very simple assumptions regarding the detectability and perceptual abilities of predators and prey; e.g., prey are always detected once they are within a specified perceptual distance from the predator. Here, we relax these assumptions for both predator and prey by allowing the probabilities of detection to decay with distance and direction according to a set of probability density functions. These probability density functions define the perceptual ranges of the predator and prey. By modifying shape parameters of these probability distributions, we simulated several types of searching strategies for predators and vigilance strategies for prey. Assuming that individuals want to maximize net energy intake per time, we simultaneously solved for the optimal probabilities of prey flight and predator attack during these simulations using evolutionary algorithms. Contrary to earlier models, we found that prey do not necessarily flee once they have detected a predator, nor do predators immediately attack once a prey is detected. This result is likely a direct consequence of imperfect perception and detectability of the predator and prey. Future directions for this work include directly linking predator and prey strategies to fitness (as a function of age), and searching for multiple strategies indicative of predator-prey games under different abundances and distributions of prey.

How Does Spatial Variation in Climate Cause Spatiotemporal Patterns in Lizard Energetics?

A lizards ability to be active and to acquire food for growth, storage, and reproduction is expected to be seasonally constrained by the complex, dynamic set of phenomena that comprise climate. Hence variation in climate among locales should vary in how they constrain lizard activity and production. The western fence lizard (*Sceloporus occidentalis*) occupies a diversity of ecosystems from southern California to central Washington. Two locales that contrast markedly in climate in Washington state, in the northern end of the species geographic range, are coastal temperate forest and the warm, dry pine-oak woodland of the states interior. How *S. occidentalis* is affected by this geographic climate change was examined by correlating daily and seasonal patterns of temperature, precipitation, and cloud cover with the patterns of lizard daily activity and energy expenditure, feeding rates and food availability along with related aspects of lizard population structure. Despite the greater food availability for coastal lizards, the lizards in the warm, sunny woodland site were active longer, ate more, and grew faster. Currently, the optimum climates for this species are not known, but future investigations of elevational and mesic-xeric gradients may enable predictions of population structure and population density patterns in the face of climate change.
Non-Esterified Fatty Acid Concentrations in Galápagos Marine Iguanas during a Mild El Niño Year

The Galápagos marine iguana (*Amblyrhynchus cristatus*) undergoes long periods of fasting during an El Niño year. How these animals are able to survive periods when food is scarce is unclear. During a fast, we predicted that these animals mobilize endogenous fat stores to meet metabolic energy requirements. Plasma concentrations of non-esterified fatty acids (NEFA) are generally indicative of fat metabolism in fasting animals. We investigated plasma NEFA concentrations in marine iguanas collected in January of 2007, which was a mild El Niño year. Blood samples from both female and male marine iguanas were analyzed in this study. We also determined body mass (g) and body condition index (body mass/snout-vent length) of the same animals in order to correlate NEFA concentrations with body condition. We hypothesized that the animals with a low body condition index would have low plasma NEFA levels and would be less likely to survive. Our data suggest that in female iguanas there is a positive correlation between body mass and snout-vent length (SVL) (\(R^2 = 0.34\); \(n = 19\)) and a positive correlation for body condition index vs. plasma NEFA concentrations (\(R^2 = 0.32\); \(n = 70\)), but did not show any correlation between body condition index and NEFA concentrations. Overall, we conclude that female iguanas in 2007 were in better condition to survive a long fast compared to male iguanas.

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Variability of Walking in Humans

Almost all humans walk, but the morphology of their leg muscles and kinematics of their gait patterns differ visibly among individuals. In this study, we examine the relationship between the variability of gait patterns and neural control patterns with differences in body shape (i.e., muscle size) during walking in 19 young adults (mass = 60.9 +/- 6.9 kg; height = 1.67 +/- 0.09 m; average SD). We used ultrasonography to measure muscle morphology of the lateral gastrocnemius (LG), medial gastrocnemius (MG), and soleus (SOL) muscles at rest, and then recorded the muscle activity of these muscles and joint kinematics (Qualysis) during walking on a treadmill at 0.6 m/s. In 37% of those Western blots, the estimated molecular weight of the gall fly dehydrin-like protein is 66 kDa.

Sexual dimorphism of electrocommunication signals across populations of the weakly electric fish Apteronotus albifrons

Weakly electric fish produce electric organ discharges (EODs) for electrolocation and communication. Both EOD frequency (EODf) and EOD modulations (chirps) vary across species, sexes, and individuals. EOD modulations can also vary across populations of the same species (Turner et al. 2007). The focus of this study was to examine population-level variation in the sexual dimorphism of electrocommunication signals. We characterized EODs in four populations of A. albifrons, and used mtDNA cytochrome-b sequence to examine genetic relationships between populations. Individuals from populations in the Orinoco drainage (CO-oc and CO-in) or the Amazon drainage (PE and BR) were presented with playbacks of synthetic conspecific EODs, and their EODs and chirps recorded. EODs were sexually dimorphic in both CO populations, but did not differ significantly between the sexes in the PE and BR populations. Consistent with previous studies (Dunlap et al. 1998; Kolodziejski et al. 2005), chirp rate did not differ between sexes in any of the A. albifrons populations. Chirp frequency modulation and duration were also sexually dimorphic in the Orinoco, but not the Amazon populations. Overall, populations from the same river systems were more genetically and behaviorally similar than populations in separate river systems. This is consistent with the hypothesis that diversity in sexually dimorphic EOD behavior has evolved in allopatry, with South American watersheds acting as barriers for reproductive isolation.
The evolution of fin reduction and loss in fishes

Body elongation has evolved a number of times independently in vertebrates. In highly elongate vertebrates, the limbs/fins are often reduced or lost. For example, a number of elongate tetrapods have been described as having reduced limbs; many times in association with a transition to a burrowing habit. Less is known about changes to the fins in elongate fish lineages. Previous study has shown that loss of the pelvic fins has occurred in a number of fish lineages regardless of body shape. The goal of this study was to determine whether there is fin reduction in fish lineages where there is body elongation and to determine the specific musculoskeletal changes associated with fin reduction in fishes. In this study, we collected fin and body measurements from a number of ostariophysan and gasterosteiform species. Additionally, we described the musculoskeletal anatomy for at least two species that differ in degree of body elongation from both Ostariophys and Gasterosteiformes. Highly elongate members of these lineages do not have pelvic fins. Our results indicate that the pectoral fins are smaller in more elongate fishes in these lineages. In examining the musculoskeletal system of elongate and non-elongate species from the same lineage, we have found that there is a difference in number and arrangement of the pectoral fin muscles between closely related elongate and non-elongate species. This work provides a critical basis in understanding anatomical changes to the paired fins that are associated with changes in body shape.

Do Circatidal or Circalunidian Clocks Control Locomotor Rhythms in the American Horseshoe Crab?

Like many other inter-tidal dwellers or visitors, the American Horseshoe Crab, Limulus polyphemus, expresses endogenous locomotor activity rhythms that can be synchronized to the tides. While these biological rhythms have been long recognized, the nature of the timing system controlling them is somewhat controversial: the system could theoretically be comprised of either two 24.8h (circalunidian), or one 12.4h (circatidal) clock and there is evidence that seemingly supports both possibilities. The horseshoe crab expresses exceptionally clear circatidal rhythms and is thus a good choice for addressing this issue. Our results suggest the presence of two circulunidian clocks in horseshoe crabs: 1) When animals were given two tidal cues of different periods (24.4 and 24.2h), synchronization to both tides occurred. 2) In some animals these rhythms persisted in constant conditions in phase with previous tidal cues suggesting entrainment of two separate clocks. 3) Rarely, but significantly, two bouts of activity were observed, each with different free running periods. 4) In other experiments, only one bout of activity/day was evident during either constant conditions or during tidal cycles; later under the same conditions, two bouts of activity/day could be observed. Taken together these results and others are consistent with the hypothesis that in this species locomotor activity is controlled by two circalunidian oscillators that are strongly coupled. In addition, since it is not uncommon to see only one bout of activity/day, decoupling of one of the oscillators from downstream locomotor centers may commonly occur, an outcome that could serve intertidal species well in areas where there is only one tide/day.

Transcriptional Profile of the Penaeid Shrimp Litopenaeus vannamei to Hypoxia and Hypercapnic Hypoxia

Many crustaceans inhabit estuarine ecosystems where they are frequently exposed to hypoxia. High levels of CO₂ (hypercapnia) often occur in the presence of hypoxia, and both factors may impair the abilities of crustaceans to maintain optimal metabolic processes, preserve acid-base balance, and uphold immune defense against pathogens. Many of the strategies employed by marine crustaceans to cope with hypoxia and hypercapnia involve changes in transcription and translation of sets of genes, some of which may be uniquely linked to these stressors and some of which may be components of a common stress response in shrimp. In the present study we tested the hypothesis that stress responses of Litopenaeus vannamei to hypoxia (P₂O₅ = 4.0 kPa, P₃O₅ < 0.06 kPa) and hypercapnic hypoxia (P₂O₅ = 4.0 kPa, P₃O₅ = 1.8 kPa) are represented by unique transcriptional profiles as compared to normoxia (P₂O₅ = 20 kPa, P₃O₅ < 0.06 kPa) or to each other. Shrimp were held for either 4 h or 24 h (n=8 per treatment and timepoint). At the end of the treatment period, gill and hepatopancreas were dissected and preserved. RNA isolated from hepatopancreas of individual animals was hybridized to custom oligonucleotide microarrays containing 22,000 unigenes expressed in L. vannamei. These results should contribute to a more detailed understanding of shared and unique gene sets involved in the crustacean stress response to environmental change. Supported by NSF IBN-0212921 and NOAA OHH at HML.

In situ filtration rates of pelagic tunicates: results from morphometric measurements

Salps are suspension-feeding pelagic tunicates that filter higher volumes of seawater than almost any other planktonic grazer. Oral and atrial siphons are at opposite ends of the barrel shaped body and a unidirectional feeding current is produced by rhythmically contracting circular muscle bands. Seawater and associated small particles (0.1 m-1 mm) are filtered through a mucous mesh that fills the mostly hollow pharyngeal cavity. Accurately measuring filtration rates poses a challenge because salps are delicate, difficult to collect and maintain, and may not behave normally in the laboratory. Morphometric analysis of salps swimming in situ provided a way to measure the volume of fluid passing through the mucous filtering mesh. High definition video sequences were collected by SCUBA divers and then video frames were digitized to measure time-varying swimming kinematics and body volume over a pulse cycle. This in situ technique has been applied to several species of salps and compares reasonably to results from other methods. Differences in filtering efficiency between Salpa cylindrical, Pega conofoederata and Cyclosalpa sp. will be presented.

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The importance of courtship song in female mate choice in the Pacific field cricket, Teleogryllus oceanicus

In many animals, multiple signals, in one or more modalities (e.g. visual and chemical) and either simultaneously or separately, are used in mate selection. More specifically, field crickets have two acoustic signals used in mate choice: a calling song which attracts females from a distance and a courtship song that follows once a female makes contact with a male. Much research has focused on the role of the calling song, but significantly less has looked into the role of the courtship song and mate selection. The courtship song of the Pacific field cricket, *Teleogryllus oceanicus*, is important in eliciting a proper female mounting response, but whether females prefer certain males over others based on the song itself is unknown. By employing a two day mating tournament, we predicted that the preferred males would have courtship songs that were longer in length with a higher duty cycle (more sound per unit time) and a lower fundamental frequency. The tournament demonstrated that females do in fact base their mating decisions on the courtship song itself, and preferred males have longer courtship songs with a higher duty cycle, but not necessarily a lower frequency. These results are consistent with the idea that the courtship song is potentially conveying information about the quality of the male.

Diapause regulation in *Pyrrharctia isabella*

When trying to survive stressful environmental conditions, insects can enter one of two types of dormancy: quiescence or diapause. Quiescence is a direct response to current conditions and is easily reversible when conditions revert to normal. In contrast, diapause occurs in anticipation of unfavorable seasonal conditions and is characterized by a period of insensitivity to current conditions. Metabolic depression is an indicator of diapause. *Pyrrharctia isabella* overwinters as the banded woolly bear caterpillar. Previous studies found that *P. isabella* in northern populations enter diapause. However it was suggested that there may be latitudinal population differences in the type of dormancy *P. isabella* enters. We examined a Pennsylvania population of *P. isabella* larvae. We exposed fall and winter field acclimatized larvae to summer temperatures and photoperiod, and measured changes in metabolic rates and development. Although metabolic data were inconclusive, winter collected larvae continued development while fall collected larvae did not, thus indicating that this population enters diapause and not quiescence. Our current objective is to repeat metabolic measurements and determine how long this Pennsylvania population of *P. isabella* larvae remain in refractory phase of diapause and when diapause is terminated. We will expose field acclimatized larvae from early October through late December to summer temperature and photoperiod periodically throughout the fall and winter. We will record changes in metabolic rates and continuation of development. We will also measure seasonal changes in supercooling points and glycerol production as indicators of freeze-tolerance. Data are forthcoming.

Mechanisms of maternal yolk corticosterone action in developing Japanese quail

Evidence from a wide variety of species indicates that exposure to maternal steroids during development can have long-lasting effects on offspring phenotypes. Maternally derived corticosterone in avian eggs influences the development and function of the hypothalamic-pituitary-adrenal (HPA) axis later in life, however, the developmental mechanisms by which maternal steroids act are elusive. I injected Japanese quail (*Coturnix coturnix japonica*) eggs either with corticosterone (9 ng) or an oil vehicle prior to incubation and evaluated mRNA expression of the SF-1 receptor in 3.5 d old embryos using quantitative RT-PCR. Steroidogenic factor 1 (SF-1) is an orphan nuclear receptor that plays a critical role in gonad development and differentiation as well as normal adrenal development and function. Elevated corticosterone in eggs significantly decreases SF-1 expression relative to vehicle-treated controls prior to gonad or adrenal gland development in the embryo. These results indicate that maternal steroids may have organizational effects on developmental processes that occur very early in development, prior to the embryos own production of steroids.
P3.29 REESE, S. A.; BLACK, P.*; ADAIR, E.; KOETHER, M.; Kennesaw State University; reese@kennesaw.edu

Thermoregulation during Flight in the Brazilian free-tailed Bat (Tadarida brasiliensis), were measured. Body temperature (Tb) of free-ranging Brazilian free-tailed bats, Tadarida brasiliensis, were measured with infrared thermography over a range of ambient temperatures (T). Mean Tb was determined for the body, head, wings, and tail membrane during emergence flights at dusk and during return flights at midnight and dawn. Tb increased with T for all body regions (p>0.001). At dusk, only the body was 0.06C warmer than Ta; all other regions were cooler. During midnight return flights, the body and head were warmer than Tb by 1.3C and 0.8C, respectively. Wings and tail were both 1.0C below Tb. Similarly at dawn, the body and head were 1.2C and 0.6C above Tb, respectively, and the wings and tail were each 2.1C below Tb. Cool membranes may result from bats flying in cool air immediately prior to measurements or from evaporative cooling. Mean internal Tb decreased between emergence flights (36.8C) and return flights (34.4C). However, Tb increased from 5.4C to 9.0C above Tb between emergence and return flights, suggesting increased heat production during this time. The sides beneath the wings were the warmest body regions, providing high potential for heat loss. At ground level, cool wings would not facilitate heat dissipation. By shunting blood away from naked wings during flight, bats reduce potential water loss that would otherwise result from blood flow to these membranes. At the same time, warmer regions on the body dissipate heat from flight muscles.

P3.28 REHOREK, S.J.; HILLENIUS, W.J.*; LEIGH, C.; FIRTH, B.T.; Slippery Rock Univ., College of Charleston, Univ. of Adelaide, Univ. of Adelaide; hilleniusw@cofc.edu

The anterior orbital glands in Sminthopsis crassicaudata: a nomenclatural conundrum

The anterior orbital glands of tetrapods include the Harderian and nictitans glands, both located in the nictitating membrane. Usually these can be differentiated either anatomically (nictitans gland is more anterior) or histochemically (Harderian gland secretes lipids). However, conflicting statements exist in the literature about the presence of these glands. For example, of the two studies on Sminthopsis crassicaudata (Dasypodidae; Marsupiala), one failed to note any anterior ocular glands and the other used no histochemical analyses. This study reexamined the structure of this glandular complex of S. crassicaudata. Histological examination revealed a well-developed, two-part (anterior vs posterior) glandular structure in the nictitating membrane. Histochemically and ultrastructurally it was shown that secretions of both glandular portions are mainly serous with sparse lipid droplets. The nomenclature of this complex depends upon the definition used. According to the anatomical definition, S. crassicaudata would have two glands: an anterior nictitans and a posterior Harderian gland. Fetal examination will be required to confirm that distinction. In contrast, the histochemical definition holds that both masses are Harderian glands, as both produce lipid and appear to use a merocrine secretory mechanism. However, the histochemical definition faces problems with respect to the mechanism of secretion, multiple secretions and glandular plasticity. Alternatively, the unitary definition refers only to the medial position of this gland and allows for multiple unconnected ducts. Based on this definition, S. crassicaudata would have one bilobed gland with an anterior and a posterior lobe. This last definition is broad enough to account the level of anatomical variation in the anterior ocular glands of tetrapods.

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Thermoregulation during Flight in the Brazilian free-tailed Bat

Adult aquatic turtles usually spend the winter months submerged underwater to escape freezing temperatures. In northern latitudes, this can lead to long months without access to air as the surface waters freeze. If O2 is available in the water, aquatic turtles utilize various extrapulmonary routes to extract oxygen from the water. However, in some hibernacula, there is little (hypoxia) to no (anoxia) O2 available in the water. Some species of turtles (anoxia-tolerant), namely painted turtles (Chrysemys picta) and common snapping turtles (Chelydra serpentina) can survive these prolonged bouts of anoxic submergence by buffering metabolic acid end-products using calcium and magnesium carbonates stored in their bone, particularly their shell. Other species (anoxia-intolerant) do not have this capacity and must avoid hibernacula that might become anoxic to survive the winter months. Hatching turtles of all species studied to date are born with low bone content and low buffer stores. As such, these animals will have a reduced capacity to survive harsh winters unless they quickly accumulate the buffers necessary or avoid those hibernacula likely to become anoxic. We analyzed hatching Red-eared slider turtles (an anoxia-tolerant species) for shell bone content. We measured [Ca2+], [Mg2+], [K+], [Na+], and [CO3]2- to determine if the hatchlings for these animals start out similarly to other species. We hypothesized that hatching Red-eared slider turtles would lack sufficient bone content and buffer stores after hatching to withstand entry into a hypoxic or anoxic environment. We compared these results to hatchlings of known anoxia-tolerant and anoxia-intolerant species as well as to adult painted turtle shell content.

P3.213 REIN, R.*; WEIGAND, K.L.; DEAROLF, J.L.; Hendrix College, Conway, AR; reinr@hendrix.edu

Do prenatal steroids affect maternal breathing muscles?

Prenatal steroids are administered to expecting mothers who begin to go into labor prematurely in order to quickly develop the lung tissue of their fetuses. Previous research has shown that exposure to these steroids has caused atrophy of adult muscles, including diaphragm. Thus, we hypothesize that exposure to prenatal steroids will cause atrophy of maternal muscle fibers, specifically in four breathing muscles: the diaphragm, scalenus, rectus thoracis, and rectus abdominis. Pregnant guinea pigs (Cavia porcellus) were injected twice weekly for three weeks with betamethasone (0.5 mg/kg body weight at 65%, 75%, and 85% gestation) or sterile water. Samples of all four muscles were collected from treated and control adults and prepared for histochemistry. Sample sections were cut in a cryostat and stained for myosin ATPase. The diameters of twenty-five fibers of each type (fast and slow twitch) were measured using Sion Image, and the data were compared across treatment groups. The fast twitch fibers in the treated scalenus (41.5 +/- 4.0 m) and rectus thoracis (45.5 +/- 3.8 m) were smaller than their respective controls (42.2 +/- 3.8 m; 47.8 +/- 1.6 m). In addition, the slow twitch fibers in the treated rectus abdominis (53.5 +/- 2.8 m) were smaller than those in the control muscles (57.1 +/- 1.3 m). Thus, the effects of steroid exposure seem to be muscle and fiber type specific. However, no significant differences were found between the treated and control fiber diameters in all four muscles. These results demonstrate that exposure to a prenatal steroid caused no significant fiber atrophy in the four breathing muscles and suggest that the maternal muscles are receiving little to none of the steroid, which is all being delivered to the fetus as desired.
Distinct Sarcomeric Protein Isoform Differences in Mammalian Fast and Slow Muscle Fibers are Associated with Muscle of Origin

We previously reported the existence of a novel slow fiber type ("S1F") in limb muscles of mammalian species with relatively large adult body mass (Bicer & Reiser, J. Muscle Res. Cell Motil., 25:623-633, 2004). These fibers express slow-type myosin heavy chain (MHC-I) and slow-type myosin light chains 1 and 2 (MLC1S, MLC2S), as well as fast-type MLC1 (MLC1F) and variable levels of fast-type MLC3. Conventional slow fibers in the same species express exclusively slow-type MHC and MLC isoforms. We also reported (Reiser & Bicer, Biophys. J. 94:2301-Pos, 2008) characteristics of "F1S" fibers, common in species with low adult body mass (e.g., rodents) that, unlike conventional fast fibers which express exclusively fast-type MHC and MLC isoforms, express MLC1S, along with fast-type MHC and MLC isoforms. We now report that there are multiple subtypes of S1F fibers and of F1S fibers, that differ from each other with respect to the level of expression of specific sarcomeric protein isoforms, and these differences are consistently associated with their muscle of origin. S1F fibers isolated from dog gastrocnemius and tibialis cranialis differ from each other with respect to the relative level of S1F: ~7% and 40%, respectively, of total essential MLC (i.e., MLC1 + MLC3). F1S fibers in rat gastrocnemius and tibialis cranialis consistently differ from each other with respect to the expression of fast-type isoforms of troponin-T. These results reveal even greater complexity in patterns of sarcomeric protein isoform expression and in the distribution of fiber types in mammalian limb muscles than previously recognized. Possible influences of these differences in isoform expression on functional properties will be discussed. Supported by the National Science Foundation.

Acoustic signaling and temperature variations: their effects on the physiology and hatching synchrony of the developing avian embryo

Hatching synchrony is a strategy utilized by some oviparous vertebrates to maximize hatching survival particularly in threatening environments. In many precocial birds hens lay one egg per day until their clutch is complete (laying asynchrony) yet members of the clutch hatch within a short period of time (typically within 10% of incubation time; i.e., hatching synchrony). Various laboratory studies attribute this phenomenon to acoustic signaling among adjacent embryos; however, no investigation has been done under simulated natural conditions. In quail species, and most distinctly in the Northern bobwhite (Colinus virginianus), the time difference between the first and last egg laid is typically 14 days. In the northern portion of the bobwhites range it is believed that embryos experience developmental diapause or torpor asynchrony (i.e., MLC1 + MLC3). F1S fibers in rat gastrocnemius and tibialis cranialis consistently differ from each other with respect to the level of expression of fast-type isoforms of troponin-T. These results reveal even greater complexity in patterns of sarcomeric protein isoform expression and in the distribution of fiber types in mammalian limb muscles than previously recognized. Possible influences of these differences in isoform expression on functional properties will be discussed. Supported by the National Science Foundation.

Conservation of muscle activation patterns in the forelimbs of swimming turtles: A comparison of three lineages (Trionychidae, Emydidae, Cheloniidae)

Tetrapod limbs exhibit a diverse range of forms. Correlated with the evolution of this diversity, new locomotor styles might arise through changes in anatomy, changes in the patterns of muscle activation that produce limb motion, or some combination of both. Turtles are an excellent lineage in which to test for such changes because of their diverse locomotor styles and morphologies. Although most freshwater turtles swim using asynchronous anteroposterior rowing motions of the limbs, sea turtles swim via synchronous dorsoventral flapping of forelimbs modified as flippers. To test how such different forelimb motions are produced among groups with generally similar muscle arrangements, we compared high-speed video and electromyographic (EMG) data from swimming softshell turtles (Apalone ferox, an aquatic specialist from the basal trionychid clade) and red-eared sliders (Trachemys scripta, a generalized Emydida) to data from the derived, flipper-shaped forelimbs of loggerhead sea turtles (Caretta caretta). Despite being aquatic specialists and possessing extensively webbed forelimbs, softshell turtles show muscle activation patterns and kinematics that generally resemble those of sliders. Some differences emerge between these species and sea turtles, but all three species also show markedly similar motor patterns for some forelimb muscles despite their kinematic differences. These data indicate that some motor patterns have been conserved in the evolution of turtle limb function despite major evolutionary changes in anatomical structure.
**P1.37** RIVERA, G.U.; TURNER, T; WALTERS, L.J; University of the Virgin Islands, University of Central Florida, hebejebes25@yahoo.com

**Feeding Behavior of Juvenile Diadema antillarum, the Long-Spined Black Sea Urchin**

Diadema antillarum play an important role in the coral reef community as a keystone grazer. As such they eat algae which compete with coral for space on the reef. Their grazing maintains algal density to a low level allowing corals to flourish and facilitating the recruitment of new corals. However, in the early 1980s there was a Caribbean wide die-off of Diadema caused by a still unknown pathogen removing 99% of the population. This created the opportunity for macroalgal cover on reefs to increase. Thus, the return of Diadema to reefs is important, but the feeding preference of the juvenile urchin (< 2 cm) is uncertain. Recent availability of the juvenile urchin in Brewers Bay, St. Thomas, US Virgin Islands allowed for an assay to assess feeding preferences. Five trials were conducted, each with 30 juvenile urchins, and each urchin was fed a single algal thallus for five days. Trials tested: the red alga <i>Cornalophora specifera</i>, the brown algae <i>Dicyota menstruata</i> and <i>Lobophora variegata</i>, the calcified green alga <i>Halimeda opuntia</i>, and the uncalkified green algae <i>Caulerpa macrophysa</i>. Juvenile urchins had distinct significantly different preferences (Kruskal-Wallis, p <0.001): they ate large amounts of <i>C</i>-<i>Acanthophora</i> and <i>Caulerpa</i> but much less of the other species. This information may help managers wishing to return urchins to reefs. Funded by NIH MBRS-RISE Grant # GM6132, NSF HBCU-UP

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**P2.67** RIVERA, A.R.V.; BENNETT, N.L.*; RIVERA, G.; WYNEKEN, J.; BLOB, R.W.; Clemson University, Florida Atlantic University; anvera@clemson.edu

**Whole-body acceleration during swimming in the green sea turtle (Chelonia mydas): A comparison of upstroke and downstroke**

Sea turtles are distinctive among aquatic turtles in terms of how limb morphology and limb mechanics interact to produce thrust, the force responsible for forward movement during swimming. Sea turtles swim using synchronous, dorsoventral movements of modified forelimbs (i.e., elongated flippers) to propel themselves through water. These patterns resemble the flapping motions of flight and have been hypothesized to produce thrust during both the upstroke and downstroke segments of the limb cycle. However, to date, it is unknown whether both phases of the limb cycle contribute equally to forward propulsion. To compare the relative contributions of upstroke and downstroke to forward motion in swimming sea turtles, we analyzed high-speed video of rectilinear swimming by juvenile green sea turtles (Chelonia mydas). Maximum whole-body acceleration is considerably higher during downstroke than during upstroke. Additionally, forward displacement of the turtle does not differ significantly between upstroke and downstroke, even though downstroke is significantly shorter in duration than upstroke. These patterns are likely related to the production of greater average and peak accelerations of the flipper during downstroke, which are facilitated by the hypertrophied pectoral muscles of sea turtles.

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**P1.88** RIVERA, F. M.**; SOTO, W.; NISHIGUCHI, M. K.; New Mexico State University, Las Cruces; fmrivera@nmsu.edu

**Allelopathy in the symbiotic bacterium Vibrio fischeri; competitive exclusion prior to or during host infection?**

Many interactions exist between large varieties of organisms, including bacteria that are found in free-living habitats. One type of interaction is allelopathy, which is the process of organisms excreting chemical substances to inhibit or kill closely related strains or species. Bacteria have the capacity to use allelopathic behavior for mechanisms such as infection, colonization, and competition. Specifically, symbiotic associations that harbor environments transmitted bacteria have the ability to promote this type of behavior between competing strains prior to or during colonization. In this study, we are testing which specific strains of the squid symbiont <i>Vibrio fischeri</i>, experience antagonistic relationships as a result of exudate productions and/or milieu alterations that inhibit growth. We have used a series of cross inoculations between competing <i>V. fischeri</i> strains with spent media to determine whether certain strains are promoting any type of allelopathy. Results from previous research indicate that bacterial species do have an effect upon the growth of competing strains, and that specific substrates induce luminescence of <i>V. fischeri</i>, suggesting that intraspecific interactions occur prior or during the infection of squid light organs. Understanding the mechanisms of <i>Vibrio</i> allelopathy will provide insight as to why such genetic diversity exists among Vibrio symbionts, and whether their ecology is determined by both abiotic and biotic factors. Furthermore, this study may lead to the identification of certain chemical compounds produced by <i>V. fischeri</i> that contain properties to inhibit other Vibrio bacteria, including strains that are harmful to fisheries or pathogenic to organisms.
P2.51 RIVERA, Ajna; OAKLEY, Todd*; University of California, Santa Barbara; ajna@berkeley.edu

Eye development in a sexually dimorphic species of ostracod (Crustacea)

One of the standout questions in evolutionary biology is the novelty question: How do new features evolve? In a broad sense, this question explores how similar genomes can make different phenotypes. One way to look at this is to examine sexually dimorphic species, where nearly identical genetic backgrounds can make radically different organs. To this end, we are studying the phylomedid ostracods (Crustacea). The Phylomedidae nearly all have at least a simple median eye but also exhibit a wide array of lateral eye sizes. These range from completely absent in Igene, to huge compound eyes in Euphilomedes carcharodonta. We present a phylogeny showing that loss of eyes occurred several times and gain of eyes is also likely. On top of this is a pattern of extreme sexual dimorphism which has also likely to have been lost and gained several times. In dimorphic species, females have rudimentary eyes while males have compound eyes with up to 33 large ommatidia. In these species, male eyes appear to arise via a tissue furcation event male eye tissue splits or doubles to form a stagnant rudimentary field homologous to the female eye and a fast growing ommatidial field. This suggests that novel features can be gained by tissue duplication events. In this scenario, the duplicated tissue can now follow a new evolutionary trajectory, analogous to the gene duplication and neofunctionalization model of gene evolution. To examine the potential trajectory of a duplicated tissue, we compare gene expression between male and female E.morini during eye development.

P2.180 ROCCA, Kyle AC*; GRAY, Emilie M; BESANSKY, Nora J; University of Notre Dame; knocca@nd.edu

Thermotolerance of alternative 2La karyotypes in Anopheles gambiae

The primary malaria vector in Africa, Anopheles gambiae, is also well known for its ability to adapt to diverse climates and anthropogenic environments. Alternative chromosomal arrangements allow habitat expansion, exemplified by the polymorphic inversion 2La/2L+. Field 2La frequencies reach 100% in arid savannas, while the 2L+ arrangement is predominantly found in humid environments, implicating 2La in aridity tolerance. As ability to survive high temperature exposure is an essential component of aridity tolerance, we have conducted a study of thermotolerance in two colonies of mosquitoes dissimilar solely in 2La arrangement. We hypothesize that the colony with the 2L+ inversion will perform better in measures of thermotolerance. This is one of two meeting papers comparing stress resistance in the 2La/2L+ populations (see Gray, Rocca and Besansky). We subjected 4th instar larvae and pupae to a heat stress (40°C water bath) for 30 to 180min and assessed survival as well as pupation success of the stressed larvae. We found that larvae responded similarly to thermal stress but that, surprisingly, 2L+ pupae were overall more thermotolerant than 2La pupae. We also tested the effect of heat hardening (HH, 1h at 38°C) on thermal tolerance of larvae and pupae. We found that, in 2La, HH significantly improved survival but not subsequent pupation success of stressed larvae. In both colonies, HH had little effect on survival of stressed pupae. Preliminary thermotolerance measurements on adults suggest no difference at this life stage. These intriguing results will be discussed in terms of evolutionary fitness advantage, and the methodology can guide further study relating genetic differences and physiological traits.

P3.200 RODRIGUEZ, E.I*; SAUNDERS, K.; DAVIS, G.; SHUSTER, S.M.; AYERS, T.J; Northern Arizona University, Univ. of Florida, Univ. of Maryland, Baltimore Medical School; eir4@nau.edu

A Molecular Phylogeny for the Thermosphaeroma Species Complex

The genus Thermosphaeroma (Crustacea:Isopoda:Sphaeromatidae) consists of 3 described freshwater species endemic to thermal springs in Texas and New Mexico in the United States, as well as in Chihuahua, Durango, Coahuila and Aguascalientes in the Republic of Mexico. The easternmost described species of the genus, T. subequalum, is found in at least 9 thermal springs located on both sides of the Rio Grande River over a 150 km distance. We used an approximately 470 base pair sequence from the mitochondrial 16S ribosomal RNA gene to investigate evolutionary relationships among these populations. Our analysis included sequences from multiple individuals from all known Thermosphaeroma species and populations, as well as from 4 other species belonging to 2 currently recognized Sphaeromatid subfamilies, the Dynameniinae and the Sphaeromatinae. Our results provide (1) a molecular phylogeny for the genus Thermosphaeroma, (2) biogeographic data useful for studies of North American post-Cretaceous organisms, (3) support for the hypothesis that the Sphaeromatinae and the Dynameniinae represent distinct Sphaeromatid lineages, and (4) evidence that Thermosphaeroma belongs within the latter subfamily.

P2.92 ROGERS, Nala/L*; CARRIER, David/R; Univ. of Utah, Salt Lake City; mostlyapples@gmail.com

Sexual dimorphism in skeletal proportions of California voles

The genus Microtus (voles) is ideal for studying sexual selection because it contains several closely-related species with diverse mating strategies. We hypothesized that polygynous species will show sexual dimorphism in body proportions due to functional tradeoffs for aggressive male-male competition versus locomotion. For example, we expected polygynous males to have more robust skulls, thicker limb bones, and greater mechanical advantage at their limb joints. To test this hypothesis, we measured skeletal metrics on male and female California voles (Microtus californicus) and looked for differences in proportions while controlling for body size. The males of this polygynous species are approximately ten percent heavier than the females. Contrary to our expectations, we found no sexual dimorphism in the postcranial skeletal proportions. There was dimorphism in the skull, but the direction was opposite to our predictions; for their size, females had larger skulls. There are several possible explanations for this result. First, proportions that are advantageous for fighting may be more maladaptive for other purposes that they are not selected for even among polygynous males. Second, the same body proportions could be advantageous for both fighting and locomotion, so that specialization for fighting does not lead to a difference in shape. Finally, females might need to fight in order to guard against infanticide. In this case, both sexes would be specialized for fighting.
More than 50 million liters of aircraft deicer and anti-icer fluids (DAFAs) are used annually in North America. DAFAs contain glycols that serve as freezing point depressants and benzo triazoles that act as corrosion inhibitors. Components of DAFAs are known to make their way into aquatic ecosystems, but they are generally harmless to adult fish; however, very little is known about their effects on developing fish. Therefore, we investigated the specific effects of the DAF additives ethylene glycol (EG) and benzotriazole (BT) on zebrafish embryos to determine whether these chemicals had a teratogenic effect on fish visual system (VS) development. Eye surface area was measured at 48 hours post-fertilization (hpf) following exposure of zebrafish eggs to different concentrations of EG and BT. Mortality rates with EG treatment alone were relatively low at concentrations less than 2.5% EG, but 100% mortality was observed at 5% EG. In BT-only treatment groups, mortality followed a dose-dependent pattern, with 100% mortality observed at 0.1 mg/ml BT. In terms of ontogenic effects, 2.5% EG severely depressed VS development, leaving the eyes at 50% of their normal surface area at 46 hpf. Measures of eye surface area following BT exposure, however, had a less severe impact on VS development, with eye surface area being decreased by 12% and 16% at BT concentrations of 0.025 mg/ml and 0.05 mg/ml, respectively. Exposure to EG and BT, in combination, suppressed VS development to a greater degree. Thus we conclude that high levels of dissolved ethylene glycol and benzotriazole do affect survival in embryonic zebrafish, and sub-lethal doses do indeed have teratogenic effects that can be detrimental to the overall health of fish populations.
P1.14 RUIZ, M.*; DEMAS, G.E.; MARTINS, E.P.; Indiana University, Bloomington; mayruiz@indiana.edu

Experimentally elevated testosterone suppresses immunity in food-limited sagebrush lizards

Testosterone (T) has been shown to increase reproduction and decrease immunity in many cases. Yet, although reproductive investment decreases immune function, supplemental feedings can eliminate this effect. In this study, we considered the effect of food availability and T on immune function and reproductive behavior in sagebrush lizards to assess how T and energy availability act to affect these trade-offs. We experimentally manipulated diet and T of males in a natural population. We determined immune response by calculating the bacterial killing capability of collected plasma exposed to E. coli ex vivo. We measured reproductive behavior by counting the number of courtship displays produced in a 20-min sampling period. Immune function increased with supplemental feedings, a finding that was most pronounced in lizards with increased T. Furthermore, T increased immunity in lizards with additional food resources but not in lizards that were not supplemented. Thus, we observe an interactive effect of food availability and T on immune function. Although not significant, T exhibited a trend towards increasing courtship displays. Thus, a trade-off between T and immunity was suggested, but only when lizards were on a restricted diet. Food availability diminished this effect. Lizards with supplemental food were able to increase both courtship rates and immunity in the presence of high T. Yet, in non T-treated animals, this trade-off was not as pronounced. Collectively, this study shows that the energetic state of the animal plays a critical role in modulating the interactions among T, behavior and immunity in sagebrush lizards and likely other species.

P3.155 RYRCROFT, N*; WELLS, S; MCCONAUGHA, J; Old Dominion University; nryrc001@odu.edu

Correlation Between Female Size and Egg Quality in the Chesapeake Bay Population of Blue Crab, Callinectes sapidus

The ecologically important Chesapeake Bay blue crab, Callinectes sapidus, has recently seen a decline in the population of the species. Previous research has shown a breakdown of the allometric relationship between size and fecundity of mature females. Examination of the eggs from the 2005-2006 spawning seasons showed large inter-annual variations in both lipid and protein concentrations. The 2005 and 2006 data also showed a decrease in lipid and protein concentrations in the eggs as the season progressed. The intent of the study was to examine eggs from 2007 collections and compare the data to the 2005 and 2006 spawning seasons. We hoped to further explain the breakdown of allometry by relating the amount of lipids per egg to the size and weight of the female. Multiple extractions were used to quantify the amount of lipids per egg while a fluorescent plate reader was utilized to measure the protein concentrations. The data shows that average weight of lipids per egg does not have a significant relationship with the weight or size of the female. This does not support the hypothesis that larger crabs which produce less than expected eggs allocate more energy per egg in the form of lipids to help increase the fitness of the larvae.

P1.127 SAMUEL, D.*; LAGARES, E.; CARROLL, M.A.; CATAPANE, E.J.; Medgar Evers College; dialented18@aol.com

Identification and Distribution of Octopamine in Ganglia and Innervated Organs of Crassostrea virginica

Octopamine is a biogenic amine which was first identified in the octopus. It has been well studied in arthropods and a few gastropods serving as a neurotransmitter and hormone. Octopamine has been rarely reported in bivalves and not in Crassostrea virginica. We utilized HPLC to determine if octopamine is present in ganglia and tissues of C. virginica. Biogenic amines were measured by HPLC techniques with fluorescence detection. We used an isocratic, ion-pairing HPLC analysis with fluorescence detection to resolved norepinephrine, epinephrine, octopamine, dopamine and serotonin. Cerebral ganglia, visceral ganglia, gill and palps were dissected, weighed, homogenized, centrifuged, filtered and injected into a Beckman HPLC system with a Phenomenex Gemini 5u C18 column and a Jasco FP 2020 Spectrofluorometer. The mobile phase was 50 mM acetate buffer (pH 4.7) with 1 mM EDTA, 1.1 mM SOS and methanol (85%/15%, v/v). Octopamine was found in ng amounts in gill, palps, cerebral ganglia and visceral ganglia. Endogenous octopamine levels were increase when animals were treated with tyramine, an octopamine precursor. The octopamine peak was verified by injecting samples spiked with standard octopamine. The study identifies octopamine in the nervous system and innervated organs of C. virginica. The physiological role of octopamine in C. virginica is not known as yet and should be explored. This work was supported in part by grants 2R25GM06003-05 of the Bridge Program of NIGMS, 0516041071 of NYSDOE, 0622197 of the MRI Program of NSF.

P1.426 RUIZ-JONES, G.J.*; HADFIELD, M.G.; Chaminade University of Honolulu, Honolulu; guadalupe.ruiz-jones@student.chaminade.edu

The dissociation of the apical sensory organ of Phestilla sibogae during metamorphosis

The apical sensory organ of Phestilla sibogae undergoes radical morphological changes during metamorphosis. At the beginning of metamorphic induction (1 hour) the ASO is complete with 5 serotonergic neurons (2 type II parampillary and 3 type I parampillary) and 5 ampullary neurons filled with sensory cilia. As metamorphosis proceeds the ASO and serotonergic nerve fibers originating from the ASO that innervate the velum begin to dissociate. The 5 serotonergic neurons of the ASO are no longer present once the velum is lost. The 5 ampullary neurons of the ASO appear morphologically different by the third hour of metamorphosis. By the eighth hour of metamorphosis the ampullary neurons have lost their connections and begun to dissociate. It is evident that by the third hour, in larvae that have lost their velum, the ASO no longer exists. However, it is interesting that the ASO does persist up to the eighth hour of metamorphosis in larvae that have not lost their velum.

P3.147 RUIZ, M.*; DEMAS, G.E.; MARTINS, E.P.; Indiana University, Bloomington; mayruiz@indiana.edu

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P2.46 RUIZ-JONES, G.J.*; HADFIELD, M.G.; Chaminade University of Honolulu, Honolulu; guadalupe.ruiz-jones@student.chaminade.edu

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Investigation of integrins during pedal lacerate development in Aiptasia pallida

Integrins are cell surface receptors that play a vital role in cell attachment and are important signaling molecules in cell growth and tissue formation. These proteins have been identified in Cnidarians but their distribution and regulatory properties are not well understood. In this study we investigate the functional role of integrins during pedal laceration in the Cnidarian, Aiptasia pallida. During pedal laceration, small portions of the pedal disc are shed and reorganize to form a complete sea anemone in 48-72 hours after initial lacerate formation. This process must involve cell detachment and rearrangement and so makes it an optimal model for studying integrin signaling pathways. Through methods in immunocytochemistry and use of pharmacological agents which disrupt functional integrin-signaling pathways, we are studying the function of integrins during pedal laceration. Staining untreated pedal lacerates with an anti-integrin antibody has shown distribution of integrins centralized between the two primary epithelial layers, throughout the outer tissue layers and within the striated cortex of the mesoglea. Treating pedal lacerates with pharmacological agents suggests that integrin signaling pathways are involved in the development of the pedal lacerate. Treating lacerates with the PI3K pathway inhibitor LY 294002 (12M) and MAP kinase inhibitor PD98059 (20M) cell maturation inhibited development in 60% of the lacerates. When treated with the PI3K pathway activator SC5336 (24M) pedal lacerates showed accelerated development rate with treated animals maturing 50% faster than untreated controls. We are now looking at how disrupting integrin signaling pathways affects the integrin staining of treated pedal lacerates and adult animals to gain a more complete understanding of how pedal lacerate development is modified.

Motor Patterns of Distal Hindlimb Muscles in Walking Turtles: Implications for Models of Limb Bone Loading

Previous studies indicate that the ground reaction force (GRF) in walking turtles exerts a flexor moment at the ankle during stance. As a result, extensor muscles must be active to counter the GRF. Of four proposed ankle extensor muscles in turtles, two (gastrocnemius medialis and pronator profundus) originate on the distal femur, crossing the flexor side of the knee and potentially eliciting antagonist forces from muscles on the extensor surface of the femur that could contribute to femoral stress. Current bone stress models assume that all four muscles are active. However, if only ankle extensors crossing the knee were active during stance then femoral stresses might be higher than predicted, whereas if only those not crossing the knee were active then stresses might be lower. We recorded EMGs from the four turtle ankle extensors during treadmill walking to test which need to be incorporated into bone stress models. Analysis of synchronized footfall and EMG patterns revealed that all four muscles were active during at least part of the stance phase, corroborating previous bone stress calculations. However, functional differentiation among these muscles is evident with, for example, the two heads of the gastrocnemius exhibiting second activity bursts during swing phase, and flexor digitorum longus activity persisting through stance phase into the beginning of swing phase. These subtle distinctions in muscle contraction patterns among these four ankle extensor muscles indicate the potential for considerable flexibility in the control of distal hindlimb motion in turtles. Supported by NSF I08-0517340.

THE PHYSIOLOGICAL CONSEQUENCE OF MALARIA INFECTION IN THE WESTERN FENCE LIZARD, SCELOPORUS OCIDENTALIS.

We examined the influence of reduced hemoglobin concentrations resulting from malaria infection on thermoregulation and metabolism in the Western fence lizard, Sceloporus occidentalis. Malaria infections diminish the oxygen carrying capacity of the blood, depressing hemoglobin concentrations by as much as 25% in lizards. Western fence lizards collected from central and southern Oregon were screened for Plasmodium mexicanum. Malaria infected and uninfected 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 mm min^-1) or sprint maximally to exhaustion (<2 min of activity). Malaria infection significantly increased preferred body temperature in a thermal gradient following sustained activity (2 to 4°C increase; ANOVA P < 0.05) but had little impact on thermoregulation following exhaustive exercise. There was a strong negative correlation between hemoglobin concentration and post-activity body temperature but no indication of post-exercise anapyrexia typically reported in oxygen limited lizards. Excess oxygen consumption during recovery was about 40% higher in infected lizards when compared to uninfected after similar levels of activity. Malaria infection significantly elevated blood lactate following sprint or endurance activity (20 and 36% elevation, respectively) when compared to uninfected lizards. Our findings suggest that there are additional metabolic costs, measured as excess oxygen consumption and thermoregulation disruptions associated with malaria induced hemoglobin depression. These results may help explain limited size and reproductive success previously measured in malaria infected lizards.
**P.3.101** SCHOLNICK, D. A.; HAYNES, V. N.*; SCHWEITZER, K. I.; Pacific University, Oregon; david.schohnick@paciificu.edu

**HYPOXIA IMPAIRS ANTIBACTERIAL DEFENSE IN THE DUNGENESS CRAB, CANCER MAGISTER**

We examined the possibility that long-term decreases in environmental oxygen (hypoxia), 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. Crabs were exposed to either 50 or 100% air-saturated water for 72 h. Hemolymph was sampled every 24 h and levels of bacteria were measured as the total number of colony forming units (CFU) present per mL of hemolymph. immune response was assessed as a change in the total number of circulating hemocytes and granulocytes. Hemolymph lactic acid levels were measured to determine if changes in bacterial infection alter levels of anaerobic metabolism in hypoxic waters over time. Bacteremia increased after 24 h of exposure to hypoxia and persisted for 72 h (P < 0.05; ANOVA). Colony forming units increased from about 10 to over 4,000 per mL hemolymph during 72 of hypoxia. Crabs exposed to air-saturation had no measurable change in CFUs over the course of the experiment. The total number of circulating hemocytes were unaltered by hypoxia for 48 h and showed only a small decrease after 72 h (P < 0.05; ANOVA), consistent with a reduced capability to respond to bacteria under low oxygen conditions. Exposure to hypoxia increased hemolymph lactate levels only after 48 h suggesting that over time, elevated bacterial concentrations may limit normal respiratory function. These results suggest that low oxygen can suppress immune response and limit the crabs ability to manage intrinsic bacterial levels.

**P.2.128** SCHROEDER, TP.*; POWERS, DR; WETHINGTON, SM; TOBALSEKE, BW; George Fox University, Newberg, OR; University of Montana, Missoula, MT; Hummingbird Monitoring Network, Patagonia, AZ; tschroeder06@geofeexus.edu

**Hovering Flight Performance in Captive and Free-Living Hummingbirds**

Hummingbirds are tiny endothermic vertebrates and have high daily energy requirements. Flight is energetically expensive and few studies have linked flight-associated energy costs to daily energy budgets. Free-living and captive hummingbirds were studied and their flight costs examined. Rufous hummingbirds (Selasphorus rufus; ca. 3.3 g) were flown in a wind tunnel at wind speeds from 0-10 m/s. Mean hovering metabolic rate (HMR) was 2.56 mL O$_2$/min, decreasing to 1.3 mL O$_2$/min between 4-10 m/s. Mean HMR in free-living Black-chinned hummingbirds (Archilochus alexandri; ca. 3.0 g) and Broad-billed hummingbirds (Cynanthus latirostris; ca. 3.3 g) were 2.44 and 2.47 mL O$_2$/min, respectively. For Broad-billed hummingbirds (BB) WDL was 5.57 N/m$^2$ in males and 4.82 N/m$^2$ in females. These WDL values were 2X those calculated assuming maximal wing-beat amplitude during hovering for all birds ranging from 90-110 degrees per wing indicating less than maximal effort. WDL calculated using our measured wing-beat amplitudes were for Black-chinned hummingbirds (BC) males and females 7.95 and 7.00 N/m$^2$, respectively. For Broad-billed hummingbirds (BB) WDL was 5.57 N/m$^2$ in males and 4.82 N/m$^2$ in females. These WDL values were 2X those calculated assuming maximal wing-beat amplitude (360 degrees total). Our data suggest that even though hovering flight is the most energetically costly activity exhibited by hummingbirds their HMR is well below summit metabolism. Supported in part by NSF I0B-0615648.
P3.189 SCHUMER, Molly E.*; RENN, Suzy C. P.; Reed College, Portland OR; schumerm@reed.edu

ICGH Detects Genomic Architecture Among African Cichlids Species of the Genus Julidochromis

Cichlids are one of the largest and most diverse vertebrate families, and are remarkable for their rapid radiation. Gene duplication has been identified as a central method for rapid evolution, suggesting that it could play a role in the rapid speciation and novel phenotypic traits found among cichlid species. The genus Julidochromis is of particular interest due to distinct behavioral traits such as sex-role reversal, cooperative brooding, and parental care that vary between individual species. We have used microarrays from a closely related species, Astatotilapia burtoni in order to identify duplicated and diverged genes in four species of Julidochromis. These arrays allowed us to profile the genetic variation between Julidochromis species, and identify genes that have been duplicated or diverged in the Julidochromis family compared to A. burtoni. As expected, there were fewer duplicated (45) than diverged genes (395) when comparing A. burtoni to Julidochromis species, and only a few species-specific duplications (5 for J. dickfeldi, 2 for J. marlieri, 5 for J. ornatus, and 1 for J. transcriptus). These results are currently being confirmed by quantitative real-time PCR and cloning for sequence analysis. This study suggests that microarrays can be used to reliably identify duplicated and diverged genes among cichlid species. This information will also be critical for proper interpretation of future gene expression profiling within and between these species.

P3.115 SCULLY, T.A.*; CARROLL, K.N.; BROWN, K.M.; The George Washington University; tscully@gwu.edu

A serotonin-mediated signaling mechanism initiates cell movements during sea urchin gastrulation

Previous studies in our lab have identified several components of a serotonergic system in blastula and gastrula sea urchin embryos. These studies suggest that serotonin regulates gastrulation. In the present study we examined the role of the serotonin synthetic enzyme, tryptophan hydroxylase (TPH), in sea urchin embryogenesis. Embryos were treated with various concentrations (0.5 - 20 M) of p-chlorophenylalanine (methyl ester(methyl-CPA)), an inhibitor of TPH, beginning at fertilization or at the hatched blastula stage. Cleavage was not affected, and embryo development stopped prior to gastrulation at the mesenchyme blastula stage with higher concentrations of the drug. Lower concentrations blocked development at the early gastrula stage. The lowest levels of methyl-CPA exert effects delayed gastrulation beyond the early gastrula stage. Serotonin (100 M) or dibutyl cyclic AMP (1 M), added along with the inhibitor (20 M) at hatching, rescued embryos from the inhibitory effects of methyl-CPA on early gastrulation. Methyl-CPA also inhibited TPH activity in enzyme assays of embryo homogenates. The nonmethylated inhibitor (CPA) did not inhibit gastrulation. This study suggests methyl-CPA specifically blocks serotonin synthesis and inhibits gastrulation, and serotonin regulates the primary gastrulation phase by signaling mechanism(s) that involve cyclic AMP.
P3.136 SEARS, Michael W.; POLNASZEK, Timothy; ARTITTA, Kimberly S.; Southern Illinois University; msears@zoology.siu.edu

Optimal decision rules for dispersal under activity-mortality tradeoffs for small ectotherms in thermally-structured landscapes

Many animals perform much of their daily activity under the threat of predation. This threat is one further stress for ectotherms that must perform behaviors, such as foraging, while navigating complex thermal environments. In previous models, we have examined optimal decision rules for dispersal given the thermal preferences and physiological capacities of individuals under different configurations of habitat in thermally-structured landscapes. Here, we add a risk of mortality while foraging on the surface by implementing additional decision rules that mediate activity by an individual’s state of satiation. That is, hungry individuals are more likely to forage than satiated individuals, and mortality risk while foraging is higher than when not foraging. We use a logistic function to describe the relationship between satiation and foraging activity. In addition to optimizing decisions for movement through thermally-heterogeneous habitat, we optimize the shape of the satiation-activity function that maximize net energy intake per time discounted by mortality. These simulations were compared under different probabilities of mortality and foraging success (or food abundance) for different spatial configurations of thermal habitat. Ongoing work is relaxing implicit risks of mortality by implementing explicit predator-prey interactions in our thermally structured landscapes. We suggest that formulations and tests of the costs and benefits of thermoregulation should explicitly consider risks of mortality, in addition to net energetic gains, when considering optimal thermoregulatory strategies.

P3.118 SEPULVEDA, C.A.; AALBERS, S.A.; DONLEY, J.M.; SYME, D.A.; BERNAL, D.; Pfieger Institute of Environmental Research (PIER), Oceanside CA, PIER, Miracosta College, Univ. of California, San Diego, CA, Dartmouth; chugey@pier.org
The role of the caudal fin in the feeding ecology of the common thresher shark (Alopias vulpinus)

The thresher shark species (Alopiidae) comprise a monophyletic group of pelagic sharks most commonly recognized by their elongate upper lobe of the caudal fin. It has been hypothesized that thresher sharks utilize the elongate fin to stun small-schooling prey while feeding. The bi-functional role of the caudal fin for both thrust production and predation represents a unique adaptation that has not been described for any elasmobranch species. Despite the commercial importance of the thresher sharks, there are no published accounts on how the caudal fin is used during feeding. Field and laboratory studies were conducted to 1) acquire video recordings of feeding common threshers in the wild, 2) examine the caudal fin morphology and 3) investigate the ocular morphology which enables vision in the posterior field. Of the 140 specimens captured and released (2005-2008), only 4 sharks were hooked in the mouth while the remainder (97%) were hooked in the caudal fin. Video records of thresher shark feeding in the wild yielded footage from 20 individual caudal fin-feeding events. Morphological examination of the common thresher caudal fin revealed that the upper lobe is predominantly comprised of tendinous and cartilaginous support tissues. The dissections also revealed the presence of both aerobic (red) and anaerobic (white) muscle fibers throughout the entire length of the caudal fin. In general, the caudal fin structural architecture appears to be similar to that described for lamnid sharks, but with much larger dorso-ventral cartilaginous support elements. Preliminary findings also show that the eye has the capacity to rotate along the longitudinal axis in an anterior-posterior direction within the orbit which may enhance vision in the posterior field.

P2.38 SERAFINI, Loredana*; TOMANEK, Lars; California Polytechnic State University, San Luis Obispo; loredanaserafini@gmail.com

Environmental Proteomics: The Response of the Marine Model Organism Ciona savignyi to Acute Temperature Stress

The ascidian Ciona savignyi is a basal chordate that is commonly found along the Pacific coast of North America. Because its genome has been fully sequenced, Ciona savignyi is an ideal model organism for proteomics research. The response of Ciona savignyi to temperature is particularly interesting because previous studies have shown that temperature has a strong effect on ascidian development, especially on the metamorphosis from the motile larval stage to the sessile adult stage. In order to assess the effect of thermal stress on adult Ciona savignyi, we studied global changes in protein expression in response to heat stress. To observe the effect of heat shock, field-acclimated animals were exposed to either a 22°C or 28°C temperature treatment for 6 hours, and then allowed to recover at 13°C for 16 hours, a common seawater temperature at the point of collection in central California. Using the whole organism, with the tunic removed, two-dimensional SDS-polyacrylamide gel electrophoresis was employed to separate proteins and create protein expression profiles (PEPs). A one-way ANOVA, with a critical p-value of 0.01, was performed to determine which proteins showed a statistically significant change in expression. Of the 616 proteins sequenced, 87 were sequenced, is an ideal model organism for proteomics research. The response of Ciona savignyi to temperature is particularly interesting because previous studies have shown that temperature has a strong effect on ascidian development, especially on the metamorphosis from the motile larval stage to the sessile adult stage. In order to assess the effect of thermal stress on adult Ciona savignyi, we studied global changes in protein expression in response to heat stress. To observe the effect of heat shock, field-acclimated animals were exposed to either a 22°C or 28°C temperature treatment for 6 hours, and then allowed to recover at 13°C for 16 hours, a common seawater temperature at the point of collection in central California. Using the whole organism, with the tunic removed, two-dimensional SDS-polyacrylamide gel electrophoresis was employed to separate proteins and create protein expression profiles (PEPs). A one-way ANOVA, with a critical p-value of 0.01, was performed to determine which proteins showed a statistically significant change in expression. Of the 616 proteins sequenced, 87 were significantly up-regulated in the 22°C treatment, the 28°C treatment, or both; and 49 spots (8%) were significantly down-regulated in the 22°C treatment, the 28°C treatment, or both. Another group of 19 spots (3%) were significantly up-regulated in the 22°C treatment group, and then down-regulated in the 28°C treatment group. We are currently using matrix-assisted laser desorption ionization (MALDI) tandem time-of-flight mass spectrometry to identify proteins of interest and to characterize their role in the heat shock response of Ciona.

P2.152 SERRANO-VELEZ, J. L.; TORRES-VAZQUEZ, I.; RIVERA-RIVERA, N. L.; FRASER, S. E.; YASAMURA, T.; DAVIDSON, K. G. V.; RASH, J. E.; LAUDER, G. V.; ROSA-MOLINAR, E.*; Univ. of Puerto Rico-Rio Piedras, California Institute of Technology, Colorado State Univ., Harvard Univ., ed@hpcf.upr.edu

Neuronal Gap Junction Coupling May Mediate a Fast Copulatory Neuromuscular Circuit

During development, gap junctions are thought to disappear as chemical synapses form, with one study concluding that switching from electrical to chemical synapses requires activation of a major class of ionotropic glutamate receptors expressed throughout the vertebrate central nervous system (CNS), N-methyl D-aspartate receptor 1 [NMDAR1]. Using neural tract tracing, confocal microscopy, and freeze-fracture replica immunogold labeling in the spinal cord of an adult sexually dimorphic teleost fish Gambusia, we show large numbers of gap junctions within dendroendrinic mixed synapses between apical dendrites of coupled motor neurons and interneurons. Dendroendrinic mixed synapses are a hallmark of motor systems evolved for high-speed oscillatory neural synchronization, such as the fast neuromuscular circuit controlling the torque-thrust movement (20 ms) we identified in male Gambusia copulation. Gap junctions within mixed synapses between coupled motoneurons and interneurons were heavily labeled by antibodies to connexin 35 (Cx35), the teleost homolog of connexin 36 (Cx36) found in mammals. Postsynaptic densities [PSDs] within the mixed synapses were glutamatergic. Work reported here demonstrates that functional electrical and chemical synapses persist in mixed synapses in the adult CNS, shows that collaboration between NMDA receptor activation and gap junction coupling is possible, and suggests persistent electrical communication may have a central role in fast neuronal circuits. Supported by NIH grant 5 U54 NS 39405-08 (NINDS).

P2.33 P2.37 P2.38 P2.39 P2.40
**P2.9 SEWALL, K. B.*; SOCKMAN, K. W.; University of North Carolina, Chapel Hill; ksewall@email.unc.edu**

**Seasonal acclimation of energetics in Northern Cardinals (Cardinalis cardinalis).**

Male songbirds often establish territories and attract mates by singing. Males may assess their immediate competitors based on the relative quality of their song. In many songbirds high quality songs are longer, more complex and contain versions of particular song components, referred to as trills, that are more difficult to produce. Males should be expected to modulate their song effort to compete within the scope of their current song environment, down and up-regulating the quality or quantity of the song they produce as a function of their competitors songs. Modulation of song output could be achieved through environmentally-influenced changes in singing motivation, which may be regulated by arginine vasotocin (AVT) secretion in some midbrain or forebrain regions. Additionally, modulation of song output could be achieved through environmentally-influenced changes in song output, which are associated with the volumes of vocal-control nuclei in the forebrain. To test these predictions about the mechanisms involved in the context-dependent modulation of song effort, we manipulated the song environment of territorial male songbirds, Lincoln’s sparrows (Melospiza lincolnii) by exposing them to recordings of either high or low quality songs in the song environment produced more songs overall than males in the low quality song environment. We conclude that male Lincoln’s sparrows are sensitive to variation in the quality of songs prevalent in their surroundings and that they modulate their own mate attraction effort as a function of their social environment. These behavioral responses may be mediated by environmentally-influenced changes in AVT or the volumes of some song-control nuclei.

**P2.29 SQUEO, CE*; WAGNER, DN; WALSH, PJ; SCHAFFER, PJ; Miami University; sgueoc@muohio.edu**

**Context-dependent modulation of song effort in a territorial songbird, the Lincoln’s sparrow.**

Male songbirds often establish territories and attract mates by singing. Males may assess their immediate competitors based on the relative quality of their song. In many songbirds high quality songs are longer, more complex and contain versions of particular song components, referred to as trills, that are more difficult to produce. Males should be expected to modulate their song effort to compete within the scope of their current song environment, down and up-regulating the quality or quantity of the song they produce as a function of their competitors songs. Modulation of song output could be achieved through environmentally-influenced changes in singing motivation, which may be regulated by arginine vasotocin (AVT) secretion in some midbrain or forebrain regions. Additionally, modulation of song output could be achieved through environmentally-influenced changes in song output, which are associated with the volumes of vocal-control nuclei in the forebrain. To test these predictions about the mechanisms involved in the context-dependent modulation of song effort, we manipulated the song environment of territorial male songbirds, Lincoln’s sparrows (Melospiza lincolnii) by exposing them to recordings of either high or low quality songs in the song environment produced more songs overall than males in the low quality song environment. We conclude that male Lincoln’s sparrows are sensitive to variation in the quality of songs prevalent in their surroundings and that they modulate their own mate attraction effort as a function of their social environment. These behavioral responses may be mediated by environmentally-influenced changes in AVT or the volumes of some song-control nuclei.

**P2.129**

**P2.195 SIFORMO, T.*; BARNES, B; DUMAN, J; SCHULTE, M; Univ. Alaska Fairbanks, Univ. of Notre Dame, rfts@ualu.edu**

**Modeling ice-binding motifs in antifreeze proteins from the Alaskan beetle Cucujus clavipes punicus.**

The freeze-avoiding beetle larva *Cucujus clavipes punicus* overwinters in Alaska under the bark of decaying trees. These larvae are intermittently exposed to ambient winter temperatures as low as -45°C in situ and readily supercool to -35°C to -50°C. Under experimental conditions, some larvae do not freeze even when cooled to -100°C and enter a vitrified state between -50°C to -85°C. We modeled *C. c. punicus* antifreeze proteins (AFPs) using Sybyl molecular modeling software (7.1 and 8.0, Tripos, Ltd.) to compare sequence, model structure, and visualize putative ice-binding motifs. We found that the AFPs are similar to AFPs from the beetle Tenebrio molitor. The *C. c. punicus* AFPs are made up of 7.6 to 8.3 kDa molecules that are threonine(Thr)- and cysteine (Cys)-rich. Each molecule is composed of six loops of 12 amino acids, and most loops have a regular array of Thr-Cys-Thr, with Cys internally disulfide bridged. We also show that the spacing of Thr is approximately aligned to both ice prism and basal planes, forming the putative ice-binding face. Stability of supercooling and vitrification in *Cucujus* may be enhanced by AFPs, as well as desiccation and synthesis of cryoprotectants. NSF #0618436

**SICB 2009 Annual Meeting Abstracts**

**P2.37 SHAFER, T.H.*; KNAPP, W.E.; GOLUS, J.M.; University of North Carolina, Wilmington; shafer@uncw.edu**

**A new family of crustacean cuticle proteins possibly related to mineralization of pre-exuvial cuticle.**

A large group of closely related cDNAs was discovered by mining a database of ESTs derived from the hypodermis of the blue crab, Callinectes sapidus. Complete sequencing showed that these cDNAs code for proteins containing the chitin-binding Rebers-Riddiford-1 motif and a conserved sequence of 14 amino acid residues just C-terminal to the RR-1. This sequence and arrangement are not known from any other crustacean or insect cuticle protein except *C. sapidus* CP14.1 (reported previously and now recognized as a member of this new protein family) and calcification-associated soluble matrix protein-2 from the crayfish Procambarus clarkii. Transcription of these genes as determined by real-time qPCR is high only in pre-molt hypodermis synthesizing exocuticle that will mineralize post-molt rather than arthrodial membrane that remains soft. Interestingly, reverse transcriptase-PCR revealed two sizes of mRNAs from these genes, suggesting the presence of an unspliced intron. Sequencing the PCR products as well as genomic DNA using the same primers confirmed this. The intron is not efficiently spliced from some of the RNAs when transcribed post-molt, a period when the total transcription is very low. In other cases, transcripts containing unspliced introns were also present in hypodermis making arthrodial membrane, again where total transcription is very low. All unspliced transcripts would translate into truncated peptides because of in-frame stop codons in the introns. Though the function of this new family of proteins is not known, its expression pattern suggests a role in pre-exuvial exocuticle mineralization. A double-strand RNA reagent has been synthesized to knock out these transcripts, and RNAi loss-of-function assays are being attempted.
**P2.145 SHERMAN, AJ; MURRAY, JA; TRAN, NB; HAMMOUDI, AH; Cal. State. U. East Bay, U. Washington, U. Central Arkansas; james.murray@mac.com**  

Inactivation of an identified neuron reduces oriented turning toward the inactivated side in the sea slug Tritonia diomedea  

The nudibranch mollusk Tritonia diomedea has been used extensively to study the neural control of orientation behavior. Many of its ~7000 neurons have been established as having specific functions and are reidentifiable from one animal to another. One specific pair of neurons, Pedal neurons #3 (Pd3), receive modulatory input from water flow receptors, elicit contractions of the ipsilateral foot margin, and are thus believed to be involved in rheotactic turning behavior. Pd3 has been shown to increase in firing frequency during turning, and stimulation of Pd3 with fine wires stimulates ipsilateral turns. This study aims to determine if Pd3 is necessary for turning behavior by inactivation in either or both ganglia. If Pd3 is necessary for turning, then experimental animals will fail to turn upstream into water flow and control animals will remain able to so after the semi-intact preparation. Inactivation of right Pd3 (RPd3) resulted in the animal failing to crawl upstream, but instead continually turned left. Similarly, inactivation of left Pd3 (LPd3) resulted in the animal continually turning right. Preliminary observations indicate that turning events involve different body positioning; these movements are likely due to the effects of other pedal flexion neurons. Inactivation of Pd3 may result in the use of other neurons involved in lifting the foot margin to achieve a turning event. Kinematic analysis illustrates how and to what extent turning behavior is modified by ablation of Pd3. These results, together with those demonstrating that Pd3 is sufficient for turning, further our understanding of the sensorimotor processes involved in orientation behavior and how they are integrated to guide the animal through its habitat.

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**P2.175 SIMONIK, E*; HENRY, R.P.; Ohio University, Athens, Auburn University, AL; hennyrp@auburn.edu**  

Physiological adaptations of the intertidal green crab, Carcinus maenas to emersion  

The green crab, Carcinus maenas, is intertidal during the summer months, undergoing periods of emersion for up to 6 hr twice a day. The gills, whose lamellae are supported by the buoyancy of water, collapse in air, causing potential respiratory and acid-base disturbances. Elevated temperature and reduced humidity could further contribute to metabolic stress and desiccation. Field measurements showed that temperatures under rocks and seaweed, where crabs take shelter, were significantly lower, and relative humidity was higher than on the surface. Motor activity is minimal or absent during emersion. Crabs lost about 5% of their total wet weight during 6 hr emersion, and water loss came from the hemolymph whose osmolality increased by about 50-100 mOsm. Crabs were able to volatilize ammonia and thus had approximately the same rates of NH3 excretion in air and water. As a result, changes in hemolymph NH3 concentrations were minimal. Emersion resulted in an initial but transient bradycardia. Ventilatory rate, measured by scaphognathite frequency, decreased by about 67% during emersion but never ceased. Hemolymph total CO2 increased, but pH was not significantly depressed, and aerial VO2 was similar to that in water. The combination of low temperature, high humidity shelter and aerial respiration/excretion reduces the environmental stress of emersion and allows the green crab to maintain a near-undisturbed physiological state. Supported by NSF 02-30005 and by an NSF REU site award to the Mt. Desert Island Biological Laboratory.

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**P2.177 SIMONIK, E*; HENRY, R.P.; Ohio University, Athens, Auburn University, AL; hennyrp@auburn.edu**  

Physiological adaptations of the intertidal green crab, Carcinus maenas to emersion  

The green crab, Carcinus maenas, is intertidal during the summer months, undergoing periods of emersion for up to 6 hr twice a day. The gills, whose lamellae are supported by the buoyancy of water, collapse in air, causing potential respiratory and acid-base disturbances. Elevated temperature and reduced humidity could further contribute to metabolic stress and desiccation. Field measurements showed that temperatures under rocks and seaweed, where crabs take shelter, were significantly lower, and relative humidity was higher than on the surface. Motor activity is minimal or absent during emersion. Crabs lost about 5% of their total wet weight during 6 hr emersion, and water loss came from the hemolymph whose osmolality increased by about 50-100 mOsm. Crabs were able to volatilize ammonia and thus had approximately the same rates of NH3 excretion in air and water. As a result, changes in hemolymph NH3 concentrations were minimal. Emersion resulted in an initial but transient bradycardia. Ventilatory rate, measured by scaphognathite frequency, decreased by about 67% during emersion but never ceased. Hemolymph total CO2 increased, but pH was not significantly depressed, and aerial VO2 was similar to that in water. The combination of low temperature, high humidity shelter and aerial respiration/excretion reduces the environmental stress of emersion and allows the green crab to maintain a near-undisturbed physiological state. Supported by NSF 02-30005 and by an NSF REU site award to the Mt. Desert Island Biological Laboratory.

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**P2.178 SMITH, M.**; DAVIS, M.; WOLCOTT, T.G.; SHAWL, A.L.; N.C. State Univ., Raleigh, Harbor Branch Oceanographic Inst., Fort Pierce, FL; james.murray@mac.com  

Seagrass Epiphytes and Turbulence as Settlement Cues for Conch (Strombus alatus) Larvae  

Knowledge of the mechanisms underlying larval dispersal and population connectivity of marine organisms is needed to predict ecosystem responses to global change, manage vital habitats, conserve threatened species, and manage fishery stocks. Recruitment in benthic invertebrate species with sedentary adults often depends on delivery of larvae to suitable habitats. Most larvae are not just passive particles, and the interactions of larval behavior and the local current regime play an important role in dispersal and settlement. Conch larvae respond to contact with benthic trophic cues by metamorphosing. We hypothesized that while planktonic, they also respond to water-borne cues and increased turbulence (symptomatic of shallower water) as indicators of potential nursery habitats. By swimming down or sinking, they increase their chances to explore the substrate and come in contact with metamorphic cues. Laboratory reared larvae competent to metamorphose responded to water-borne cues from epiphyte communities common on Thalassia testudinum blades by swimming faster, which would increase the frequency of contacts with the bottom. They also metamorphosed sooner than controls. Both phenomena would increase the probability of settling in suitable nursery habitats. When exposed to turbulence typical of shallow tidal flows, competent larvae, generally already low in the water column, showed no response. Pre-competent larvae, on the other hand, withdrew their velar lobes and sank. This would favor transport along or near the bottom and increase the probability of encountering suitable nursery habitats and settling there when competent.
**P3.188** SMITH, A.R.∗; CARLETON, K.L.; University of Maryland; adasmi@umd.edu

**Neutrophil/Lymphocyte Ratio and Stress in Three Species of Myotis:** Effects of Sex, Reproductive Stage, Size-Corrected Mass and Site.

We examined variation in neutrophil/lymphocyte ratio (N/L) and fecal glucocorticoid (FG) levels in three species of bats from the eastern U.S. *Myotis septentrionalis* (MSE), *M. lucifugus* (MLU), and *M. sodalis* (MSO), in order to assess whether anthropogenic disturbance (i.e. urbanization, military activity) may constitute a chronic stressor and potentially affect the exposed animals' immunocompetence. Bats were captured by mist net at impacted and non-impacted sites in Indiana and Kentucky from May to August, 2007. Blood was taken within three minutes of capture, and analyzed to determine N/L. FG levels were obtained from fecal pellets collected up to 1.5 hrs post-capture. Size-corrected mass (SCM) was calculated as the residuals of body mass against forearm length. We compared N/L among species, sexes, sample months for males, reproductive status for females, and sites. We also examined FG levels and SCM in relation to N/L for these same groups. Males showed no significant differences. However, MSE females showed variation in N/L by reproductive stage (p<0.004): ratios for pregnant and lactating females were significantly higher than those of post-lactating females. A similar trend was present in MLU and MSO females, but not lactating females. A similar trend was present in MLU and MSO females, but not lactating females. Additionally, N/L of pregnant and lactating MSE females from impacted areas were significantly higher than those from non-impacted sites (p<0.02), suggesting that these bats may have been under chronic stress, which might have an effect on their immune response. Preliminary analysis indicates little to no relationship between N/L, FG levels, and SCM.

**P1.9** SMITH, Jeffrey J.; SEARS, Michael W.; Southern Illinois University; eutrophy@gmail.com

**The implications of body size for habitat selection as a consequence of behavioral thermoregulation**

Body size is an important factor determining the range of body temperatures available to an ectotherm on a daily basis. Typically, small- and medium-sized vertebrate ectotherms (< 1 kg) can potentially experience body temperatures that range over a span of 30 C. To optimize physiological performance, individuals can use behavioral thermoregulation to minimize this variance by differentially selecting microhabitats in an environment. The ecological implications of this behavior is that animals that differ in size will likely occupy different parts of the environment to maintain similar body temperatures all else being equal, and that time for activity will differ for individuals of different sizes across microhabitats. Here, we use a simulation to explore the implications of thermoregulation for daily and seasonal activity for differently sized reptiles in a spatially-explicit, thermally-heterogeneous landscape. Several patterns emerge from these simulations. With respect to time, relatively small individuals can take advantage of microhabitats for heating at earlier times of day than larger individuals. Further, the activity of relatively small individuals is depressed during the hottest times of day and year. With respect to space, smaller individuals cannot penetrate as deeply into cooler (shaded) habitat as can larger individuals. Implications are that these shifts in spatiotemporal patterns of activity might be able to relieve intraspecific or interspecific competition among individuals that coexist in space.

**P3.102** SMITH, L.C.∗; MENDONCA, M.T.; RICHARDSON, C.S.; WIDMAIER, E.P.; HOHMANN, M.G.; Auburn University, AL, Boston University, MA, Boston University, MA, US Army ERDC-CERL; smithll@auburn.edu

**Intrageneric Sequence Diversity in Cichlid Opin Arrays**

We examined variation in neorhodopsin gene expression in ten species of cichlids. Our results indicate that the opsin expression patterns found in different species may be created by differences in the regulatory elements controlling expression. We also examined variation in opsin expression in different species of cichlids. Our results indicate that the opsin expression patterns found in different species may be created by differences in the regulatory elements controlling expression.

**P2.41** SOLEM, R. Christian∗; EAMES, Brian F; TOKITA, M; SCHNEIDER, Richard A; Harvard University, University of Oregon, Kyoto University, University of California, San Francisco; rcsolem@gmail.com

**Mechanical and Mesenchymal Mechanisms of Secondary Chondrogenesis**

Secondary cartilages, which arise after formation of the primary cartilaginous skeleton and during later stages of osteogenesis, are found within joints, ligaments, and tendons. Secondary cartilages facilitate skeletal movement and much evidence suggests their induction requires mechanical stimulation. Thus, the evolutionary presence or absence of such cartilage reflects species-specific variations in functional anatomy. To investigate molecular, cellular, and biomechanical mechanisms that regulate secondary cartilage formation, we conduct experiments using quail and duck, which exhibit distinct jaw morphologies and modes of feeding. Duck use levered straining and have a prominent secondary cartilage at the insertion of the jaw adductor muscle. An equivalent cartilage is absent in quail, which peck at their food. We hypothesize that differences in jaw morphology and the local mechanical environment promote secondary chondrogenesis in duck versus quail. As a test of our hypothesis, we employ two experimental approaches. First, we alter the mechanical environment in embryonic duck by paralyzing skeletal muscles and by blocking mechanotransduction through stretch activated channels. Second, we re-pattern the duck jaw complex to resemble that found in quail by transplanting neural crest mesenchyme destined to form skeletal and connective tissues of the jaw. This mesenchyme is known to generate species-specific pattern. Both approaches inhibit secondary cartilage formation by altering expression of genes required for cartilage, bone, muscle, and tendon development. We conclude that mesenchyme-dependent changes in gene expression, musculoskeletal pattern, and mechanical forces control secondary cartilage induction.
How the development and microstructure of toe pad morphology reflect habitat specialization in Anolis lizards

Squamate lizards have repeatedly evolved specialized adhesive toe pads (lamellae) which provide superior clinging ability to the groups that possess them. The extraordinary adhesive properties of these toe pads are due to microscopic setae found covering each lamellar scale. While variation is known to exist in toe pad morphology among different groups of lizards, it is unclear whether this variation has functional consequences to lizards living in different habitats. It is also unknown when in development toe pad structures arise, raising additional questions regarding the performance capabilities of juvenile lizards. Anolis lizards provide the rare opportunity to examine both of these questions on a diverse radiation of lizards inhabiting different arboreal microhabitats. Anolis habitat specialists occupying different islands but similar environments exhibit remarkable morphological similarity. For example, species that live higher in the canopy typically have larger toe pads comprised of more lamellae compared to species living lower in the canopy or on the ground. In this study we have compared the microstructure of approximately 20 Anolis species occupying different microhabitats using scanning electron microscopy. Toe pads were dissected into thirds using a fine scalpel to quantify setal morphology and density. A preliminary analysis of approximately 200 micrographs indicates that several species living high in the canopy have more complex setal architecture than their ground-dwelling relatives. We have also established breeding colonies for two species, A. sagrei and A. carolinensis, to examine toe pad embryology. We found that variation in lamellae number arises at the earliest stages of toe pad development, potentially during toe pad patterning, but that setal variation does not appear to arise until at or slightly after hatching.

Molecular Basis of Facultative Asexuality in Aphids

Phenotypic plasticity allows organisms to quickly adapt in response to changing environments. Little is known of the genetic, environmental and epigenetic contribution to the expression of alternative adaptive developmental outcomes. We study aphid polyphenisms, which offer a unique, compelling opportunity to study multiple levels of biological organization, especially insect epigenetics. The pea aphid, Acyrthosiphon pisum, exhibits an adaptive reproductive polyphenism whereby genetically identical individuals reproduce either sexually (meiosis) or asexually (parthenogenesis) depending on environmental conditions during maternal development (short or long photoperiod, respectively). To understand how facultative asexuality evolved in aphids, we first determined meiosis gene activity in sexuals and asexuals. I determined that the pea aphid genome encodes single copies of homologs for the majority of the core meiotic machinery, suggesting that meiotic plasticity is not due simply to gene loss or expansion. Next, we determined if these core meiosis genes are expressed using PCR spanning across at least one intron from cDNA isolated from asexual and sexual ovaries. Surprisingly, meiosis specific genes (e.g., Sp01, Msh4, Msh5, Hop2 and Mnd1) are expressed in not only in asexual ovaries but also in somatic tissue and an obligately asexual aphid strain. Interestingly, the Sp011 PCR product contained intronic sequence, thus representing unspliced mRNA. Germline expression of Sp01, Mnd1 and Hop2 was confirmed by in situ analysis. Preliminary results identified candidate methylation sites in the Sp01 locus, indicating an epigenetic basis for this expression difference. Further characterization will help us better understand the molecular and epigenetic mechanisms underlying this adaptive facultative plasticity.

Morphological and Kinematic Variation in Upper Jaw Protrusion of Four Species of Cyprinid Fishes

Cyprinid fishes are trophically diverse with most species feeding on secondary producers such as macrocrustaceans and insects. Many basal members are benthic feeders, while others can switch between pelagic and benthic modes depending on food availability. Our previous work has suggested that morphological variation of the kinethmoid is more likely to be correlated with ecological niche than phylogenetic position of a species within the group. Here we performed kinematic analyses on four cyprinid species with widely varying kinethmoid shape. Our initial hypothesis was that Carassius auratus, a species with an elongate kinethmoid that feeds on benthos would have slower protrusion speeds than species that feed on insects and possess shorter kinethmoids. We found the opposite to be true. C. auratus protrudes its upper jaw faster than Gila robusta, Danio rerio, and Devario aequipinnatus. C. auratus is a member of the Cyprinidae, the most basal subfamily within Cyprinidae. Our data suggest that when kinethmoid-mediated premaxillary protrusion first evolved, it was a versatile mechanism, allowing basal cyprinids to search through benthos as well as effectively capture elusive prey.
P3.127 STAHLSCHMIDT, ZR*; DENARDO, DF; Arizona State Univ. - Tempe, zs@asu.edu

Effect of nest temperature on egg-brooding behavior, metabolism, and clutch-nest thermal relations in Children's pythons (Antaresia childreni)

Parental care meets several critical needs of developing offspring, and egg-brooding in pythons is an exceptional model for examining environmental influences on specific parental behaviors because python egg-brooding is limited in complexity, dynamic yet limited in spatial movement, and modulates embryonic temperature, respiration, and water balance. We used captive Childrens pythons (Antaresia childreni) to assess their facultative endothermic capability, the influence of the gradient between the nest temperature (Tnest) and clutch temperature (Tclutch) on egg-brooding behaviors, and the effect of these behaviors on the developmental micro-environment. We monitored maternal egg-brooding behavior, rates of brooding unit (i.e., female and associated clutch) respiratory gas exchange, Tnest, Tclutch, and intra-clutch oxygen tension (PO2clutch) during acute changes among four incubation temperature conditions: constant preferred temperature (31.5°C); cooling (Tnest < Tclutch); constant cool temperature (25.6°C); and warming (Tnest > Tclutch). We demonstrated that A. childreni are not facultatively endothermic because brooding unit Q10 for and were similar to other ectothermic boid snakes (1.9 - 5.7) and Tclutch conformed to Tnest at the constant, cool temperature treatment. Females coiled tightly around eggs more often during cooling to conserve clutch heat and less often during warming to expedite an increase in Tclutch. Additionally, the amount of time that females spent tightly coiled during warming significantly affected the Tnest-Tclutch gradient. Together, these results indicate that, although female A. childreni are not facultatively endothermic, they are capable of assessing the Tnest-Tclutch gradient and making behavioral adjustments to enhance the thermal micro-environment of their developing offspring.

P1.165 STICKLES, E.M.*; SAKHTAH, H.; DOORLY, N; LIEW, C.-W.; ROOT, R.G.; LONG, J.H.; Vassar College, Case Western University, Lafayette College; elstickles@vassar.edu

Modeling Swimming Behavior with Perception-Action Feedback Loops in Autonomous Biorobotic Fish

In order to model the swimming behavior of fish, we use a method borrowed from behavior-based robotics in which sensorimotor (input-output) systems are represented as perception-action feedback loops (PAFLs). PAFLs are modular feedback systems that causally connect sensory information, neural systems, motor output, and environmental interaction. PAFLs can be designed into an agent-environment system in a variety of patterns: solo, in parallel, in series, or in a nested hierarchy. Using a two-layer nested PAFL design, we have built an autonomous fish-like prey robot that forages for light and avoids, when detected, a stalking predator. This robotic simulation is designed into an agent-environment system in a variety of patterns: solo, in parallel, in series, or in a nested hierarchy. Using a two-layer nested PAFL design, we have built an autonomous fish-like prey robot that forages for light and avoids, when detected, a stalking predator. This robotic simulation is meant to mimic the neural system of fish when Mauthner and related reticulospinal cells override the central pattern generators, used in cruising, in order to create a rapid escape maneuver. Sensory systems model eyes (photoreceptors in the low-level PAFL) and a lateral line (IR proximity detectors in the high-level PAFL). Motor output models an undulating tail, capable of turning, with a vertebral column actuated by a single anterior servo motor. With this system, we are able to analyze the connections between sensory input, neural processing, body structure, mechanical properties, and behavior in the context of a predator-prey ecology. This work was supported by NSF DBI-0442269.

P1.116 STEPHENS, Tiffany/A*; BRITTON-SIMMONS, Kevin; University of Washington and Friday Harbor Laboratories, Friday Harbor Laboratories; tiffany3@u.washington.edu

Feeding preference of Strongylocentrotus franciscanus for aged versus fresh kelp

Detrital macroalgae, particularly kelp, is an important food resource for sea urchins and other animals in many regions worldwide. However, most of what is known about consumer preferences for kelp comes from feeding trials conducted using fresh tissue. Detrital kelp undergoes important biochemical changes as it ages that potentially change its palatability and nutritional content relative to fresh tissue. We investigated the feeding preference of the red sea urchin Strongylocentrotus franciscanus for fresh versus aged (7 and 14 days) blade tissue from the kelps Nereocystis luetkeana, Agarum limbriatum, and Saccharina subsimplex. Urchins were offered fresh versus aged pieces of blade tissue from each kelp species and a choice was recorded when urchins began feeding on one of the two pieces offered to them. We found that for Nereocystis luetkeana and Saccharina subsimplex urchins preferred aged over fresh tissue and the strength of this preference increased with tissue age. In contrast, fresh Agarum limbriatum was always preferred over aged tissue. These results indicate that aging can influence food preference and that the effect of aging varies among kelp species. In systems where consumers have access to both fresh and detrital kelp tissue it may be important to evaluate how aging of detrital material influences consumer preferences in order to understand patterns of resource use in the field.

P1.45 STEWART, W.J.*; MCHENRY, M.J.; Univ. of California, Irvine; wstewart@uci.edu

The unsteady flow sensed by larval zebrafish

The ability to detect the water flow generated by a predator can be essential to the survival of a larval fish. However, it is not well understood what flow stimuli a larval fish detects before triggering an escape response. Therefore, we experimentally investigated the hydrodynamics of a larval zebrafish's (Danio rerio) body during capture in tethered larvae within a flow tank specialized for creating the impulsive flow generated by a feeding predator. We measured the boundary layers generated by this flow with particle tracking velocimetry (PTV). Preliminary data show that the boundary layer along the fish body extends to about twice the height of flow-sensitive lateral line receptors. This suggests that the boundary layer attenuates the flow stimulus created by a fish predator and thereby hinders their ability to evade capture.
ONTOMONY and fusion of the mandibular symphysis in camelids
Ontogenetic ossification, or fusion, of the mandibular symphysis in mammals is thought to be associated with weaning of the infant at a diet. In particular, symphysial fusion may be biomechanically advantageous for strengthening and/or stiffening the symphysis against routine masticatory loading. Recent work on alpacas (Lama pacos), which exhibit ontogenetic symphysial fusion, demonstrate significant differences in jaw-muscle recruitment patterns and symphysial loading between pre-weaned and adult alpacas. However, the morphological context for these differences, and in particular the ontogeny of symphysial fusion, is not fully understood. Here, we describe the morphology of the pre-fused symphysial joint and characterize the pattern of ossification of the mandibular symphysis in camels using osteological and fresh specimens and CT scans of live animals. Symphysial development is then related to various masticatory parameters, including EMG and bone strain data from alpacas. The pre-fused symphysis of neonatal and infant camels consists of two relatively flat symphysis surfaces. Ossification of the joint begins rostrally, with some individuals fusing first along the lingual portion and others along the labial portion. In some individuals, minor bony interdigitations develop in the caudal and labial region of the symphyseal joint prior to full fusion. Fusion is complete between 6 and 8 months. Thus, full fusion precedes or is coincident with occlusion of the first molar yet significantly precedes the onset of adult chewing motor patterns and symphysial bone strain patterns. Although the pattern of fusion cannot be directly related to observed strain patterns, we cannot rule out that forces generated during mastication in pre-weaned individuals influence ossification of the symphysial joint.
P1.105 STREETS, Amy*; SOARES, Daphne; university of maryland; daph@dum.du.edu
Hunting strategies of the mexican tetra fish Astyanax mexicanus larva
The emergence of new species-specific behaviors is only possible due to the evolutionary malleability of neural circuits. In the tetra fish Astyanax mexicanus, we find a particularly good window into the adaptation of behavior during speciation. Currently, Astyanax is undergoing allopatric speciation and is extant in two forms: an ancestral, sighted river dwelling form and a derived, blind cave dwelling form. Although adult cavefish lack functional eyes, small eye primordia form during embryogenesis, but later arrest in development, degenerate, and sink into the orbit. Because the degeneration of the retina in the cavefish takes a few weeks posthatch, we hypothesized that these animals have a functional visual system as larvae. We used a visually guided prey catching assay to examine the level of performance of cavefish versus riverfish from 1 week to 1 month of age. We expected that if cavefish used their visual system alone to catch prey, then their performance would initially be comparable to river dwelling fish but then decrease as their retinas degenerate. Alternatively, despite having eyes, larvae could use different hunting strategies from the beginning, such paying more attention to lateral line information. We tested animals in light and dark environments and after disruption of lateral lines by exposure to an aminoglycoside antibiotic (gentamicin), which kills hair cells. It appears that cavefish already use different exploratory and prey catching behaviors from the larval stage.

P1.167 SWIDERSKI, D.L.*; BASU, I.; ZELDITCH, M.L.; Univ. of michigan; dswider@umich.edu
Modularity and Integration of the Stapes: analysis of variation in the guinea pig
Like other model systems analyzed in studies of modularity and integration, the stapes has a complex developmental history: three ossification centers form in the cartilage of the second branchial arch, which fuses to the wall of the otic capsule, and is also excavated by the stapediaal artery. Unlike those other models, the stapes has but one simple function: the transmission of sound as it is driven forcefully into the fluid-filled inner ear. Thus, the goal of our study was to determine whether variation in stapedial shape reflects the modularity of development or the integration of function. We collected stapes from adult guinea pigs that had been the subjects of unrelated surgical experiments, and quantified shape geometrically, using landmarks at discrete anatomical loci and semilandmarks outlining the crura and footplate (the legs of the arch and the elliptical saucer it stands in). Preliminary results indicate that the outer edges of the crura are more variable than the inner margins of the arterial foramen, and that the feet of the crura are more variable than the head of the stapes. The long axis of the footplate appears to be proportional to height of the arch, but its width and depth are independent. These results suggest that stapes shape is not highly integrated despite the apparent simplicity of its functional role.

P3.170 SVANCARA, Kevin; BOORSE, Graham *; Arizona State University, West Campus; graham.boorse@asu.edu
Evolution of the vertebrate CRF system: molecular cloning and characterization of CRF-like peptides, receptors and binding protein in the lizard, Anolis carolinensis
Corticotropin-releasing factor (CRF)-like peptides modulate an organism’s endocrine, autonomic, and behavioral responses to stress by binding and activating either of two G protein-coupled receptors (CRF₁ and CRF₂). At least four paralogous lineages of CRF-like peptides exist in vertebrates. Previous studies have characterized the CRF stress system across different vertebrate taxa (e.g. fish, amphibians, bird and mammals). However, no studies have characterized the CRF system of squamates (e.g. lizards and snakes). The stress system likely serves important roles in underlying common lizard behaviors such as dominance and territoriality. By analyzing the A. carolinensis genome, we have identified genes involved in the CRF system. Using molecular cloning techniques, we have successfully isolated cDNAs for lizard CRF, urocortin 3 (UCN3), CRF₁, CRF₂, and CRF-binding protein (CRFBP). The deduced amino acid sequence of each molecule shares considerable similarity with its human ortholog: CRF mature peptide (100%), UCN3 mature peptide (90%), CRF₁ (75%), CRF₂ (70%), and CRFBP (77%). An additional cDNA encoding a mature peptide that shares 61% identity with human CRF and 40% with human urocortin 1 (UCN1) was also identified. Using molecular phylogenet analyses in conjunction with synteny mapping we have tentatively identified this molecule as lizard UCN1 rather than CRF. Tissue distribution of these genes via RT-PCR and binding affinity studies are currently underway.

P3.170 STRILEY, D.S.*; BUDEON, A.T.; ARONOWSKY, A.; WESTNEAT, M.W.; Biodiversity Synthesis Center, Field Museum; aaronowsky@fieldmuseum.org
Using the Encyclopedia of Life for New scientific discoveries: the Biodiversity Synthesis Center
The Encyclopedia of Life (EOL) has a simple but ambitious vision: to develop a webpage for every species on earth that is freely accessible to all and contains up to date, vetted scientific information. Recently launched, the EOL is moving quickly towards its goal, currently featuring almost 100,000 species pages containing multimedia visualizations of species and their ecosystems, descriptive text, and links to a vast library of scanned scientific literature. This unprecedented resource will serve as a primary research and educational tool for a worldwide audience that includes scientists, government agencies, conservationists, teachers, and students. To extend the EOL's impact and to begin using it to answer vital scientific questions, the Biodiversity Synthesis Center (BioSynCe) functions as the EOL think tank. As such, it is a place where researchers and academics from around the world gather in focused Synthesis Meetings to ask and answer new scientifically revolutionary questions about the biology of life. Synthesis meetings cover a range of topics, including: megadiverse groups, novel research questions in biogeography, evolution, systematics and taxonomy, visualization of large data sets, and the study of biodiversity hotspots. We will present summaries of recent synthesis meetings which have developed content and informatics tools for the EOL. We will also demonstrate some of the new tools to allow systematists to organize and archive their content on the EOL.

January 3-7, 2009, Boston, MA
L. cardium pustulosa is more genetically diverse than samples, 19 different haplotypes were present, versus L. cardium. Preliminary data indicate the percent of DNA was extracted from the tissue clippings and the mitochondrial as substrate composition and water velocity. To determine the extent to which mussel assemblages above and below the St. Croix Falls differ, and that this has been observed in previous studies that the perches for L. cardium pustulosa are known to have structure. Both hosts for transportation, this barrier could greatly affect mussel population involves a larval growth phase in which the mussels are dependent on fish human disturbance in the watershed, although since 1903 there has been a St. Croix River is a superior habitat for mussels, likely due to relatively light half of them are listed as endangered, threatened, or of special concern. The There are forty-eight species of mussels native to Minnesota, and more than A comparison of genetic variation between populations of pocketbook and pimpleback mussels above and below the St. Croix Falls dam (Minnesota/Wisconsin, USA) There are forty-eight species of mussels native to Minnesota, and more than half of them are listed as endangered, threatened, or of special concern. The St. Croix River is a superior habitat for mussels, likely due to relatively light human disturbance in the watershed, although since 1903 there has been a hydroelectric dam at St. Croix Falls. Because the life cycle of mussels involves a larval growth phase in which the mussels are dependent on fish hosts for transportation, this barrier could greatly affect mussel population structure. Both Lampsilis cardium and Quadrula pustulosa are known to have multiple fish hosts, primarily catfishes for Q. pustulosa and sunfishes and perchs for L. cardium. It has been observed in previous studies that the mussel assemblages above and below the St. Croix Falls differ, and that this variability is not likely to be a result of variation in microhabitat factors, such as substrate composition and water velocity. To determine the extent to which mussel populations above and below the dam are isolated from one another, small tissue samples from the mantles of 20 L. cardium and 20 Q. pustulosa were collected at four locations; two above the dam and two below the dam. DNA was extracted from the tissue clippings and the mitochondrial gene ND1 was sequenced. Preliminary data indicate the percent of polymorphic sites to be 3.30% for L. cardium and 8.44% for Q. pustulosa. From 42 L. cardium samples, 19 different haplotypes were present, versus 27 haplotypes from 35 Q. pustulosa samples, indicating that for ND1 Q. pustulosa is more genetically diverse than L. cardium.

P3.85 SZUMOWSKI, Suzy C.; BOYER, Sarah L.; HORNBACH, Daniel J.; HOVE, Mark C.; Macalester College; sszumowski@macalester.edu
A comparison of genetic variation between populations of pocketbook and pimpleback mussels above and below the St. Croix Falls dam (Minnesota/Wisconsin, USA) There are forty-eight species of mussels native to Minnesota, and more than half of them are listed as endangered, threatened, or of special concern. The St. Croix River is a superior habitat for mussels, likely due to relatively light human disturbance in the watershed, although since 1903 there has been a hydroelectric dam at St. Croix Falls. Because the life cycle of mussels involves a larval growth phase in which the mussels are dependent on fish hosts for transportation, this barrier could greatly affect mussel population structure. Both Lampsilis cardium and Quadrula pustulosa are known to have multiple fish hosts, primarily catfishes for Q. pustulosa and sunfishes and perchs for L. cardium. It has been observed in previous studies that the mussel assemblages above and below the St. Croix Falls differ, and that this variability is not likely to be a result of variation in microhabitat factors, such as substrate composition and water velocity. To determine the extent to which mussel populations above and below the dam are isolated from one another, small tissue samples from the mantles of 20 L. cardium and 20 Q. pustulosa were collected at four locations; two above the dam and two below the dam. DNA was extracted from the tissue clippings and the mitochondrial gene ND1 was sequenced. Preliminary data indicate the percent of polymorphic sites to be 3.30% for L. cardium and 8.44% for Q. pustulosa. From 42 L. cardium samples, 19 different haplotypes were present, versus 27 haplotypes from 35 Q. pustulosa samples, indicating that for ND1 Q. pustulosa is more genetically diverse than L. cardium.

P3.69 SZARKO, M.J.*; BERTRAM, J.E.A.; University of Calgary; mjsarko@ucalgary.ca
Some Tissues Like It Fast: Dynamic, Low Magnitude, High Frequency Analysis of Viscoelastic Tissues As limbs strike the ground during terrestrial movement ground reaction forces composed of relatively high frequency transient stress waves (over 100 Hz during human heel strike) travel up the skeleton. Many natural shock-absorbing structures within the musculoskeletal system have viscoelastic, time-dependent behaviours that may be sensitive to this high frequency loading, especially if compromised by over-use, over-loading or disease. Identification of loading-rate dependent behaviour, non-destructive low amplitude (0.01 MPa) dynamic compression tests were used. Loading involved 0.1-100 Hz equal amplitude sinusoidal waveforms periodic in the time record. Storage and loss moduli derived from load-deformation results allowed the calculation of both complex stiffness and hysteretic energy loss. As a model, articular cartilage was used to characterize loading-rate dependent behaviours of viscoelastic tissues. Investigating an osteoarthritic disease model of articular cartilage revealed that an intact collagen network is critical for normal hysteresis, above 30 Hz. Identifying mechanical freeze-thaw effects on articular cartilage found lower frequency (<20Hz) hysteretic differences for tissues stored at -20°C and high frequency differences for tissues snap frozen in liquid nitrogen and stored at -80°C. Sodium movement in articular cartilage, hypothesized as a cause for the altered biomechanics caused by freeze-thaw was assessed by exposure to a range of sodium concentrations. Stiffness decreased at lower frequencies (<20Hz) at 1M NaCl, but increased at higher frequencies (40-59 Hz) at 5M NaCl. The loading-rate sensitivity found in articular cartilage may be applicable to other viscoelastic musculoskeletal tissues and reveals low magnitude, high frequency dynamic testing as a new avenue for discovering novel tissue responses to the physiological range of loading rates.

P3.77 TAMONE, SL*; CHUNG, JS; University of Alaska Southeast, UMBI-Center of Marine Biotechnology; stamone@uas.alaska.edu
SEQUENCE ANALYSIS OF CRUSTACEAN HYPERGLYCEMIC HORMONE FROM TANNER CRAB CHIONOCETES BAIRDI Crustacean hyperglycemic hormone (CHH) is an eyestalk neuropeptide secreted from sin gland tissues that functions in the regulation of circulating glucose. This neuropeptide is important for crustacean metabolism and should serve an important role in animals under environmental stress; animals that have increased metabolic rates to compensate for environmental change. Crustacean hyperglycemic peptide has been purified from multiple brachyuran crab species to date, but not from the cold water Tanner crab, Chionoecetes bairdi, a species found in Alaskan waters. The purpose of purifying and sequencing C. bairdi CHH is to establish tools for further study of cold water crab metabolic physiology. Cold water crabs such as those in the genus Chionoecetes are currently a good model for understanding the role that climate change and associated water temperature changes might have on metabolic physiology. Sinus glands were dissected from male C. bairdi and the neuropeptides were purified using reverse-phase HPLC. Two neuropeptides were identified as CHH with an enzyme-linked immunosorbant assay (ELISA) using a heterologous antibody specific for Callinectes sapidus CHH. The bioactivity of these two peaks was assessed by injecting OH containing samples into eyestalk-ablated Tanner crabs and measuring subsequent circulating glucose. The full length cDNA sequence of the larger eyestalk CHH from C. bairdi was determined through amplification, cloning and sequencing of first strand cDNA and was subsequently constructed from overlapping clones. A phylogenetic analysis of amino acid sequence data from six brachyuran crab species showed C. bairdi CHH most closely related to the majd crab, Libinia emarginata (P56888). Future studies will include comparative metabolic physiology with the warm water crab C. sapidus.
Patterns of Antioxidant Defenses Vary Among Zooxanthellate Symbioses

Cnidarian hosts experience hyperoxia as a result of photosynthesis by their endosymbiotic zooxanthellae. As a result, these hosts experience elevated exposure to reactive oxygen species (ROS), including superoxide, hydrogen peroxide, and the hydroxyl radical. The primary defenses against ROS in most metazoans include the enzymes superoxide dismutase (SOD) and catalase (CAT) as well as several low-molecular-weight organic molecules such as ascorbate, glutathione, and urate. Some cnidarian hosts, such as sea anemones in the genus *Aiptasia*, do not regulate activities of SOD and CAT in response to artificially elevated oxygen tensions or acclimation to increased light intensities. In fact, SOD activity is remarkably low in this genus. Other cnidarians, however, such as the temperate sea anemone *Anthopleura elegantissima*, do regulate some of these enzymes. The primary defenses against ROS in *Aiptasia* spp. appear to be saturating concentrations of uric acid, a potent scavenger of hydroxyl radicals, and constitutively elevated activities of CAT. Furthermore, CAT activity is inversely correlated with acclimation irradiance, indicating that direct photoactivation of catalase in this symbiosis occurs. Given that defenses against ROS in other cnidarian zooxanthellate symbioses follow different patterns, including more robust enzymatic defenses, studies of such defenses among symbiotic cnidarians need to consider the exact pattern of defenses for the species under consideration.

Assessing the capacity for sympathetic control of cardiovascular physiology in embryonic snapping turtles (*Chelydra serpentina*)

Control of cardiovascular function during development of amniotic vertebrates remains poorly understood, particularly for reptiles. We have previously determined that an active cholinergic and adrenergic tone on cardiovascular function is present late in the embryonic development of snapping turtles. However, the source of the adrenergic tone, whether circulating hormones or the autonomic nervous system, is unknown. In this study, sequential pharmaceutical sympathectomy and receptor blockade was utilized to isolate the source of the adrenergic tone in embryonic snapping turtles. Initially, pharmacological sympathectomy with 6-hydroxydopamine increased arterial pressure, which remained elevated for the duration of the experiment, while heart rate transiently increased. This treatment was followed by injection of receptor blocking agents. Administration of the muscarinic antagonist, atropine, increased heart rate and had minimal impact on arterial pressure. The beta-adrenergic antagonist, propranolol, induced a marked decrease in heart rate, while arterial pressure transiently increased. Finally, administration of the alpha-adrenergic antagonist, phentolamine, caused a marked decrease in arterial pressure without affecting heart rate. Collectively, data support the previously established presence of cholinergic and adrenergic tone in this embryonic reptile, and suggest that the adrenergic response may originate primarily from circulating catecholamines in snapping turtle embryos at 90% of development.
P3.27 TAYLOR, K.N.; WEIGAND, K.L.; BAATZ, J.E.; DEAROLF, J.L.; Hendrix College, Conway, AR, the Medical University of South Carolina, Charleston; taylorkn@ hendrix.edu
Can the maternal weight of a guinea pig be used to determine the glucocorticoid steroid dose to its fetuses?
Glucocorticoid steroids accelerate the development of body organs before birth and are therefore given to mothers who are expected to give birth prematurely, primarily to stimulate the development of their fetuses lungs. However, from previous studies, we hypothesize that prenatal glucocorticoids will decrease the percentage of fast twitch fibers in the breathing muscles of guinea pigs, which would affect the ability of these muscles to contract quickly during ventilatory challenges. To test this hypothesis, a steroid dosage protocol based on a study in fetal sheep was used, in which the mothers weight determined the amount of steroid administered (0.5mg steroid/kg maternal weight at 65%, 75% and 85% gestation). But, given that maternal weight is not a good indicator of litter size in guinea pigs, it is not known if all of the fetuses in this study have received the appropriate steroid dose. Since glucocorticoids stimulate lung surfactant production, the presence of these proteins can be used to determine if the fetuses have received this dosage. Lung samples were collected from all fetuses in the study and prepared for SDS-polyacrylamide gel electrophoresis. Proteins were separated using nonreducing conditions on a 12% Tris/Glycine SDS-PAGE gel, run at 200V for 40 minutes and transferred (25V, 80 min) to nitrocellulose membranes for Western Blots. Membranes were probed with an anti-lung surfactant protein B (SP-B) primary antibody and developed using chemiluminescence. Relative changes in SP-B as a function of glucocorticoid exposure were then used to determine the validity of using the mothers weight as a basis for the dosage of these steroids in animals that give birth to litters.

P3.156 TEARE, Amber*; ROSTAL, David; MARLEY, Philip; MOSS, Amanda; Georgia Southern University; amber_r_tear@georgiasouthern.edu
Reproductive Biology of the Alligator Snapping Turtle (Macrochelys temmincki)
Knowledge of a species biology is necessary for a better understanding of its phylogeny, as well as for more successful conservation and management. Reproductive biology is especially important in comprehending the fitness potential of individuals and growth potential of populations. Reptiles allow for unique inquiry in the field of reproductive biology due to their long life spans and late sexual maturity. Freshwater turtles are often studied as models of ectothermic reproduction. The alligator snapping turtle is a slowly-maturing, low fecund, freshwater turtle that, despite overwhelming trapping during the 1960s-1980s, has been understudied. Being confined to river systems that drain in the Gulf of Mexico, this species may be more severely impacted by habitat destruction and environmental modification. Early studies on M. temmincki demonstrated basic reproductive similarities to other turtles, particularly its sister species Chelydra serpentina. However, practically nothing is known about alligator snapping turtle reproductive ecology or physiology, especially with respect to hormonal seasonality. The Flint River, Georgia population of alligator snapping turtles is under study to delineate their reproductive hormone cycle, gonadal development, egg production and nesting attributes. Seasonal estradiol, testosterone, and corticosterone cycles will be examined via ELISA. Individuals will also undergo ultrasound, x-ray and laparoscopy to determine reproductive status. Nests will be collected to reveal hatching success and sex ratios. These findings will allow for comparisons among testudines, particularly Chelydridae, and for more accurate management techniques for this threatened species.

P3.144 TEMKIN, M.H.*; MISERCOLA, B.; SONAGERE, M.; DIXON, E.; St. Lawrence Univ; mtemkin@stlawu.edu
Homebox gene characterization and expression in developing zooids of the marine bryozoan Membranipora membranacea
Bryozoans are a large group of colonial invertebrates that live in marine and freshwater habitats. New individuals, or zooids, of a bryozoan colony are added through a process of asexual budding. As each zooid forms, it develops specific structures along its anteroposterior axis. During animal development, regions of the body along the anteroposterior axis are specified through the biochemical environment established by transcription factors that are coded for by homeobox genes, including a subclass of homeobox genes called Hox genes. Initial steps in understanding how bryozoan zooids establish structures along their anteroposterior axis are to characterize their homeobox genes and to determine the expression of these genes during the differentiation of asexually budded individuals. Here we present data on the full protein coding sequences of four homeobox genes expressed during the development of zooids in colonies of the marine 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. Initial sequences for these genes were obtained by PCR using primers complimentary to conserved homeobox regions of genomic DNA. Using primers based on these conserved homeobox regions, the mRNA sequences of these genes were obtained by 3' and 5' RACE. RT-PCR was used to confirm that the sequences obtained from 3' and 5' RACE belonged to the same mRNA. Based on these mRNA sequences probes were synthesized for visualizing gene expression in developing zooids using in situ hybridization.

P3.92 TEW, Whitney Y.*; SECOR, Stephen M.; University of Alabama; wytew@bama.ua.edu
Actin polymerization underlies the postprandial lengthening of the pythons microvilli
Pythons experience with feeding dramatic upregulation of intestinal function that appears to be explained in part by the unprecedented lengthening of their intestinal microvilli. Within 24 hours after feeding, the microvilli have increased in length by as much as 5-fold. This increase in length and surface area matches the postprandial increase in nutrient transporter and enzyme activities. We hypothesized that an underlying mechanism of microvillus growth is the rapid polymerization of filamentous actin (F-actin), the internal skeleton of the microvilli, from cytoplasmic globular actin (G-actin). To demonstrate the postprandial mobilization of G-actin and the formation of F-actin with microvillus lengthening, we labeled with fluorescent probes both G-actin (DNase 1) and F-actin (phalloidin) of the intestinal epithelium of fasted and fed Burmese pythons. Fasted pythons exhibited a high concentration of cytoplasmic G-actin, whereas for fed pythons, G-actin concentrations were less and F-actin was highly concentrated at the brushborder membrane. To experimentally test the role of actin polymerization in postprandial microvillus growth, we infused either cytochalasin D, an inhibitor of actin polymerization, or DMSO, a control, into the intestinal lumen of digesting pythons. We observed a significant reduction (40-50%) in the length of the microvilli following 24 hours of infusion with cytochalasin D compared to snakes infused with DMSO or those fed without infusion. In addition to being shorter, microvilli exposed to cytochalasin D were irregular in shape and bent. We suspect that feeding triggers the mobilization of G-actin molecules and other cytoskeletal proteins from the cytoplasm to rapidly lengthen the microvilli. Upon the completion of digestion, these steps are apparently reversed to shortenthe microvilli.
Effect of Incubation Temperature on the Morphology and Endocrinology of the Reproductive Tract of a Turtle with Temperature-Dependent Sex Determination

The differential fitness hypothesis suggests that temperature-dependent sex determination could be advantageous because it allows the matching of sex to fitness. The current study addressed the potential physiological mechanism by which temperature-dependent sex determination (TSD) might affect fitness. The effects of specific incubation temperatures on the morphology and endocrinology of the gonads and reproductive tracts were examined in the red-eared slider turtle (Trachemys scripta). Gonads and reproductive tracts were compared between late-stage embryos incubated at temperatures that produced either 1) all females, 2) mostly females, 3) mostly males, or 4) all males. The gross morphology and histology of the reproductive tracts of these four groups were compared and the testosterone and estradiol-17B content were measured. The results indicate significant variation between the gonads of females incubated at different temperatures and moderate differences in the males. The results show morphological and physiological variation in the gonads of from turtles incubated at different temperatures. These findings provide a potential mechanistic basis for the differential fitness hypothesis. Further, the results provide insight on optimal incubation temperatures for turtle conservation programs that artificially incubate eggs.

Estimate of Survival Time of Diamondback Terrapins Caught in Crab Traps Based on Voluntary Dive Times and Metabolic Rates

Mortality in commercial crab traps has contributed to the decline of local populations of the diamondback terrapin, Malaclemys terrapin. It is unknown how long a terrapin can survive after entering a submerged crab trap. For this reason, behavioral and physiological analyses were conducted to estimate survival time. Average (Mean +/- SD) voluntary dive time (8.4 +/- 5.7 min; n = 9) of captive terrapins was determined by videotaping animals in the laboratory. Females (9.2 +/- 6.8 min; n = 5) generally had longer dives than males (7.4 +/- 3.4 min; n = 4) and dive length was not correlated with body mass. The longest voluntary dive was 50 minutes. In contrast, the average time of submergence for seven crab traps set in tide creeks over a 4-day period was 58 +/- 54 min for morning high tides and 314 +/- 61 for evening high tides. Oxygen consumption was determined at 10, 20 and 30 °C. As expected, metabolic rate increased with temperature (Q10 = 1.73). Using mass-specific lung volume and metabolic rates, it was calculated that a ~200g terrapin in this study had enough oxygen stores to sustain aerobic metabolism for ~11 min at 25°C. Therefore, our data seem to indicate that voluntary dives in the laboratory are terminated before the anaerobic diving threshold has been reached. Because commercial crab traps are likely submerged for several hours at high tide, terrapins that are accidentally caught in these traps must rely extensively on their ability to sustain anaerobic metabolism to avoid drowning.

Using Artificial Selection to Determine How Sexual Size Dimorphism Affects Within-Sex Size Variation

An important issue concerning the evolution of sexual size dimorphism is that strong genetic correlations between the sexes constitute a genetic constraint. Although females may be subject to fecundity selection for larger body size and males for small body size, the evolution of sexual size dimorphism could be constrained by genetic correlations between the sexes. Thus, selection for sexual size dimorphism coupled with genetic correlations between the sexes may help maintain body size variation within each sex. Using artificial selection on red flour beetles (Tribolium castaneum), we tested the prediction that selection for extreme sexual size dimorphism will broaden within-sex variation in body size. We established 3 replicated selection lines: a) increased female-biased sexual size dimorphism b) reduced sexual size dimorphism and c) control line. We assessed T. castaneum body size via a multivariate approach based on principal component analysis of five linear measures: head width, pronotum width, tibia length, pro sternum width and third abdominal sternite length. After three generations of selection, we compared the effect that increasing or decreasing sexual size dimorphism had on intrasexual variation in body size. These results provide new insight into the evolutionary significance of sexual size dimorphism.
P2.130 TJORNAS, G*; PATI, A; HOCHBERG, R; Univ. Massachusetts Lowell; rich_hochberg@uml.edu

On the structure and function of larval muscular systems in trematodes (Platyhelminthes: Neodermata): intramolluscan stages from sporocyst to metacercaria.

Freshwater molluscs serve as intermediate hosts for trematodes that parasitize amphibians, birds, fish and other vertebrate animals. An individual snail can harbor multiple larval stages of a single trematode species or even multiple species. Different species and ontogenetic stages of intramolluscan trematodes often show characteristic behaviors (movement patterns) that may be correlated with their body shape and the architecture of their muscular systems. Patterns of musculature may also be of systematic relevance. To date, few studies have examined muscle pattern diversity within a clade or even the ontology of a single species - from sporocyst to redia to cercaria and metacercaria. To understand how muscle patterns may differ between systematic groups, or even within the ontology of a species, we examined multiple larval stages of select trematodes from the pulmonate hosts, *Menetus dilatatus* and *Physa sp.*, using fluorescent phalloidin stains and confocal laser scanning microscopy. Our results reveal similarities in muscle arrangement among comparable larval stages, and interesting differences between larval stages within a single species. This study underscores the need for greater attention to larval morphology (beyond taxonomic characters) to understand the functional significance of different muscle patterns and their importance for trematode systematics.

P2.29 TODD, Nancy E.*; MONTELLO, Maxine; Manhattanville College; tod@mv.cc.manhattan.edu

The potential for disruption of aggressive behavior in female by environmental estrogens

The Siamese Fighting Fish, *Betta splendens* is a popular aquarium fish, and is known for its aggressive behavior. Males cannot be kept more than one to a tank, but many hobbyists and pet stores keep multiple females together, not thinking they are very aggressive. Recent research at Manhattanville suggests otherwise, that females are just as aggressive as the males of the species, and will actively defend their territory. In the wild, these fish live in flooded rice paddies and other stagnant bodies of water in Asia, environments that are potentially susceptible to contamination with chemicals containing estrogenic compounds such as pesticides, waste chemicals from factories, and other non-point sources. The effects of these estrogens on aggressive behavior is studied here. Female *Betta splendens* were exposed to 2.5ul of 17B estradiol for 28 days to evaluate the effect on their aggressive behavior. Females were visually exposed to male and female controls for behavioral observation pre-treatment, 28 days after treatment, and 28 days after treatment was ended. The control females showed no difference in behavior before and after treatment, but females treated with 17B estradiol exhibited a statistically significant difference before and after treatment and 28 days after treatment ceased. All observed behaviors differed in frequency, not just a few. This indicates that environmental estrogens can decrease aggression in females, and can ultimately affect their dominance hierarchy and reproductive success.

P1.11 TORREY, K.W.; BAKER, P.J.; Swarthmore College; ktorre1@swarthmore.edu

Plastron redness in Red-bellied Turtles as an index for fitness

Carotenoid-based ornamentation is thought to be an honest signal of health in many vertebrate taxa; however, this relationship has not been studied in turtles. The Eastern Red-bellied Turtle, *Pseudemys rubriventris*, displays carotenoid pigments as ornamentation on its plastron, (ventral shell); carotenoids may also be used, however, to protect the body from oxidative damage. One hypothesis is that because vertebrate animals cannot synthesize carotenoids *de novo*, their use for ornamentation demonstrates that oxidative defense needs are met and exceeded. To test our hypothesis that there is a relationship between plastron coloration and fitness, we matched principle components analysis of color values with data from assays measuring two indices of fitness, the carotenoid content and antioxidant capacity of plasma. We devised an inexpensive and effective way to quantify plastron coloration, by capturing digital images of turtle plastrons (n=8) under standardized conditions and lighting. From these images, measurements of hue, saturation, and brightness (HSB) were found by sampling randomized points on a grid overlay of the plastron. Analyzing the HSB values yielded a first principle component (PC1) that accounted for 79.3% of the variability in the HSB color space. PC1 correlated strongly with hue, (r²=0.687) saturation, (r²=0.866) and brightness (r²=0.786). Preliminary analysis has not indicated a relationship between PC1 scores and plasma carotenoid content, though further analysis will explore this connection. However, we found a strong correlation between PC1 scores and total antioxidant capacity of plasma (r²=0.563), supporting our hypothesis and suggesting that a relationship indicative of honest signaling may exist between plastron coloration and fitness in Red-bellied Turtles.

P2.146 TORKUM, M.*; YAGER, D.D.; Univ. of Maryland, College Park; ddyager@umd.edu

Central nervous system responses to stimulation of the mesothoracic cyclopean ear of the praying mantis, Pseudocrobranchus ocellata

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. A few mantis lineages have evolved a second, serially homologous, mesothoracic auditory system tuned to 2-4 kHz sounds. Based on extracellular recordings using 2.5 kHz stimuli at 15-25 dB over threshold, information from the mesothoracic ear ascends via at least two interneurons with high conduction velocities and arrives in the cephalic ganglia 17-24 ms after stimulus onset. A rapid pathway is indicated by activity in three or more interneurons descending from the cephalic ganglia only 25-30 ms after the stimulus, which suggests minimal intermediate processing. These descending responses habituate strongly. A slower pathway is indicated by a weakly habituating descending interneuron with very large spikes in the extracellular record and latencies of 50-70 ms. The tuning curves for the descending units are identical in shape to the ascending units' curves, but the thresholds are 15-20 dB higher (means of 68 dB SPL vs. 50 dB SPL at 2.5 kHz). In addition, at least three axons descend from the mesothorax into the abdomen. Average latencies at 15-25 dB over threshold recorded between the 2nd and 3rd abdominal ganglia ranged from 14-20 ms. There was no indication of long-latency activity descending from the head into the abdomen. Thus, information about 2-4 kHz sounds is typically present before 20 ms. This is a pattern commonly seen in arthropod escape systems where behavioral latencies are typically 40-80 ms. Nonetheless, attempts to elicit behavioral responses to diverse 2-4 kHz stimuli in a broad range of contexts were not successful. The behavioral role of mantis mesothoracic hearing remains unknown.
Does myosin heavy chain expression in intercostal muscles of Cavia porcellus vary with exposure to betamethasone?

Premature infants are at a higher risk of complications due to a lack of development of the organs associated with ventilation and gas exchange, so glucocorticoids, like betamethasone, are used in the medical community to accelerate the development of the lungs. However, the effects of these steroids on breathing muscle development are currently unknown. Since these steroids are known to stimulate differentiation, we hypothesize that treated muscles will express more adult fast (neonatal, Ila, Ix) myosin heavy chain (MHC) isoforms than control groups. To test this hypothesis, pregnant guinea pigs underwent two steroid injection protocols. In the short protocol, females had two injections at 70% gestation 24-hours apart, while the long protocol had females injected at 65%, 75%, and 85% gestation, two injections per week, 24-hours apart. Intercostal muscle samples were collected from all fetuses and extracted with a urea/thioura buffer. Extractions were separated in SDS-polyacrylamide (7%) gels run at 275 V and 8°C for 24-hours. After being silver stained and dried, the gels were analyzed with Scion Image to determine the average proportions of fetal, neonatal/Ila/Ix, and slow MHC isoforms relative to the total myosin present.

In the short protocol, treated muscles expressed significantly less fetal (46.1+/-2.5%) and more adult fast (36.2+/-2.2%) than controls (49.7+/-0.7%; 30.3+/-1.3%). In comparison, the treated muscles in the long protocol expressed significantly more fetal (27.7+/-1.9%) and less adult fast (46.8+/-3.8%) than controls (22.8+/-2.9%; 58.2+/-4.2%). The results from the short protocol support our hypothesis that betamethasone accelerates muscle development, which suggests that the intercostals of treated neonates will be better prepared for function at birth.

The receptor and signal-transduction pathway that mediate planular settlement of the coral Pocillopora damicornis

Larvae of the scleractinian coral Pocillopora damicornis are induced to settle and metamorphose by the presence of marine bacterial biofilms. The swimming planula requires this natural cue to select a suitable substratum, attach and grow into a benthic polyp. However, not all bacteria are inducive, and the inductive capacity of each strain is highly species-specific. Induction is mediated by a receptor that detects the external cue and triggers a signal-transduction pathway that initiates metamorphosis. The primary goal of this study is to determine what type of receptor and signal-transduction pathway are involved during metamorphosis of P. damicornis, a basal metazoan, to better understand metamorphosis of invertebrate larvae. Evidence from studies on larvae of hydrozoans and another anthozoan suggest that G protein-coupled receptors (GPCRs) and fibroblast growth factors (FGFs), respectively, are good candidates. In addition, other possible receptor types include lectins and ligand-gated ion channels. Preliminary results suggest that a mannose-binding lectin is localized in the apical region of the larvae of P. damicornis. Current experiments include settlement assays in which competent larvae are exposed to neuropharmacological agents that affect a specific type of receptor and/or pathway, in the presence and absence of biofilm. Agents tested here induce, inhibit, or do not affect metamorphosis of these larvae. This study provides insight into the underlying physiological mechanisms that regulate metamorphosis in the larvae of P. damicornis, in comparison to other invertebrate taxa.
P2.6 TUCKER, Mitch*; HUMFELD, Sarah C.; GERHARDT, H. Carl; University of Missouri, Columbia; matkcc@mizzou.edu
Effects of polyploidy on female call preference in gray treefrogs, Hyla chrysocelis.
The gray treefrog complex consists of two cryptic species; Hyla versicolor is a tetraploid (4N=48) species that arose from the polyploidization of its diploid counterpart, Hyla chrysocelis (2N=24) and two other extinct treefrog species. Speciation via polyploidy is almost instantaneous because polyploid species are reproductively isolated from their non-polyploid ancestors. However, the establishment of new polyploid lineages requires assortative mating between polyploids. Genome duplication has been shown to affect the quality of the male's species-specific mate-attraction signal (pulse repetition rate), thus polyploids could potentially be reproductively isolated from their diploid ancestors as a result of changes in the species communication system. We are investigating the influence of ploidy on female preferences for advertisement calls to determine whether polyploidization is a means by which senders and receivers in a communication system can evolve in tandem. To answer this question, we have created autoploidy individuals and will test the acoustic mate-choice preferences of female polyploids upon reaching sexual maturity. The experimental tests compare preferences for call traits that vary between the two species, including call peak frequency, pulse shape, and pulse rate. We are also testing the hypothesis that changes in calls and preferences of polyploids are mediated through the influence of genome size on cellular and/or tissue dimensions by examining the behavior and cellular dimensions of H. chrysocelis raised at different larval densities. We expect to find that polyploidy and cellular dimensions affect the advertisement-call preferences of female H. chrysocelis treefrogs, independent of other factors. We will present preliminary results from these two sets of experiments including female preferences and effects of larval densities on cell dimensions.

P2.13 VACCARO, EA*; HOUCK, LD; Oregon State University; vaccaro@science.oregonstate.edu
Courtship pheromones modulate female behavior in a plethodontid salamander
Female sexual receptivity is a behavior at the crux of mechanistic and evolutionary perspectives of reproductive behavior. Recent work addressing receptivity has established that plethodontid salamander courtships show a reduced time to insemination when the female has received male pheromone. A reproductive Plethodon shermani male has a mental (chin) gland that produces proteinaceous courtship pheromones, and all 26 species in its clade employ the same method of pheromone delivery: the male taps his mental gland on the females nares. Pheromones enter the females nasal cavity and are shunted laterally to the vomeronasal organ (VNO). This VNO-initiated pathway likely transmits pheromonal information to sites in the brain known in other vertebrates to be involved in endocrine regulation and enhancement of sexual behavior. I investigate three candidate mechanisms for how courtship pheromones modulate female behavior: 1) by enhancing a central state of sexual motivation, or 3) by affecting specific sensorimotor integration mechanisms in individual sensory modalities. Females treated with pheromone are assayed for enhanced response to visual and olfactory cues (both male- and food-related), as well as differences in heart rate, general locomotor activity, startle response, and foraging activity. By investigating the proximate aspects of a signal-response system, this study ultimately may provide insights into how the perception of a chemical signal can induce a specific change in behavior.

P2.34 VALENZUELA, J.J.*; TOMANEK, L.; Montana State University - Bozeman, California Polytechnic University - San Luis Obispo; jjvalenz@calpoly.edu
The Acute and Chronic Heat Stress Response in the Purple Sea Urchin, Strongylocentrotus purpuratus: A Proteomics Approach
Purple sea urchins (Strongylocentrotus purpuratus) inhabit intertidal zones where they experience extreme temperature fluctuations. In this study we used a proteomics approach to characterize the protein expression profiles in response to heat. We acclimated sea urchins to 11C and 18C for four weeks and subsequently exposed animals to 25C for 4 hours. Afterwards animals were brought back to their respective acclimation temperature for a 16 h recovery period. We excised tube feet tissue immediately after recovery and homogenized it in urea-containing buffer. Proteins were separated using two-dimensional gel electrophoresis (2D-GE): first we used an immobilized pH gradient to focus proteins according to their net charge and, second, we used sodium dodecyl sulfate- polyacrylamide gel electrophoresis (SDS-PAGE) to separate proteins according to their molecular weight. Gels were stained with a fluorescent stain and 2D gels were subsequently analyzed using image analysis software (Delta2D) to determine which protein spots are differentially expressed in response to heat. The expression of 28 proteins (7% of 425 total) changed with acute, and of 25 (6%) with chronic (acclimation to 18C) heat stress. 12 (3%) protein spots showed an interaction effect. We are currently using matrix-assisted laser desorption/ionization tandem time-of-flight (MALDI-TOF-TOF) mass spectrometry to identify the differentially expressed proteins. These preliminary results may provide insights into the global response of the sea urchin proteome to environmentally relevant heat stress following different thermal conditions.
Matrix metalloproteinases (MMPs) are a family of highly conserved, proteolytic enzymes found in most organisms. MMPs can degrade most types of extracellular matrix protein, making them important enzymes in the regulation of development. In fruitflies, MMPs are critical for metamorphosis throughout development in the tobacco hornworm, Manduca sexta (Horn, 2009). These enzymes are important for molting and metamorphosis. Recently, MMPs have been identified in another lepidopteran, the waxmoth, Galleria mellonella. In the waxmoth, MMPs are hypothesized to be important for immune function, as they are upregulated upon exposure of hemocytes to bacterial lipopolysaccharide. If M. sexta MMPs are also important for immune function, then we should find MMP expression in immune-related organs such as fat body, hemolymph or hemocytes. However, we were unable to detect any proteolysis in the fat body, suggesting that MMPs present there may be inactive. Furthermore, MMP activity detected in hemolymph and hemocytes was found sporadically, indicating that MMP expression in these tissues may require induction by an immune response.
**P2.42** VON DASSOW, M.*; DAVIDSON, L.A.; Univ. of Pittsburgh; mvondass@yahoo.com

**Slicing, shocking, and sucking on embryos to differentiate active and passive mechanical behaviors of developing tissues.**

A fundamental problem in the biomechanics of morphogenesis is differentiating active force generating processes from passive viscoelastic properties of embryonic tissues. We use micro-aspiration to assay the apparent stiffness of gastrulating *Xenopus laevis* embryos in vivo. We apply suction to a patch of the embryo surface through a 125 micrometer diameter channel and measure the resulting deformation. Previously we observed that these tissues occasionally contract with sufficient force to counter the applied suction (5.4 Pa) over a period of one to several minutes. Rapid, stochastic contractions are also visible in time-lapse videos of embryos that are minimally manipulated, just constrained enough to stay in place. If we could experimentally induce contractions it would open up new means to investigate the relations between active contractility and passive viscoelasticity, and to identify potential regulators of contractility in embryos. We noticed that wounding stimulates contraction in both the wounded embryo and adjacent embryos. Hence, a diffusible factor released by wounding can induce contraction. We wondered if electrical stimulation could also cause contractions. The micro-aspirator channel can serve as an electrode so it allows measurement of apparent stiffness and simultaneous electrical stimulation. Stimulating the ~125 micrometer diameter aspirated tissue with ~0.1 mA for 0.05 to 0.4 ms induced strong contractions. Peak contraction occurred ~1 min after stimulation, with relaxation occurring over the following 1 to 2 minutes. Hence, we can now combine mechanical testing with acute control of contractility, opening up new avenues to experimentally differentiate active and passive mechanical behaviors in living, developing embryos.

**P2.12** WACK, CL.; SCHUBERT, SN; WOODLEY, SK; Duquesne University; wackc@duq.edu

**Endocrine sensitivity to pheromonal signals in a terrestrial salamander, *Plethodon shermani***

Behavioral interactions can induce changes in hormone levels. Furthermore, exposure to social signals involved in behavioral interactions can induce changes in hormone levels. Many amphibians utilize chemosensory cues as social signals. To determine whether endocrine status is modulated by exposure to conspecific chemosensory cues in the plethodontid salamander, *Plethodon shermani*, we examined the endocrine response to exposure to male courtship pheromones. Two studies, conducted in different years under slightly different experimental conditions, were performed. The first study measured changes in plasma corticosterone, testosterone and estradiol in males, reproductive females, and nonreproductive females after exposure to a saline control and two different chemosensory cues: male courtship pheromones and female skin secretions. This first study found that exposure to male courtship pheromones resulted in increased corticosterone in males. A second study, conducted to confirm the findings of the first experiment, also found that exposure to male courtship pheromones resulted in increased plasma corticosterone in males. This is the first evidence that endocrine status is sensitive to pheromonal signals in an amphibian.
**P1.38** WALTERS, L.*; TURNER, T.; KUFFNER, IB.; PAUL, VJ.; RITSON-WILLIAMS, R.; GRABLOW, K.; SETTAR, C.; RIVERA, G.; HICKEY, TD.; Univ. of Central Florida, Univ. of the Virgin Islands, US Geological Service, Smithsonian Inst.; lwalter@pegasus.cc.ucf.edu

**Coral-Algal-Urchin Interactions in Caribbean Waters**

The die-off of the long-spined black sea urchin *Diadema antillarum* in Caribbean waters in the 1980s coincided with a dramatic increase in macroalgal biomass on coral reefs. Scientists and resource managers have hypothesized that the return of this keystone herbivore will drastically reduce current algal biomass and enable corals to once again dominate. On reefs in St. Thomas, United States Virgin Islands, *Diadema* abundance in shallow waters has greatly increased in recent years. We are beginning to address the impact of their recovery by: 1) running in-situ, recruitment assays with larvae of the hard coral *Porites astreoides* and dominant macroalgal species (*Dictyota menstrualis*, *Lobophora variegata*, *Acanthophora spicifera*, *Halimeda opuntia*) and 2) looking at survival of coral spat on tiles when placed in contact with these same macroalgae with and without *Diadema* present. Tiles from the different treatments and appropriate controls were checked after 14 hr (overnight) and at the end of 6 days. While coral recruitment was significantly impacted by some tested species of macroalgae (*D. menstrualis*), any negative effects associated with the macroalgae, predation or accidental damage was minimal when *Diadema* was able forage over the tiles with attached coral spat. Thus, it appears that, at their present densities, *Diadema* is not detrimental to the survival of this common hard coral species. Our data support the hypothesis that *Diadema* facilitates coral recruitment by removing chemically active species of macroalgae.

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**P1.102** WANG, D.*; NAVA, S. S.; MORENO, L.; MARTINS, E. P.; Indiana University and The Center for the Integrative Study of Animal Behavior, Bloomington; dw3@indiana.edu

**Visual Performance is Lateralized in Male and Female Sceloporus undulatus Lizards**

Behavioral laterality is the specialization of the left or right brain hemisphere in certain behaviors and functions. Many animals exhibit visual laterality and asymmetry during social interactions, foraging, and predator detection, i.e., the left and right eyes are used differentially for different tasks. For example, many animals show a left-eye bias during aggression and territorial contexts. While visual laterality has been shown to occur in many behavioral tasks and responses involving aggression, little is known whether the left and right eyes exhibit differential sensitivity, i.e., can one eye see better than the other? We measured and compared spectral sensitivity to the blue coloration exhibited by male *Sceloporus undulatus* lizards from both the left and right visual fields in adult male and female *S. undulatus* lizards. We found that left and right visual fields differ in spectral sensitivity and present here evidence for sex-specific variation of laterality. Specific results and data will be discussed.

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**P1.109** WARD, W. Timothy*; KRISTAN, Deborah; California State University San Marcos; ward033@csusm.edu

**Tapeworm Co-infection Alters Life History and Distribution of the Nematode Heligmosomoides bakeri**

In nature, most hosts harbor more than one parasite species concurrently. When different parasite species occupy the same site in the host, there may be direct and indirect effects of one parasite on the other. We investigated if an established infection with the bile duct tapeworm (*Rodentoleps microstoma*) influenced life-history (survival, sex ratio) and habitat selection (location along the small intestine) of the nematode *Heligmosomoides bakeri*. Laboratory mice (*Mus musculus*) were infected with either 0 (control), 4 (low-intensity group) or 12 (high-intensity group) *R. microstoma* cysticercoids. At 21 days post-*R. microstoma* infection, the same mice were inoculated with 300 infective stage *H. bakeri* larvae. Mice were euthanized 6 days post-*H. bakeri* infection and the following variables were measured for fourth stage *H. bakeri* larvae: total number of worms, sex ratio, and location of larvae along the small intestine. We also determined the number and mass of *R. microstoma*, bile duct mass, and circulating alkaline phosphatase in mouse plasma. Alkaline phosphatase is elevated during bile duct obstruction associated with liver disease but has not been tested during bile duct obstruction due to parasite infection. We found that, during tapeworm co-infection, 57% fewer *H. bakeri* larvae established (*p < 0.0001*) and larvae were located more distally along the small intestine (*p < 0.0001*) compared to mice with nematode only infection. There was no effect of *R. microstoma* on *H. bakeri* sex ratio (*p = 0.55*). *R. microstoma* infection increased bile duct mass more than two-fold (*p = 0.02*), but there was no change in serum alkaline phosphatase (*p=0.19*), regardless of the number of adult *R. microstoma* (*p=0.34*).

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**P2.144** WALTON, D.B.*; PIRTLE, T.J.; Abilene Christian University; dbw04a@acu.edu

**The Effect of Cyclic Nucleotide Dependent Protein Kinase Activity on Swimming in Clione limacina**

Both serotonin and nitric oxide have been shown to increase swimming speed in reduced preparations of the pteropod mollusk *Clione limacina*. Additionally, isoliquiritigenin, an activator of guanylyl cyclase, has a similar effect as serotonin and nitric oxide in that it enhances swim frequency. On the other hand, forskolin, an activator of adenylyl cyclase, suppresses swimming. These results indicate that cGMP accelerates swimming while cAMP inhibits swimming. We hypothesize that the changes in swim frequency that occur with cGMP and cAMP are the result of their action on cyclic nucleotide dependent protein kinases. To test this hypothesis we applied H-9, an inhibitor of cyclic nucleotide activated kinases. Application of H-9 had a biphasic effect. Initially, within the first minute of application, H-9 increased swim frequency. A complete cessation of swim activity followed this initial enhancement. Furthermore, application of serotonin did not recover H-9 induced inhibition of swim activity. Our results indicate that the initial enhancement of swimming is a consequence of inhibition of cAMP-dependent protein kinase and that the termination of swimming that follows is a consequence of inhibition of cGMP- dependent protein kinase.
P1.75 WASSMER, Gary; Bloomsburg University of Pennsylvania; gwassmer@bloomu.edu
Characterization of a Photoperiodically Regulated Protein from a Woodroach.
The woodroach, Parcoblatta pennsylvaniaica, is one of the few species of
roach that is able to overwinter at subtfreezing temperatures. As winter
approaches, the growth rate of the insects slows and molting ceases.
Laboratory and field studies have shown that this change in post-embryonic
growth rate is photoperiodically regulated, not a direct result of lower
temperature. Other studies have shown that, in parallel with the changes in
growth rate, the concentration of hemolymph proteins is photoperiodically
controlled. Hemolymph concentration increases in response to shortening
daylight. In addition, we see that the types of protein change with
photoperiod. In particular, one hemolymph protein which we have called
DASP (Development Associated Storage Protein) is abundant during long
daylight but unnoticeable when daylight shortens. We believe this protein
to be one in the class of storage proteins in insect hemolymph. This
conclusion is based on several observations that are consistent with the
characteristics of other reported storage proteins: 1) it is very abundant in the
hemolymph, 2) the molecular weight is close to other reported values for
storage protein, 3) the holoprotein is a hexamer, 4) it is not another suspect
apolipophorin, and 5) it is not detectable in the adult male. The results
presented here show further characterization of DASP, including partial
amino acid sequence and suspected homology with other proteins isolated
from insects.

P1.104 WEEDMAN, J.M.; NAVA, S.S.; MARTINS, E.P.; Indiana University and the Center for the Integrative Study of Animal Behavior; jaweedma@indiana.edu
Short-term Environmental Experience Alters the Visual Acuity of Adult Zebrafish.
Visual plasticity is a mechanism by which the visual system is able to change
or adjust in response to the environment. For fish, environmental factors
such as water turbidity, light quality and intensity, and habitat structure can
greatly influence overall performance of visual function. A growing body of
evidence has shown that during early development the fish visual system
can exhibit considerable plasticity and that the adult visual system tends to
be less plastic and fairly fixed in maturity. Here, we tested for plasticity of the
adult visual system. We tested the effects of short-term visual experience on
the visual performance of adult zebrafish (Danio rerio). Specifically, we
measured visual acuity from adult zebrafish, exposed the fish to one of two
visual treatments (complex and simple) for eight days, and finally
re-measured and compared the visual performance from all fish. We found
that while the visual acuity of adult fish that experienced a simple visual
background changed very little, the visual acuity of adult fish that
experienced a complex visual background significantly improved. Specific
results and data will be discussed. Our findings suggest that the adult visual
system is much more plastic than commonly thought and that researchers
interested in the effects of environmental factors on vision related tasks, such
as foraging, predator/prey detection, communication, should take into
consideration the effects of visual plasticity in the adult visual system.

P2.115 WATERS-LINDQUIST, L.G.; WOLCOTT, T.G.; KAMYKOWSKI, D.; NC State Univ., Raleigh, NC State Univ, Raleigh; lindgwen@gmail.com
Seeding red tides: behavioral experiments with Plankton Mimics
How are toxic red tides seeded on the west Florida coast? The dinoflagellate,
Karenia brevis, does not form resting cysts. One hypothesis is that "seed"
populations persist in deep water offshore, are advected onshore by upwelling,
and bloom when they have an ample supply of both light and
nutrients. Robot "Plankon Mimics" are testing whether a simple, biologically
rational behavioral model could keep such a seed population of motile algae
deep, and alive, under realistic field conditions. The model, derived from lab
studies and field distributions, uses a clock-driven diel vertical migration
(DVM), but modulated by in-situ conditions via physiology. The Mimics swim
upward faster when "hungry" for photosyntheate (C) and downward faster
when "hungry" for nutrients (N). The vertical distribution of nutrients near
shore, especially during upwelling, may have several peaks. Offshore it is
very different. Most of the water column is oligotrophic, and cells encounter
significant N only at their DVMs low point when they are in the near-bottom
layer, into which N diffuses from the sediment. In field experiments, Mimics
under "neartheshore" conditions exhibited a DVM with the water surface as its
upper bound, while Mimics under "oligotrophic + near-bottom nutrients"
conditions returned to the bottom on each diel cycle. Mimics in nearshore
conditions filled their C and N pools and "divided" in 3-4 days (typical of
nutrient-replete cultures) while under oligotrophic conditions about half of
them "died" after 10 days without acquiring enough C and N to divide. This
indicates that physiological modulation of DVM could allow deep offshore
populations to persist, albeit with very low rates of increase, at depths from
which they could be moved inshore during upwelling and seed a bloom.

P2.139 WEIGAND, K.L.; DEAROLF, J.L.; Hendrix College, Conway, AR; weigand@hendrix.edu
Prenatal steroids: altering myosin heavy chain isoform expression in guinea pig diaphragm
Glucocorticoid steroids are given to women at risk for preterm delivery to
induce rapid development of the lungs of their fetuses and decrease the risk of
mortality. Because these steroids stimulate cellular differentiation, we
hypothesize that fetal diaphragms exposed to a steroid (treated) will express
less developmental (fetal) and more adult (fast: neonatal, Ila, Ix; slow: I)
myosin heavy chain isoforms than control (sterile water) fetal muscles. To
test these hypotheses, we investigated 2 protocols in guinea pigs. The short
protocol called for 1 round (2 injections, 24 hours apart) of betamethasone
(0.5 mg/kg maternal weight) injections, and the fetal diaphragm samples
were collected at 70% gestation. The long protocol called for 1 round (2
injections, 24 hours apart) of betamethasone injections, and the fetal
diaphragm samples were collected at 85% gestation. The long protocol called for 3 rounds (1
round/week) of injections, and the samples were collected at 85% gestation.
Diaphragm samples from both injection protocols were collected and
extracted using a urea/thiourea sample buffer. SDS-polyacrylamide gel
electrophoresis was used to separate and identify the myosin isoforms (fetal,
neonatal/Ila/Iix and slow) present in these samples. Each gel was silver
stained, dried, and scanned into digital format. Scion Imaging software was
used to quantify the proportion of each isoform relative to the overall myosin
content of the sample. There was no significant difference in the myosin
expression of either control or treated fetal diaphragms in the short protocol.
However, there was significantly more fetal myosin in the muscles of the
untreated fetuses ([T] 20.10 +/- 1.23%; [C] 12.73 +/- 2.12%) and less adult fast
myosin ([T] 62.42 +/- 2.24%; [C] 87.12 +/- 1.46%) in the long protocol. Since
fetal myosin has a slower contraction speed than adult proteins, the delay in
development will reduce the ability of the diaphragm to respond to ventilatory
challenges.
P1.107 WEINER, S.A*; BAUTISTA, G.M.; SANDERS, D.B.; RYAN, J.; WOODS, W.A.; STARKS, P.T.; Tufts University, Morehouse College, Northern Essex Community College; susan.weiner@tufts.edu

Reproductive roles in Polistes dominulus: The cost of maintaining ovarian development

Polistes paper wasps are an important model system for studying the evolution of eusociality, because the castes are totipotent, and as such, workers can reproduce. However, workers and subordinate foundresses reproduce little if at all on most nests and generally have ovaries that are much less developed than those of dominant or solitary foundresses. In order to add to our understanding of why wasps would not maintain fully developed ovaries, we measured the energetic cost of maintaining reproductive development in workers and in dominant, subordinate and solitary foundresses. The resting metabolic rate (RMR) of each wasp was found by measuring CO$_2$ production and ovarian development was determined by measuring average egg. Egg length was correlated strongly with RMR, indicating that maintaining ovaries is energetically costly. In addition, egg length relative to headcap width was also correlated with mass-specific RMR, indicating that it is more energetically costly for smaller animals (such as workers and subordinates) to maintain highly developed ovaries. Furthermore, the slope of RMR on egg length was higher for workers than for foundresses, suggesting that it was more difficult for workers to maintain larger ovaries. These costs may partially explain why workers and subordinates do not maintain fully developed ovaries.

P1.184 WHITE, Joshua P.*; ROBERTSON, Ian C.; Boise State University; white@boisestate.edu

Seed predation on slickspot peppergrass, Lepidium papilliferum (Brassicaceae), by the Owyhee harvester ant, Pogonomyrmex salinus (Hymenoptera: Formicidae)

Owyhee harvester ants (Pogonomyrmex salinus) actively remove fruits and seeds from slickspot peppergrass (Lepidium papilliferum), a rare mustard endemic to southwest Idaho. We conducted a study to establish whether P. salinus is the only major seed predator of L. papilliferum, and to determine the importance of seed predation as a source of offspring mortality for this plant. We monitored a total of 15 L. papilliferum beyond the foraging distance of P. salinus and found no evidence of seed predation. We then conducted an experiment to determine the extent of seed predation for plants located within the foraging distance of P. salinus. A total of 13 pairs of plants were included; each pair was located within 10 m of an ant colony. One plant per pair was assigned as the treatment and the other as the control. Treatment plants were enclosed to bar any ant access. We visited the plants weekly; counting the number of attached fruits, depredated fruits, and naturally dehisced fruits on random inflorescences of each plant in the pair. Plants accessible to ants experienced a direct loss of at least 40% of its fruit and seed, while plants with no ant access suffered very little seed loss (ANOVA F$_{1,20}$ = 67.60 p < 0.0001). Likewise, ants removed over 90% of seeds placed on the ground, compared to almost no loss when ant access was denied (Mann-Whitney U test N = 20 p < 0.0001). One hundred percent of seeds collected by ants (N = 100) were returned to the nests and presumably eaten. A search of 30 midden piles revealed large amounts of empty fruit husks but no intact seeds. We conclude that harvester ants are the main seed predators of L. papilliferum, and possibly an important source of offspring mortality for this rare plant.

P2.140 WERNER, Bianca J*; ROOT, Robert G; Lafayette College; wernerb@lafayette.edu

Does diffusion matter? Assessing the importance of diffusion in phosphagen metabolism for a fast start

The Phospho-Creatine Shuttle is a buffering system that stores and transports energy for muscle contractions, among other metabolic processes. Phosphocreatine (denoted PCr), is a phosphagen that serves a dual purpose in cells: 1) it acts as an energy reserve, providing large amounts of energy within short time periods by maintaining a high ATP/ADP concentration ratio in the A band of myofibrils; and 2) it transports energy to myofibrils from mitochondria located adjacent to I bands of the myofibrils. PCr is synthesized in mitochondria, then diffuses into myofibrils. Is this PCr diffusion fast enough to contribute significantly to maintenance of high ATP concentration in fully contracting muscles, considering fast starts occur in 10-100 milliseconds? Constructing a mathematical model using parameters derived from published results of other’s experiments, we find that diffusing PCr does materially assist in buffering ATP.
**P1.151 WIDDER, P.D.; Virginia Tech; widder@vt.edu**

**Early testosterone exposure in amphibian eggs: no effects on development, growth, or behavior**

In a variety of egg-laying taxa, steroid hormones have been found to be maternally transferred to the yolk of eggs. Furthermore, additional studies, especially in birds, have found that early exposure of the developing embryo to testosterone can influence development, growth, and behavior. I recently verified that amphibian eggs also contain steroid hormones at laying and that the amounts of testosterone vary by female; however, the influence of this early exposure to testosterone on amphibian development, growth, and behavior is not known. I collected four clutches of freshly laid Rana sylvatica (Wood frog) eggs and exposed each of them to three different levels of testosterone for 48 hours. At the end of 48 hours, I sampled a subset of eggs and, using a radioimmunoassay, verified that the egg hormone levels were elevated, yet remained within physiological limits. The remaining eggs were raised to hatching, and time-to and stage-at hatching were recorded, as well as several morphological variables. After one month of development, at Gosner (1960) stages 26-27, I measured tadpole activity level, fast start behavior, and again assessed tadpole morphological variables. Finally, after two months of development (Gosner stages 30-36), morphology was assessed a third time. Throughout the experiment, changes in development, growth, or behavior were never observed relative to testosterone treatments; however, significant clutch effects were observed in most measures. Thus, the significance of maternally-derived testosterone in amphibian eggs remains unclear.

**P1.40 WIJESENA, N.**; KUMBUREGAMA, N.S.; WIKRAMANAYAKE, A.; University of Miami; naveen@bio.miami.edu

**Investigating the role of Wnt/PCP signaling in the evolution of embryonic polarity in metazoans**

Evolution of mechanisms that established developmental polarity in ancient animal embryos was likely prerequisite for germ layer evolution, but these mechanisms are unknown. Extensive use of Wnt/Planar Cell Polarity (PCP) signaling to generate diverse embryonic polarity events hints that PCP signaling may have had a primitive role in evolution of embryonic polarity. To begin to gain insight into this idea we initiated studies to functionally characterize the core PCP genes in Nematostella vectensis, and identified NvStrabismus as a localized maternal mRNA. Since Strabismus signaling is known to antagonize Wnt/β-catenin signaling in bilaterians, we asked if NvStrabismus has a role in restricting Wnt/β-catenin signaling to endoderm, thereby mediating germ layer segregation. We will present experimental results showing that NvStrabismus signaling modulates Wnt/β-catenin signaling in Nematostella. These findings raise the possibility that interaction between Wnt/β-catenin and Wnt/PCP pathways played a role in establishing the embryonic polarity that led to germ layer segregation.

**P3.59 WIKTOROWICZ CONROY, A*; DOUBE, M; SHEFELBINE, S; HUTCHINSON, JR; The Royal Veterinary College, Structure and Motion Laboratory, University of London; awiktrowicz@rvc.ac.uk**

**Scaling of the appendicular skeleton: CT scan-based analysis of whole-bone geometry for clades Proboscidea and Felidae**

Most studies of long bone scaling have focused on external measurements alone, especially for midshaft diameter or circumference and length, and generally have focused on proximal limb elements only, avoiding the metapodials and limb girdles for example. Here we demonstrate a technique using computed tomography (CT) scans to obtain internal and external geometry and quantify scaling of bone geometry throughout the entire bone, for all major bones from the girdles to the metapodials. We examine Proboscidea (elephants), including some data for fossil mammals and dwarf elephants, to quantify interspecific and intraspecific scaling at giant body size and near-columnar limb posture. We also examine Felidae (cats) to test whether whole-bone geometry changes in order to maintain skeletal stresses across size, as it has been demonstrated that posture does not change markedly with size in this clade. Our results refine and expand on previous studies of these clades, showing that near-isometric scaling predominates within Proboscidea (but weak positive allometry when viewed intraspecifically), versus slight positive allometry within Felidae. Our integrative analysis reinforces the notions that (1) different clades can have quite unique scaling relationships, (2) bone stresses may differentially be maintained by a combination of changes in length, diameter and moments of area, as well as potentially regional bone density, (3) bone strengths or safety factors may be strongly influenced by regions that are weaker than the midshaft.

**P2.157 WILLIAMS, C.M.*; SINCLAIR, B.J.; University of Western Ontario, London, Ontario; cwilli67@uwo.ca**

**The effects of continuous and discontinuous gas exchange cycles on CO2 and H2O production**

When investigating insects that show a variety of patterns of respiration, it can be very difficult to objectively choose a representative portion of a respiration trace to evaluate. *Erynnis propertius* (Lepidoptera:Hesperidae) overwinters in diapause as a caterpillar, during which time they show both continuous respiration and discontinuous gas exchange cycles (DGC). This provides an opportunity to investigate the effects of sample selection and pattern of respiration on measured CO2 and H2O production and estimated metabolism. CO2 and H2O production by diapausing *E. propertius* caterpillars (n=20) was recorded for four hours at 1 and 8 C after a three hour acclimation period, and all analyzable sections of data were compared. At 8 C, 40.5 % of individuals showed solely continuous respiration and 47.6 % solely DGC; but 11.9 % of individuals switched between patterns during the four hour period. In individuals that had more than one complete discontinuous cycle, CO2 production did not change over time; however H2O loss declined throughout the trace. There was no effect of mode of respiration (continuous or DGC) on CO2 production, but H2O loss was significantly lower during DGC. All individuals showed continuous respiration at 1 C, which we attribute to the onset of chill coma. We discuss these results with regards to the evolution of DGC and suggest some guidelines for determining standard metabolic rate in insects that exhibit a combination of gas exchange patterns.
A comparative study of MIH signaling in the brachyuran molting gland

Molt inhibiting hormone (MIH) regulates the production of ecdysteroids by the crustacean molting gland (Y-organ or YO). Ecdysteroids are hormones that regulate the physiological process of molting. Upon binding to a membrane receptor in the YO, MIH induces a second messenger cascade involving cyclic nucleotides (cAMP and cGMP), which inhibit ecdysteroidogenesis. Previous studies have used pharmacological agonists in an attempt to mimic the effects of MIH on YO ecdysteroid secretion in vitro. Adenylyl cyclase activators, cAMP and cGMP analogs, and NO-donors inhibit ecdysteroidogenesis in the YO. Moreover, YOs express NO synthase (NOS) and GC-I. These data suggest that NOS and GC-I are components of the MIH signaling pathway. The purpose of this study was to determine if antagonists of the putative signaling components block MIH action in YOs in vitro. This analysis involves two species of brachyuran crab, Geocarcinus lateralis and Carcinus maenas. The effects of adenylyl cyclase, NOS, or GC-I antagonists on MIH-dependent YO inhibition will be reported. Supported by NSF (IBN-0342982 and IOS-0745224).

Nonlinear growth patterns in tadpoles based on parental call length

Females in many species prefer to mate with males bearing showier ornaments or more energetic displays. Yet, these preferences are not always linear: bigger is not always better. Female gray treefrogs (Hyla versicolor) show a nonlinear mating preference, strongly preferring males with long or medium call lengths, while avoiding males producing very short calls. According to the good genes hypothesis of sexual selection, females choose mates in order to obtain high quality genes for their offspring. Genes for high larval growth rates should help offspring to avoid environmental stresses and predation and should, therefore, provide a better chance to survive. We hypothesize that the nonlinear mating preference of female gray treefrogs reflects nonlinear benefits of mate choice. Specifically, we predict that the developmental rate of offspring mirrors the nonlinear preference function for call duration exhibited by females, in that the progeny of males producing long- and medium-length calls will develop more rapidly than the progeny of males producing short calls. To test these predictions, we used artificial fertilizations to cross twenty-seven males with long, medium, and short call lengths with six females. Five hundred and forty tadpoles were raised individually in the laboratory. During development, the tadpoles were subjected to high and low food treatments to test effects of environment on their development. We weighed the tadpoles at three weeks of age and at metamorphosis. Preliminary results indicate that progeny of short-duration callers grew better than progeny of long- and medium-length callers in both food treatments. Food treatment affected growth for progeny of all parental call lengths. The nonlinear growth function does not mirror that of the female preference.

Nonlinear growth patterns in tadpoles based on parental call length

P2.120 WILLIAMS, S. C.*; MCBRAYER, L.D.; Georgia Southern Univ., Statesboro; swilliams@georgiasouthern.edu
Sources and Consequences of Intraspecific Variation in the Movement Patterns of the Ambush Foraging Lizard Sceloporus woodi

Movement patterns as they relate to foraging behavior have played an important role in the understanding of lizard ecology and their evolutionary history. Surprisingly little attention has been given to the proximate factors that influence movement patterns and foraging behavior within a species. While movement patterns are often related to foraging, individuals also move for other reasons. If females remain stationary and are patchily distributed (as is the case in ambush foragers), breeding males may move more to acquire mates than they would to forage. Such an increase in movement by males could alter their growth, foraging patterns, diets, or at the very least, skew estimates of their true foraging effort. In 2007, preliminary data suggested that the ambush foraging lizard Sceloporus woodi showed a trend towards sexual dimorphism in movement patterns during the late breeding season and early post breeding seasons. The current study hypothesizes that male and female S. woodi differ in both movement and foraging patterns within the breeding season and between the breeding and post-breeding seasons. This study summarizes a full year of focal observations on male and female lizards from early breeding season to late post breeding season. Standard movement variables (percent time moving and moves per minute) will be presented and compared with additional metrics of foraging behavior (e.g. rate of foraging attempts, attacks while stationary). Lag sequential analysis will also be used to determine whether differences in movement patterns correspond to differences in the manner in which prey is acquired.

Nonlinear growth patterns in tadpoles based on parental call length

P2.126A WILSON, R S*; NIEHAUS, A C; WHITE, J; RASMUSSEN, A; KUCHEL, L.; Univ. of Queensland; r.wilson@uq.edu.au
Using video documentary-making to enhance learning in large first year Biology classes

Engaging Biology students in course material can be notoriously challenging in large first year undergraduate classes. We trialed the use of video documentary-making as a vehicle for enhancing the engagement and participation of students in a first year Ecology course with 590 students. Students were given the task of making a 5-7 minute documentary about a topic of important local or national environmental significance and communicating the science underlying the issue. Students worked in groups of 4 students and were given access to a library of 50 Sony digital video cameras and a large computer lab fitted with iMac computers. We found students spent an order of magnitude more time on their video assignment than their writing assignments of equal assessment weight. In addition, we found students directly engaged with professional scientists during the making of their videos and each group interviewed at least one scientist for their documentary. This trial clearly emphasized the benefits of utilizing novel technologies for motivating students across broad science and non-science majors to take a greater interest in the natural sciences and explore the science underlying environmental issues.
**P3.52** WILSON, M.P.; SIMS, E.L.; SCHMITT, D.; DUKE UNIVERSITY; megan.pruette@duke.edu

**Ankle flexion and foot clearance during flexed hip and knee walking**

Modern humans walk with a relatively stiff gait that minimizes the muscular work done to move the lower limbs and the center of mass. Nonhuman primates, and perhaps our earliest ancestors, use a form of bipedalism in which the hip and knee are held in a deeply flexed position and the center of mass undergoes very little vertical oscillation. This study follow up on other studies examining loading and energetic costs during these compliant walking gaits by examining the effects of increased hip and knee flexion on the dorsiflexion of the ankle and the toe clearance in adult humans. During a flexed hip and flexed knee gait, our subjects demonstrated an average increase in dorsiflexion of 16 degrees during stance phase and 13 degrees during swing phase, as well as reduced toe clearance compared to a normal walking style. Increased dorsiflexion requires more muscular effort to stabilize the ankle during both stance and swing phase, and may explain differences in distal tibia orientation and muscle markings on bones between apes, early humans, and modern humans. The decreased foot clearance during flexed hip and knee gait suggests that the changes at the hip, knee, and ankle were still not enough to bring about the same foot clearance as normal walking. This, in combination with the fact that our ancestors had unusually long feet and particularly long toes, suggests that they would have had to use other mechanisms such as toe flexion to clear the substrate. These data provide novel insight into the nature and costs of locomotion in bipedal primates and the earliest human ancestors.

**P3.19** WINDSOR, P.J.; LEYS, S.P.; Univ. of Alberta; pwindsor@ualberta.ca

**Multipolar sponges: a putative role for Wnt signaling in the most basal metazoans**

The Wnt signaling pathways play important roles in multiple developmental mechanisms: oral-aboral patterning in cnidarians, tissue differentiation and cell migration in *C. elegans*, segment and limb polarity in *Drosophila*, and body polarity and patterning in vertebrates. Lithium chloride has classically been used in experimental embryology as a tool for understanding axial specification in animals ranging from cnidarians to vertebrates. Treatment with lithium mimics the Wnt signal, creating a constitutively active signal to transcribe downstream targets such as Hox genes. As a result, normal development of body polarity can be interrupted as seen in *Hydra* and *Xenopus*. We sought to understand the role of the Wnt pathway in a sponge using lithium treatment, as more familiar molecular tools such as RNAi are as yet unavailable for these animals. High doses of lithium caused sponges to lose essential traits in the normal functioning of a juvenile or adult individual, including the canal system that is responsible for current intake and thus feeding. Threshold doses of lithium produced sponges with a disorganized canal system with multiple excorrent openings (oscula) in 95% of individuals (n=21). Sponge polarity is determined mainly by the flow of water in and out of its canal system, so having multiple oscula indicates a multiplication of the main body axis. Wnt pathway components have only recently been identified within the sponge genome and no functional studies have been carried out to date. Future work will include further isolation and analysis of conserved Wnt pathway components including frizzled, beta-catenin and gsk-3beta, as well as attempting new methods for functional characterisation.

**P1.78** WOLFF, S.W.; ELY, T.E.; CHANTAROJWONG, T.M.; HELBING, C.C.; PROPPER, C.R.; Northern Arizona University, University of Victoria; sw245@nau.edu

**Effects of 4-tert-octylphenol on amphibian metamorphosis**

Many chemicals released into the environment impact physiological function. These compounds are often referred to as endocrine disrupting compounds (EDCs). Some EDCs impact thyroid hormone function. Because metamorphosis in amphibians is under direct regulation by thyroid hormone, this developmental process provides a strong endpoint for evaluation of a compounds potential to impact thyroid-mediated developmental measures. We examined thyroid hormone-related development. Our results demonstrate that exposure to OP at environmentally relevant levels does not impact thyroid-mediated developmental measures. Future studies will examine how OP impacts development of the gonads.

**P1.119** WONG, G.K.; CHABOT, C.C.; Quinnipiac University, Plymouth State University; Gene.Wong@quinnipiac.edu

**The Bioscience Education Network (BEN) Digital Library Portal and Collaborative**

The Internet provides ready access to a large volume of material that can be used for teaching purposes. Digital libraries in particular offer a vast repository of easily accessible resources for use by teachers at all audience levels. However, in searching for specific learning items, it is often difficult to separate the "wheat from the chaff" and find accurate and useful information and techniques for the classroom or laboratory. In the biological sciences, the Bioscience Education Network (BEN) portal provides easily searchable access to digital libraries maintained by more than 25 different professional organizations (including SICB). This peer-reviewed content includes images, animations, and activities that have been tested in the laboratory or classroom and been found to be effective in helping students understand important biological principles. While over 11,000 peer-reviewed resources covering 77 biological sciences topics are available, the BEN portal allows the user to easily narrow down the content using not only the typical search attributes such as keywords or title, but also by discipline (subject), pedagogical use, resource type, audience (education levels), author, or author institution. Organization members of the BEN Collaborative also accept materials for inclusion in the digital library through a peer-review process. The BEN Collaborative was established in 1999 by the American Association for the Advancement of Science (AAAS) with 11 other professional societies and coalitions. In 2005, the BEN Collaborative was selected as the National Science Digital Library (NSDL) Pathway for Biological Sciences education. An overview of the BEN portal and its advantages in preparing course materials will be illustrated in this poster session.
Neonatal mammals, because of their increased metabolic rates, breathe faster than their adult counterparts. For example, neonatal guinea pigs take 123 breaths per minute, a rate 40% higher than the adult ventilatory rate (87 breaths/minute). These increased breathing rates suggest that neonatal ventilatory muscles have greater proportions of fast-twitch fibers than adult muscles. But, to support neonatal breathing rates, the fast-twitch fibers also need to have adult contractile abilities. To test these hypotheses, the fiber-type profiles and myosin heavy chain (MHC) expression patterns of neonatal and adult guinea pig diaphragms were determined. We expect that the muscles of neonates will contain 40% more fast-twitch fibers than the diaphragms of adults, based on the difference in their ventilatory rates. To have adult contractile abilities, neonatal muscles will also express only adult MHCs. Muscle samples were collected from 1-day-old neonatal and adult (49- and 59-days gestation) guinea pigs and prepared for histochemistry or SDS-polyacrylamide gel electrophoresis. The neonatal diaphragm contained 87.5% (±0.67) fast-twitch fibers, approximately 40% more fast-twitch fibers than found in the adult muscle (63.7% ± 2.5). These results support the hypothesis that neonatal breathing muscles contain greater proportions of fast-twitch fibers than adult muscles. They also fit our expectation for the neonatal guinea pig diaphragm. Our findings suggest that the differences in ventilatory rates between neonatal mammals and their adult counterparts can be used to predict the fiber-type profiles of neonatal breathing muscles, if the adult profile is known. Preliminary analyses of the myosin gels show only adult MHCs being expressed in the neonatal diaphragms, indicating that these muscles have adult contractile abilities.

Assessing Students Beliefs and Knowledge Regarding Animal Research

Although much biomedical and physiological research involves animals or animal tissues, the use of animals in the classroom is decreasing. Hence, students pursuing careers in biomedical and physiological research may be unprepared for the ethical and regulatory issues involved. Undergraduate students knowledge and opinions regarding animal research were assessed with a survey. Subjects consisted of students enrolled in a physiology course and students enrolled in a required biology seminar. Both groups possessed many common misconceptions about animal research. For example, none understood the difference between animal rights and animal welfare, and most were unaware of the extensive animal research regulations. I argue that it is important for biology teachers, especially physiology teachers, to discuss these issues with students. I propose several teaching strategies that can be used in physiology courses to educate students about animal research. I also describe how the effectiveness of these tools can be assessed.

Plasticity of gender-biased behavior in the Julidochromis cichlid

Most monogamous cichlids exhibit gender-biased social and parental behavior. Conventionally, males are larger and are more aggressive and territorial than females, while females provide the majority of direct parental care. This is the case in the African cichlid Julidochromis transcriptus. However, in the closely related Julidochromis marlieri, females are larger and are more aggressive sex. To determine the socio-environmental influences on this gender-bias reversal, we experimentally manipulated the relative sizes of monogamous pairs in both species. Then, using the freeware program Jwatcher, aggressive behavior was quantified continuously during 10-minute observations using a universal ethogram for all species and sexes. Aggression was measured both towards conspecifics on the other side of a clear divider and towards heterospecifics introduced to the tank. Males were found to be more aggressive overall in J.transcriptus, while females were more aggressive in J.marlieri. However, size-reversed pairs of both species were found to be behaviorally reversed in respect to aggression: female J.transcriptus and male J.marlieri showed more aggression than their mates. This work defines an interesting model with which to address the molecular and hormonal basis of gender-roles and gender-biased behavior. As cichlid fish enter the "post-genomic" era, it becomes possible to address these questions on a genome wide basis.

Statistical modeling of real time PCR data for membrane transporter expression in Manduca sexta larvae.

We examined the relationship between midgut transporter expression and larval instar in the tobacco hawkmoth Manduca sexta, testing the hypothesis that increased expression of midgut transporters compensates for reduced surface area to volume ratio as larvae grow. We used real-time PCR to investigate expression of two transporters: masBSC, a cation-chloride cotransporter, and KAAAT, a potassium amino acid cotransporter. masBSC mRNA was detected in all tested tissues including foregut, midgut, hindgut, salivary gland, and Malpighian tubule, with no significant differences in expression level between tissues. KAAAT mRNA was also detected in all tested tissues with approximately 500 fold higher expression in middle and posterior midgut than other tissues. Midgut expression of both genes was increased by 2 to 9 fold in the fifth compared to fourth instar larvae. We compared standard parametric methods (t tests and ANOVA procedures) with Mann-Whitney-Wilcoxon and Kruskal-Wallis tests, competing nonparametric procedures. With the exception of a few cases, the parametric and nonparametric tests yielded similar test statistics resulting in no change in significance. Ansari-Bradley tests showed no significant differences in the variability between instars. Sensitivity analyses showed that outliers did not have a significant effect on our inferences. For masBSC, multiple linear regression models explained approximately 89 percent of the variability in Ct. Similar models were fit and analyzed for KAAAT, using Ct and delta Ct as response variables. The multiple regression model for KAAAT explains approximately 96 percent of the variability in delta Ct, with significant instar, tissue, and interaction effects. (This project was supported by Kenyon College.)
P1.99 WORTHAM, J.L.*; MCRAE, L.K; University of Tampa; jwortham@ut.edu
A Comparison of Grooming Behaviors in Smasher and Speaker Mantis Shrimp

Grooming behaviors are frequent actions performed by crustaceans. However, there is much variation in how many grooming appendages are used and what body regions are cleaned. Mantis shrimp are marine benthic crustaceans that groom their bodies, using one pair of grooming appendages. Generally, mantis shrimp can be divided into two morphologically and ecologically different groups, smashers and speakers. Speakers are usually dull in color, have poorer vision, live in murky waters, and are active at night. In contrast, smashers are normally bright in color, have detailed vision, live in clear waters, and are active in the day. Both groups live in a burrow, rather it be self-excavated in the sand or in a pre-existing cavity in rock. Grooming behaviors, in terms of frequency, region groomed, and length of groomed action, were observed in 17 different species (15 smashers; 2 speakers) of mantis shrimp across 112 individuals. Differences in areas groomed and grooming frequencies were compared between species and sexes based on group, type of burrow, and time of day they are active. Data analyses infers that 1) both groups groom their bodies frequently, 2) regions of the body groomed vary between groups, and 3) grooming behaviors do vary between groups that live in different ecological habitats.

P3.198 WRIGHT, M.L.*; SWINSTROM, K.; CALDWELL, R.L.; Univ. of California, Berkeley, Santa Rosa Junior College; seadragon83@gmail.com
A phylogenetic examination of social monogamy in stomatopod crustaceans

The Lysiosquillidea, a super-family of stomatopod crustaceans, includes several socially monogamous genera, providing an unique system to study the evolution of monogamy. Social monogamy is maintained by different mechanisms within these genera. In the family Lysiosquillidae, energetic costs of making burrows, predation risks, and spousal feeding behaviors all likely contribute to the maintenance of monogamy. In contrast, selection for biparental care maintains monogamy in some species in the Nannosquillidae. Using comparative phylogenetic methods, I examined the evolution of social monogamy in the Lysiosquilloidea. To test the monophyly of the Lysiosquilloidea and provide more internal resolution of the clade for future studies, I used the mitochondrial loci 16S and 12S, as well as a morphological matrix (Ahyong 2000), to create phylogenies using maximum parsimony and Bayesian tree-building methods. The monophyly of Lysiosquilloidea was well-supported in the analyses. The internal branching of the four families was consistent in both analyses, indicating that Nannosquillidae and Tetrasquillidae are sister clades, and that Lysiosquillidae is sister to all other Lysiosquilloidea. I then reconstructed the evolution of social monogamy on the Bayesian tree (MK1) and the parsimony trees (MP). Social monogamy has originated at least three times in stomatopod crustaceans, suggesting that further phylogenetic comparative studies on the correlations between monogamy, environment, and biparental care in this group will be fruitful. The relationships between superfamilies, as classified by Ahyong (2000, 2001), were not stable in this analysis and should be re-examined using more characters, especially molecular and genomic data.

P2.148 WU, Wen-Hui*; HILL, J; COOPER, Robin; university of KY; wuwenhu2@gmail.com
Influence of nicotine on physiology, development and behavior of Drosophila melanogaster

The effects of nicotine (NIC) on physiology, development and behavior of Drosophila were examined. The effects of nicotine, in a dose-dependent manner, in relation to larval body wall and mouth hook movements were quantified. Acute exposure to 0.1M reduced eating behavior substantial within 10 minutes with less of a reduction at 0.01M with no significant effect at 0.001M. Whereas a 24 Hr exposure showed some effects at all concentrations but in a dose dependent manner. Body wall movements were also substantially reduced at 0.1M with less of an effect at lower concentrations. The death rate of larval from 1st instar to pupation was enhanced in a dose-dependant manner 0.001M to 0.1M. In larvae, NIC also enhances the CNS motor unit drive in segmental roots. This enhancement is enhanced in a dose-dependant manner, in relation to larval body wall and mouth hook movements were quantified. Acute exposure to 0.1M reduced eating behavior substantial within 10 minutes with less of a reduction at 0.01M with no significant effect at 0.001M. Whereas a 24 Hr exposure showed some effects at all concentrations but in a dose dependent manner. Body wall movements were also substantially reduced at 0.1M with less of an effect at lower concentrations. The death rate of larval from 1st instar to pupation was enhanced in a dose-dependant manner 0.001M to 0.1M. In larvae, NIC also enhances the CNS motor unit drive in segmental roots. This enhancement is blocked by mecamylamine an antagonist to nicotinic receptors. We are currently performing learning assays on larval and adult Drosophila that have been exposed to various concentrations of nicotine and the nicotinic receptor blockers. The results allow one to analyze how sensory perception is brought about on the cellular and molecular level and the role of the nicotinic receptors in this system. To assess the effects of nicotine directly on the larval heart, the exposed heart was monitored without the CNS intact. [Support: G. Ribble Fellowship in Biology at Univ. KY (JH)]
Nitric oxide (NO) a signaling molecule, produce in situ by nitric oxide synthase regulate metamorphosis in some invertebrates as well as ascidians. NO has both, apoptotic and antiapoptotic properties mediated via activation of caspases and guanyl cyclase respectively. NO is also involved in cellular dynamics of regressing tail of anuran tadpoles. The objectives of the present study were to investigate a) cell specific localization for NOS using immunohistochemistry (IHS) b) if thyroid hormones control gene expression for NOS isoforms and c) changes in NO sensitive guanyl cyclase in intestine and tail during different stages of metamorphosis of *Xenopus laevis* tadpoles. Immunostaining shows that, both NOS I and III are expressed in cytoplasm of epithelium and brush border of the intestine just before remodeling begins, and in epidermis of tail before regression begins. Though, there was stronger expression for NOS I than NOS III in both the tissues. NOS II was not expressed at all in either tissue. Increased apoptosis during critical period of intestinal remodeling and tail regression is associated with high expression of NOS I. RT-PCR results show that during spontaneous metamorphosis, when endogenous T3 levels are at peak, (as well as following exogenous T3 treatment) there is down regulation of NOSI in intestine. However, in tail there is up regulation of NOS I at the same stage (beginning of tail regression). Absence of guanylyl cyclase in either tissue indicates lack of NO signaling via formation of cGMP, but it may be via caspasases favoring apoptosis. In conclusion, NOS(c) might be playing a crucial role as an endogenous regulator of NO signaling in intestinal remodeling and tail regression of anuran tadpoles promoting apoptosis in a tissue and/or cell specific fashion.
P.3.13 YOUSSGF, S. K.; FISCHER-DROWOS, S.; MORRIS, R. W.; VATNICK, I.; NAGENGAST, A. A; Widener University, Chester, PA; syoussef@mail.widener.edu

**The Effect of Perfluorooctane Sulfonate Exposure on Gene Expression and WBC in Mouse**

Perfluorooctane sulfonate (PFOS) and similar organofluorides have been used in applications such as clothing, carpets and fast food containers by companies such as 3M for over fifty years. PFOS bioaccumulates and significant levels have been found in mammals, fish, and birds. In laboratory studies, rats exposed to PFOS showed a dose-dependent decrease in bodyweight, increase in corticosterone and norepinephrine, and a decrease in reproductive ability. In humans, PFOS has a serum half-life of 8.5 years and has been detected in people of all ages in many places around the world. In vitro studies suggest PFOS exposure may have an immunosuppressant effect. In order to explore the health effects of PFOS exposure, we measured the force and work required to contract the elastic structures in 25 animals. These results suggest that PFOS has an immunosuppressant effect and verifies previous in vitro studies. We are currently investigating gene expression levels in the 3ng/kg/d and 5ng/kg/d group mice compared to control mice by microarray analysis. Because factory workers in PFOS-producing plants had a higher rate of bladder cancer, we are extracting RNA from the bladders of control and exposed mice to probe microarray chips containing 25,000 genes. We expect to find variation in expression of genes associated with bladder cancer, particularly fgfr3, hras, rb1, tp53, tsc1.

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**Elastic energy storage and the mantis shrimps powerful predatory strike**

Storage of elastic energy is key to increasing the power output of jumping and predatory strikes. One notable example is the energy stored prior to the extremely rapid raptorial strikes in mantis shrimp (Stomatopoda). Several structures have been proposed as the site of elastic energy storage, including a leaf-spring shaped structure (meral-V) and a saddle-shaped structure (saddle) located on the lateral and dorsal sides of the merus segment of the raptorial appendage, respectively. The goals of this study were to determine the location of elastic energy storage, characterize the elastic behavior, and to examine the scaling of energy storage across a range of body sizes. Using a materials testing apparatus, we directly measured the force and work required to contract the elastic structures in 25 Gonodactylus falcatus individuals. We found that the force needed to contract the appendage exhibits a positive and linear correlation with the distance it has been contracted. Thus, this system can be modeled as a simple Hookean spring with a spring constant of 58.3 N.mm⁻¹ (10.6). The overall force required to compress the spring is positively correlated with body length and appendage size, but the spring constant is not correlated with body size. The primary site of elastic energy storage is in the meral-V rather than the saddle. However, removal of the saddle causes the system to exhibit greater fatigue and dramatically increased the probability of failure. In conclusion, the meral-V provides the elastic energy storage to power the strike, and the saddle most likely confers dynamic stability. Uniformity of the spring constant suggests that larger individuals simply compress a similar spring over greater distances to power their larger appendages.

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**Effects of winter temperature on the energetics and hydration of lizards**

Global climate change has the potential to increase winter temperatures, resulting in higher winter metabolic rates of ectotherms, and thus, altering energetic requirements for survival. To test the impacts of winter temperature on survival of ectotherms, we subjected side-blotched lizards (Uta stansburiana) to relatively warm (8 C) or cold (1 C) winter conditions for up to 149 days. As in previous experiments, animals in the cold survived longer than those in warm winter conditions. As lizards died naturally we quantified neutral lipids using HPTLC of the liver, fat body, and tail as well as carcass moisture content. We also euthanized lizards as controls during the experiment. Results indicate that animals that died naturally lost significantly more mass than controls with a marginal temperature trend (warm treatment lost more mass than cold). However, organ masses were not related to temperature or type of death (natural/control). Furthermore, percentages of triacylglycerol (TG) in fat bodies and tails were not different in animals exposed to warm or cold temperature, but animals in the cold had higher levels of liver TG than animals in the warm treatment. Thus, only liver TG appears to be affected by winter temperature. Yet, there was no difference in liver TG between natural death and control animals suggesting that lack of TG was not the cause of death. When we compared moisture content of animals we found that those exposed to a warm winter contained less water at death than those exposed to the cold. Furthermore, animals that died naturally contained significantly less moisture than controls. These results suggest that the primary effects of winter temperature in these lizards are on hydration rather than energetics and that water loss is the main cause of winter mortality.
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**Linear Modeling of Tracking Behavior in Weakly Electric Fish**

Weakly electric knifefish swim to maintain their relative position within a moving refuge. Dynamical system models provide a language for describing such systems. When applicable, linear dynamical systems models admit a particularly powerful suite of analyses that facilitates the generation of novel hypotheses. Here, we present a methodology for assessing the regimes for which linear dynamical systems approximate experimentally measured sensorimotor performance. Using this methodology, we tested the linearity hypothesis for refuge tracking in several species of weakly electric knifefish (*Eigenmannia virescens*, *Apteronotus leptorhynchos*, *Apteronotus albifrons*) for refuge movements limited to approximately 2 Hz oscillation frequency and 15 cm’s maximum velocity. We measured the system output (fish position and velocity) to an array of input signals (refuge trajectories), including pure sinusoids, sums of sinusoids, and band-limited noise. Tools for data analysis included ARMAX (autoregressive moving average with exogenous input) modeling and coherence analysis. ARMAX modeling provided a way to statistically quantify the linear dynamics of tracking responses using model parameters. Coherence analysis, commonly used for characterizing neural activity, provided a way to assess frequency regimes in which tracking behavior was linear. The results were consistent with the linearity hypothesis proposed in Cowan and Fortune (2007).

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**A new species of Phrynobatrachus (Anura: Phrynobatrachidae) endemic to Mount Oku, Cameroon, with discussion of puddle frog biogeography across the Cameroon Volcanic Line**

A new miniature species of puddle frog of the genus *Phrynobatrachus* restricted to Mt. Oku in the Republic of Cameroon is diagnosed on the basis of morphological characters and molecular data. Unlike all other miniature *Phrynobatrachus* (snout-vent length < 20 mm), males of this species have unique ventral coloration characterized by a black throat with a dark brown belly, while the proximal portions of the forelimbs are cream in color. Minute spines cover the venter in males, often appearing as white asperities. The description of this new species supports the significance of this montane ecoregion as a biodiversity hotspot for anurans. Patterns of species description of this new species supports the significance of this montane ecoregion as a biodiversity hotspot for anurans. Patterns of species divergence among eleven species of *Phrynobatrachus* from Cameroon were determined using phylogenetic analyses of mitochondrial DNA sequence data from 12S rRNA, valine-tRNA, and 16S rRNA. A clad endemic to the mountains of Western Cameroon and Eastern Nigeria, part of the geologic rift zone termed the Cameroon Volcanic Line, supports the view that montane regions have acted as centers of speciation. Bioko Island (Equatorial Guinea), located 32 km off the coast of Cameroon, is populated by three different lowland *Phrynobatrachus* species from the mainland. Two of these species reach submontane elevations on Bioko Island (up to 1200-1300 m) when compared to only lowland populations on mainland Cameroon.

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**Seasonal variation in innate and adaptive immunity of adult red-eared sliders, Trachemys scripta**

Previous studies on the reptile immune system have shown that aspects of the innate and adaptive immune response exhibit seasonal variation that is specific. Sex may play a role in seasonal variation in red-eared slider turtles *Trachemys scripta*, as male and females have different patterns of resource allocation across the seasons. The purpose of this study was to examine the effects of season on various branches of the immune system of adult red-eared sliders. Blood samples were taken from male and female turtles during the active season which occurs from late April until October. A bactericidal assay that measures the killing capacity of plasma against bacteria was used to measure cell-mediated immunity. Total immunoglobulin levels will be determined by ELISA as a measure of humoral immunity. Results indicate a significant effect of season on both killing capacity and the DTH response, Killing capacity peaked in late May and continued into early June before dropping off dramatically in August and September. The DTH response peaked in late May before dropping off to a consistent level for the remainder of the active season. There was no significant correlation between an individual’s killing capacity and the DTH response. No significant effect of sex on the killing capacity and the DTH response was found, therefore differences in resource allocation between the sexes are most likely not driving the observed seasonal variation in immune function. Our results suggest that there is a complex relationship where the change in season affects each branch of the immune system differently.
Differential response of AMP activated protein kinase (AMPK) and HSP70 to temperature stress in a gastropod

*Nucella lapillus* is a common gastropod in rocky intertidal habitats of the North Atlantic. Populations are polymorphic for shell color, with light-colored shells predominating on warmer, wave-protected shores and dark-colored shells limited primarily to cooler, wave-exposed shores. Color morphs exhibit differential heating during thermal stress, with darker shells attaining higher body temperatures than lighter shells. These results suggest that heat stress may determine field distribution patterns. However, there is currently little evidence of physiological consequences of thermal stress in these organisms. Following the guiding hypothesis that heat stress leads to cellular energy depletion, we explored whether AMPK is activated by heat stress, and compared this response in both color morphs to the expression of a heat shock protein (Hsp70). Hsp70 is widely used as an indicator of thermal stress, but it can also be induced by other stressors. AMPK is a central energy regulator in mammals that activates ATP-generating catabolic pathways and inactivates ATP-consuming anabolic pathways. Though AMPK is highly conserved during evolution, it has rarely been studied in invertebrates. Two color morphs of snails were tethered to a rock, exposed to varying levels of heat stress (within the range known to occur regularly in the field), and sampled at three time points. AMPK activity increased earlier and at lower temperatures than HSP, and was higher in dark vs. light color morphs. Furthermore, AMPK activity had decreased by the onset of HSP expression. Our results suggest that AMPK may be an early indicator of thermal stress in gastropods, and a useful tool for studying thermal stress in the field.

Effects of hypoxia and sedimentary naphthalene on the activity of *N*-acetyl-beta-glucosaminidase in the epidermis of the brown shrimp, *Penaeus aztecus*

The brown shrimp, *Penaeus aztecus*, is subject to dual stresses of environmental hypoxia and contamination of polycyclic aromatic hydrocarbons (PAHs) in the northern Gulf of Mexico. The effects of hypoxia and sedimentary naphthalene, administered alone and in combination, on epidermal activity of *N*-acetyl-beta-glucosaminidase (NAG) were investigated. It was found that hypoxia and sedimentary naphthalene, when given together, significantly inhibited epidermal NAG activity. Since NAG activity is a biomarker for ecdysteroid signaling in the epidermis, the inhibitory effects of simultaneous exposure to hypoxia and sedimentary naphthalene suggest that these two environmental stressors together can have adverse effects on molting of the brown shrimp. The results of this study also show that sedimentary naphthalene potentiates hypoxia effects on epidermal NAG activity.