UCA College of Natural Sciences and Mathematics

21st Annual Student Research Symposium

HPER Gymnasium

April 17, 2015
2 - 4 P.M.

Welcome from the Dean

Welcome to the 21st Annual College of Natural Sciences and Mathematics Student Research Symposium. Today you will see some of the research that is being undertaken by students in the College. This year we have research from many fields - there are 76 posters involving 110 students mentored by 54 different faculty members. We encourage you to drop by the HPER Center to join us in celebrating the accomplishments of our students.

I look forward to seeing you there.

Cordially,

Stephen R. Addison

Stephen R. Addison, Dean
College of Natural Sciences and Mathematics

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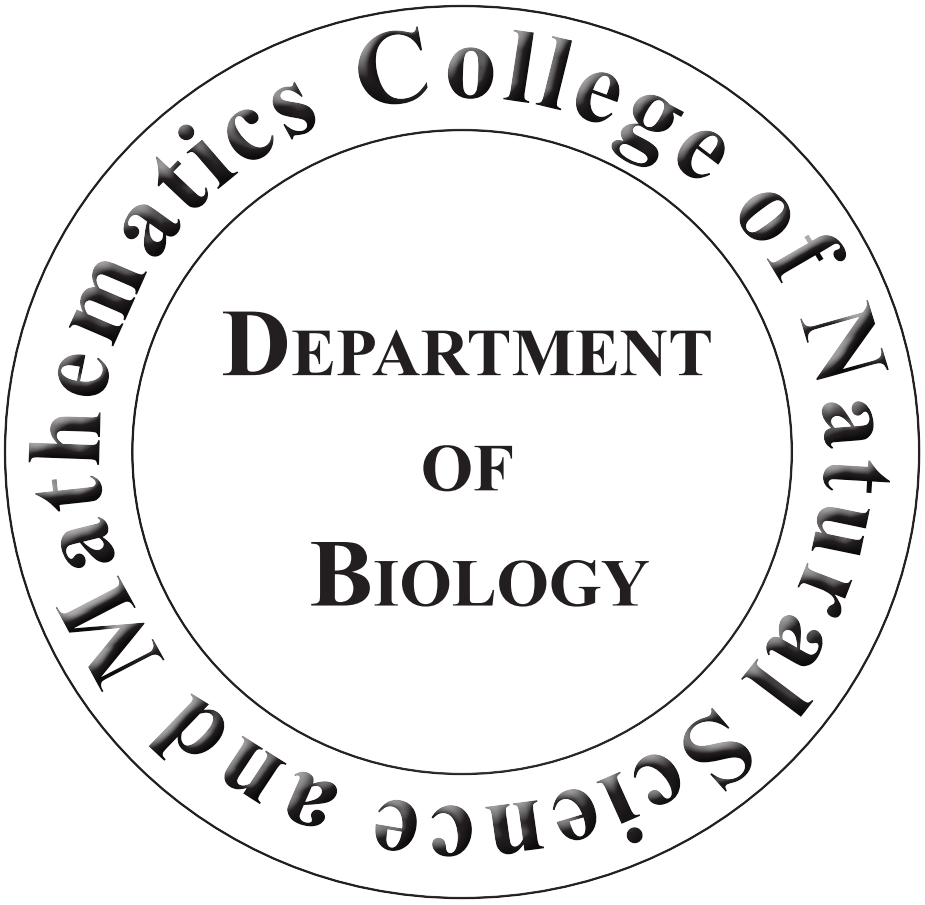
College of Natural Science and Mathematics
DEPARTMENT
OF
BIOLOGY

Isolation by Drainage: Connectivity of Salamander Populations Occupying Headwater Streams

Amber Anderson
Faculty mentor: Don Shepard

Dispersal of individuals and their genes is fundamental to evolution, population demography, and community assembly. Geographical and environmental heterogeneity can have profound effects on the genetic structure of a species across its range. In stream-associated species, population connectivity is often determined by stream network structure and drainage divides can act as barriers to gene flow among populations in different basins. A reduction of gene flow among populations in different drainage basins is predicted to increase genetic divergence among populations and may ultimately lead to speciation if there is a long-term lack of gene flow. Many salamanders are restricted to microhabitats associated with aquatic systems and this is thought to explain the high levels of genetic structure frequently observed across small spatial scales. My research examines how microevolutionary processes in headwater stream populations of salamanders generate genetic structure and drive divergence between populations in different drainage basins. The Caddo Mountains in southwestern Arkansas are headwaters for the Cossatot and Little Missouri rivers. In this region, these headwaters are separated by a few hundred meters, but their river systems do not join until the confluence of the Red and Black rivers ~400 km to the south. We used DNA sequences from 14 populations of the Caddo Mountain Salamander, *Plethodon caddoensis*, spanning the divide between the Cossatot and Little Missouri rivers to test if genetic structure is explained by stream drainage basin. Consistent with our prediction, we found that stream drainage explained a significant amount of the genetic variation among populations independent of geographic distance. Future work will examine gene flow within and between headwater streams spanning this drainage divide in the Ouachita Dusky Salamander, *Desmognathus brimleyorum,* which should show an even stronger relationship than *P. caddoensis* because of its more aquatic habits.

Does Environmental Context Mediate Stream Biological Response to Anthropogenic Impacts?

Lucy Baker
Faculty Mentors: Sally Entrekin and Michelle Evans-White

Central Arkansas streams support clean water for downstream drinking, swimming, fishing, and biological diversity. Stream catchments were once mostly forested land and are now used for natural gas extraction and crops. Stream catchments vary in their physical sensitivity to land alterations. For example, greater soil erosive potential, less forest, and greater slope, could predict more sediment erosion that alters biological communities following disturbances. We calculated sensitivity and ranked each stream catchment (Hydraulic Unit Code 12 (HUC12, n=211)) in the Arkoma Shale Basin. Streams that ranked in the lower 25th percentile were considered least sensitive and were 29% of the total HUC12s in the study area. Those catchments at or above the 75th percentile were considered most sensitive and included 34% of all catchments in the Arkoma Basin. Our objective is to compare the rate of biological change in either more or less sensitive catchment across a gradient of unconventional natural gas extraction or row crop agriculture. Benthic macroinvertebrates will be sampled in ten streams in all four treatment combinations. We predict the rate of biological change will be greatest in naturally sensitive catchments along a gradient of gas well activity. We will investigate site selection and statistical design in our poster.

Reproductive Biology of a Catadromous Striped Mullet in the Lower Arkansas River

Kristin Caserta
Faculty Mentors: Ginny and Reid Adams

We are studying a population of striped mullet (*Mugil cephalus*) approximately 940 km from the Gulf of Mexico in the Lower Arkansas River, hypothesized to exhibit catadromous behavior, spawning in the Gulf from December to February. Our objective is to study reproductive biology (gonadal development) of fish while in the lower Arkansas system to further understand the life history strategy of this population. Fish were collected in the main channel downstream of Wilbur D. Mills Dam (Dam #2) and at a nearby oxbow, Morgan Point Bendway Lake, where fish are semi-isolated and impeded from migrating to spawn. Fish were collected in October and December 2014, and length, weight, age, gonadosomatic index (GSI), and gonadal stage were determined. Sex ratio was highly skewed towards females. In the oxbow lake mullet, mean female GSI (n= 40) increased from 8.8% to 21.9%, and male (n= 6) GSI increased from 8.1% to 24.3%. Female (n=27) and male (n= 3) GSI in the channel mullet were similar to the oxbow lake mullet in October, but remained low in December. Oxbow lake mullet appear to be following a gonadal development pattern similar to marine residents, while channel mullet reflect outmigration by spawners and/or capture of fish that will not spawn this cycle.

Knockdown of Telomerase in Human Cancer Cell Lines Using shRNAs

Ethan M Clement
Faculty Mentor: Calin Marian

Cellular senescence denotes the biological aging of the cell due in part to the shortening of telomeres. In somatic cells, during normal chromosomal replication, the lagging DNA strand is not continuously replicated like the leading strand. This phenomenon, known as the end replication problem, leads to gradual telomere shortening after each cell division. In some normal actively proliferating tissues (such as skin, gut lining, hair follicle, etc.) as well as majority of cancer cells the end replication problem is solved by telomerase, a specialized enzyme that has the capacity to add telomere repeats to the end of chromosomes. Telomerase has two components, the RNA template (hTR) and the reverse transcriptase (hTERT). The re-activation of telomerase has been widely regarded as playing a vital role in the immortality of cancerous cells. Recently, telomerase inhibitor drugs have been shown to induce critical telomere shortening in various cancer types. Our major interest is to investigate the impact of these critically short telomeres on cancer cell functions, specifically on self-renewal pathways mediated by OCT4 and NANOG transcription factors. In order to avoid potential drug off-target effects we will generate critically short telomeres by knocking down telomerase activity in three prostate cancer cell lines using shRNAs that target the hTERT subunit of telomerase.

Phenotypic and Genetic Integration of the Cranium of Diamondback Watersnakes (*Nerodia rhombifer*)

Ian T. Clifton
Faculty Mentor: Matthew E. Gifford

Organisms occurring in different areas are exposed to different environmental pressures often causing variation in some trait or suite of traits. These variations tend to be advantageous to the organism in some way. Throughout Arkansas we find diamondback watersnakes (*Nerodia rhombifer*) in natural areas as well as fish farms. These snakes are frequently found in large densities on these fish farms because of the high food abundance. Fish farms provide an ideal system for the study of morphological variation because the size of fish available varies from farm to farm. Because snakes are gape-limited predators they can only consume prey items that are small enough to be swallowed whole. Therefore, snakes with large heads should be able to swallow larger prey than snakes with smaller heads. Given enough time it is possible that different populations would diverge in morphological traits in such a way that head size is best suited to the prey that is available to them. However, for this to happen the variation must be heritable. To determine if the observed variation is genetic we can take measurements on a mother and her naive offspring and use this information to estimate heritability.

The Influence of Ammonium Polyphosphate Fertilizer on the Metal-Glyphosate Complexation Activity of Roundup®

Michelle Ellington-Burns
Faculty Mentor: Laurie W. Warren

Over the years, glyphosate has been considered a relatively safe alternative to other post-emergent herbicides due to its ability to bind tightly to the soil in many cases, reducing phytotoxicity and mobility. Studies have shown that glyphosate can reduce the toxicity of heavy metals by reducing bioavailability of the metal. The ability of glyphosate to form chelated complexes with cations can be affected by several factors, such as pH levels and the availability of binding sites. Phosphorus and/or phosphates can compete with the herbicide for binding sites on cations and can significantly increase the leaching of glyphosate from the soil. This study focuses on the chelation of metal-glyphosate complexes in the presence of ammonium polyphosphate fertilizer as an indicator of availability and potential toxicity to non-target organisms. P-NMR analysis was used to study the competitive binding tendencies between glyphosate, polyphosphates and metals. Because glyphosate is prevalent in many water systems (including aquifers), the aquatic toxicity tests were conducted with *Daphnia magna*, a commonly used test organism due to its sensitivity to environmental toxicants. The toxicity of copper (Cu) on the test organisms was used as an indicator of the chelating action of glyphosate and its potential for reactivation in the presence of ammonium polyphosphate fertilizer. Results from this study suggest that RoundUp®, at low concentrations (1.25ppm) can significantly reduce the toxicity of copper at 360 ppb, which is over four times the LC_{50} concentration determined during this study (Cu LC_{50} 80ppb) and over two times greater than concentrations that resulted in 100% mortality (LC_{100} 160ppb). Additionally, P-NMR analysis indicates that competition binding behavior does occur between glyphosate and polyphosphates in the presence of metals.

The Effect of Science Fair Participation on Students' End of Course Biology Exam Scores

Hailey Ellison
Faculty Mentor: Mark W. Bland

Arkansas public high schools administer the End of Course Biology Exam (EOC) to thousands of 10th grade students every spring, as mandated by the 'No Child Left Behind Act' of 2001. This exam covers several broad themes within biology, including molecules and cells, heredity and evolution, classification and the diversity of life, ecology and behavioral relationships, and the nature of science. Students' scores range from 0 to 513, and are used to determine general student performance in these categories: below basic, basic, proficient, or advanced levels. We hypothesized that students who participate in academic extracurricular activities would have higher EOC scores than students who do not participate in such programs. One such program is the Science Fair, which is an annual event in Arkansas and is open to all Arkansas schools. Nine schools of similar sizes and student demographics from different regions of the state, some of which participate in the Science Fair and others that do not, were identified. EOC scores from these schools were obtained from the Arkansas Department of Education. A comparison of student performance on the EOC between these two groups is presented, and implications are discussed.

Distribution Modeling and Ecological Divergence of Arkansas Queen Snakes, *Regina septemvittata*

Derek Filipek
Faculty Mentor: Don Shepard

Allopatric speciation, that is the origin of new species caused by geographic isolation of populations and an absence of gene flow, is generally considered the primary mode by which new species arise. Geographic isolation can be caused by physical barriers such as rivers or mountains or by environmental changes that make intervening areas uninhabitable for a species. The queen snake (*Regina septemvittata*) is a medium-sized, semi-aquatic snake that ranges throughout much of eastern North America. A disjunct population of *R. septemvittata* occurs in northern Arkansas, which is >400 km separated from the species' eastern range and represents the only *R. septemvittata* population west of the Mississippi River. Given their geographic isolation, Arkansas *R. septemvittata* may be genetically and ecologically distinct from *R. septemvittata* east of the Mississippi River and the two range segments may represent different species. To evaluate predictions of this hypothesis, we used GIS-based species distribution modeling techniques to address the following questions: 1) Are Arkansas *R. septemvittata* separated from eastern *R. septemvittata* by unsuitable habitat?, 2) Was the distribution of *R. septemvittata* more contiguous in the past and is the current fragmented range a consequence of climatic changes associated with Pleistocene glacial cycles?, and 3) Do Arkansas *R. septemvittata* occupy a different ecological niche than eastern *R. septemvittata*. Future research includes comparing DNA sequences of *R. septemvittata* from across their entire distribution to determine if Arkansas populations are genetically divergent and represent a distinct evolutionary lineage.

What's Your Life History Strategy?: Response of Orangethroat Darters (*Etheostoma spectabile*) to Natural Gas Development on the Fayetteville Shale Gas Play

Brittany Furtado
Faculty Mentor: Ginny Adams

Natural gas extraction from unconventional sources is a practice that has grown exponentially in Arkansas over the last 15 years due to advances in technologies like hydraulic fracturing. Natural gas development (NGD) on the Fayetteville Shale alone has occurred at a rate of 700-900 new wells drilled/year. The impact of these practices on aquatic systems includes increases in fine sediments and increasing concentrations of nickel and lead with rapid gas well development, as well as contamination of surface waters from leaks and spills. Previous studies have also found biotic responses to NGD including decreases in sensitive taxa and simple lithophilic spawners, and increases in tolerant taxa like green sunfish (*Lepomis cyanellus*). Plastic responses including alteration of sex ratios, mean clutch size, and overall reproductive investment (measured as GSI) have been observed in populations of redfin darters (*Etheostoma whipplei*) in response to higher levels of NGD.
For this study reproductive characteristics of eight populations of orangethroat darters (*Etheostoma spectabile*) exposed to varying levels of natural gas development were analyzed. Fishes were collected once a month between March-May 2012 at eight sites representing a gradient of gas well densities. Data including GSI, mean clutch size, mean oocyte diameter, mean oocyte mass, and sex ratio will be presented.

Investigating the Plant Genes that are Differentially Expressed During Nls (Nodule-Like Structures) Formation in Rice and Studying the Colonization Pattern of These Structures by the Rice Endophyte, *Azorhizobium caulinodans*

Alexander Howell, Hamilton Newhart, Ryan Hiltenbrand, Hannah Posey
Faculty Mentor: Arijit Mukherjee

Plants are limited in ways they can acquire nitrogen from the environment. This has caused an unsustainable dependence on fertilizers with negative economic and environmental effects. Taking advantage of existing plant-microbe symbioses is a promising alternative for the over dependence on fertilizers. For instance, legumes (soybean, alfalfa, peas) can form a beneficial symbiotic association with rhizobia. In this process, the rhizobia fix atmospheric nitrogen for its host plant inside specialized root structures, *nodules*. Unfortunately, this symbiosis is species-specific and is restricted to legumes. Therefore, important agronomic crops like rice, corn, wheat etc. are still heavily dependent on fertilizers for their productivity. Studies have revealed plant hormones are crucial in establishment of legume-rhizobial symbiosis. For instance, in *Medicago truncatula,* auxins have been shown to induce nodule-like structures (NLS) in the absence of bacteria. Interestingly, rhizobia can colonize the NLS and fix nitrogen. Furthermore, plant hormones can induce similar NLS structures in cereals such as rice, wheat and maize. These NLS can be colonized by nitrogen fixing endophytes, and aid significantly in nitrogen acquisition. Unfortunately, we have no knowledge of the genetic mechanisms governing this NLS formation in cereals. By identifying the underlying transcriptomic responses during hormone-induced NLS formation, we can further our understanding of this biological process. We had previously performed an RNASeq experiment in rice to identify differentially regulated genes during NLS formation. We are currently validating the expression pattern of selected genes via RT-PCR. In addition, we are studying the colonization pattern of these NLS by the nitrogen-fixing endophyte, *Azorhizobium caulinodans*. We optimized the experimental conditions and confirmed that Azorhizobium colonizes rice roots and the NLS structures vusing histochemical assays (X-gal staining) and plate counts. We are currently preparing samples for an RNASeq experiment to determine the host plant genes that get differentially expressed during colonization by Azorhizobium.

Extent and Trends of Lead Poisoning in Raptors Of Arkansas

Deana Hughes
Faculty Mentor: Victoria McDonald

Avian lead toxicity from bullet fragments has been documented in waterfowl since the 1950s and more recently in birds of prey, or raptors, which acquire lead contamination from their prey and scavenged food. My project will assess the extent, trends, and sub-lethal levels of lead in Arkansas raptors. Currently in Arkansas, bald eagles (Haliaeetus leucocephalus) are the only raptors tested for lead. Testing all species of raptors for lead poisoning would give better insight into the extent and geographical scope of lead exposure to birds in Arkansas. Arkansas has wildlife rehabilitation facilities throughout the state. Several of them have offered to have all birds admitted tested for lead. Historical data indicating lead levels in bald eagles are also available. Analyzing the toxicity of chemicals in top predators and scavengers is a good indicator of overall ecosystem health, because any declines in these populations will have ripple effects down all the trophic levels in the community. My specific research questions are as follows: What is the extent of lead poisoning in Arkansas and is there a certain geographical region of the state that shows higher lead toxicity? Is there a seasonality toxicity levels based on hunting season/ winter? Are gender, bird age-classes, and different species of raptors differentially impacted by lead levels in the environment? We expect to see statewide exposure to lead, however, we predict higher toxicity in areas near human hunting camps. We also predict more cases of lead-exposed birds in the winter months when live prey is scarce for the raptors, and when recreational hunting by humans is more prevalent. To date, I have obtained partial data on three bald eagles tested since January 2015. My research results from analyzed blood samples will begin to come in during summer 2015. The results will be used to help wildlife decision-makers educate the public regarding lead poisoning in birds.

Regulation of the Sarcoplasmic Reticulum Calcium ATPase pump (SERCA) by 17-β estradiol in mice

Quinton Kaufman
Faculty Mentor: Brent Hill

In today's society cardiovascular diseases remain one of the leading causes of death in the United States and it is expected that 40 % of the Population will be effected by some form of cardio vascular disease by the year 2030. In females, menopause decreases gonadal estrogen levels circulating in the bloodstream. Many calcium regulating proteins are influenced by estrogen, thus this decrease in circulating estrogen causes an increased risk for heart disease in females. One of the proteins regulated by estrogen is the SERCA 2 protein family. SERCA stands for Sarco/Endoplasmic Reticulum Calcium ATPase pump. This group of proteins is responsible for the intake of calcium from the cytosol of the cell into the sarcoplasmic reticulum. Previously in our lab we have proved that estrogen is responsible for the upregulation of the SERCA2 family of proteins. This project will be a continuation of that by studying what happens to SERCA2 in the absence of circulating estrogen as well as the determination of which protein of the SERCA2 family is influenced most by the decrease in estrogen. The SERCA 2 family mainly consists of two isoforms of SERCA, 2a and 2b, during most experiments involving SERCA there is no distinction made between SERCA 2a and 2b they are both probed for at the same time. My hypothesis for this experiment is that both SERCA 2a and 2b will decrease equally in expression as circulating estrogen is lowered

Using Sanger Sequencing to Resolve Targeted Complex Regions for Flowering Plant Chloroplast Genomes

Brittanie Kling
Faculty Mentor: Richard D. Noyes

In flowering plants, the chloroplast genome is circular and has about 150 kb of DNA. A chloroplast genome consists of four regions: a large single copy region (LSC), small single copy region (SSC), and two inverted repeats (IRa and IRb) that separate the LSC and SSC. Next generation sequencing (using Miseq technology) of entire chloroplast genomes is now possible, which uses massive parallel sequencing and assembly of short reads (150 or 300 bp) into the genome. However, short read assembly may not be effective at sequencing complex intergenic regions within genomes. In our chloroplast genome sequences for goldenrod (*Solidago)* and aster (*Symphyotrichum)*, we determined that the 4 junctions (regions #1-#4) and 10 other complex regions (#5-#14) required validation. To validate these regions, we used PCR amplification and Sanger sequencing to provide an independent and robust sequence of the regions. The resulting forward and reverse sequences were assembled into contigs and compared with the Miseq genome sequence. In general, Sanger sequences agreed with our Miseq assemblies; however, a few corrections needed to be made. For *Solidago*, comparisons showed that 13 out of 14 regions had no discrepancies, and region #11 required one 48 base pair insertion into our original Miseq assembly. For *Symphyotrichum*, 6 out of 14 regions required corrections, including two ~200 bp insertions, three ~10 bp insertions, and one 5 bp deletion.

E-Cadherin Expression in Prostate Cancer Cells is Modulated by Adhesion Status

John A. Martindale
Faculty Mentor: Calin O. Marian

Imetelstat is currently being evaluated in clinical trials as a treatment against some of the most lethal forms of cancer. Imetelstat displays a two-pronged attack on cancer cells. It acts as a competitive inhibitor of telomerase, a cornerstone enzyme in cancer cells; telomerase inhibition leads to progressive telomere shortening and ultimately apoptotic death. A secondary attribute of imetelstat is the morphological affects it has on cells rendering them incapable of adhesion to a substrate. This lack of adhesion has been hypothesized to prevent the transition of cancerous cells from benign to metastatic. Though the telomerase inhibitor function of imetelstat was well studied, the significance of adhesion loss is largely unknown. This process must be fully understood before imetelstat can be approved as an anti-cancer drug.

Some studies have been conducted on the loss of adhesion phenomenon to establish a relationship between imetelstat and specific cytoskeleton components. A recent study suggested a link between the loss of adhesion and E-cadherin, a transmembrane glycoprotein that plays an important role in cell to cell adhesion. This study determined that treatment with imetelstat correlated with a down-regulation of E-cadherin. However, E-cadherin expression may change as a result of lack of attachment to the substrate. Through our testing we hope to determine whether the down-regulation of E-cadherin is a direct result of the drug or simply a secondary response to growth in suspension. By performing tests which analyze E-cadherin levels in three prostate cancer cell lines grown in suspension we hope of establishing a mechanism by which lack of adhesion takes place.

Effects of Population Dynamics and Hormones on Titillation Behaviors of Melanistic and Non-Melanistic Freshwater Turtle, *Trachemys scripta*

Lori H. Monday
Faculty Mentor: William B. Cash

Titillation has been described as an excitatory courtship behavior consisting of a series of stereotyped movements whereby a male turtle will extend his forelimbs parallel to the head of a female and vibrate his foreclaws near or against her eyes. This classic description of titillation has led to research assumptions that it is strictly a ritualistic courtship display especially in the *Trachemys scripta*, red-eared slider turtle. If titillation is a strict courtship behavior, it should occur most often during mating season, when reproductive hormones peak, between two sexually mature individuals of the opposite sex and of the same species. However, there is no empirical evidence to support this assumption, while there are published data that contradict it. There is an ontogenetic shift in titillation behavior and melanism in red-eared sliders that may be a response to similar challenges with different strategies depending on various social and environmental contexts.

There are positive correlations between melanism and body size, aggression, and testosterone, while there is a negative correlation between melanism and titillation. This leads to a causal relationship between melanism (a byproduct of hormone variation) and courtship strategy. The physiological responses will be quantified by measuring corticosterone and testosterone concentrations prior to and after behavioral trials. In order to elucidate the true function of titillation, we must evaluate the response of turtles receiving the signals in differing population structures. I will quantify the duration and frequency of titillation behavior to investigate the importance and function of the behavior in courtship and successful reproduction of red-eared slider turtles.

A Safe and Thrifty Approach to Silver Staining Ciliates

Taylor Newman and Taylor Tarbutton
Faculty Mentor: Ben Waggoner

Ciliates belong to a phylum of invertebrates known as Alveolata, aptly named for the flattened vesicles—alveoli—located just under the plasma membrane. As their name implies, ciliates are completely covered with rows of cilia, which are anchored to the cell via basal bodies. Oddly enough, upon flushing the organisms with silver, the basal bodies and silverline system absorb the metal, allowing visibility of anatomical structures that may otherwise be invisible under a light microscope. The patterns of the ciliature are species-specific, and, thus, the silver impregnation procedure allows for precise identification of different species of ciliates. The species-specific results of this protocol allow students to make meaningful observations about unique characteristics of various ciliates. Our goal was to modify an existing silver staining protocol (which called for the use of hazardous chemicals, such as picric acid) to make it safer and more cost- and resource-efficient for secondary and post-secondary laboratory settings. This was accomplished by replacing dangerous chemicals with commercial photographic developer. Our procedure could easily be implemented into any classroom and is valuable to high school campuses that may not have access to state-of-the-art technology.

Characterization of Gym Microbes

Duy Nguyen
Faculty Mentor: Benjamin Rowley

Methicillin-resistant *Staphylococcus aureas* (MRSA) has been identified as an emerging threat to the general population. Multidrug resistant strains of the bacterium have been isolated from healthy adults. Risk factors for health care-associated MRSA (HA-MRSA) infections included extended hospitalization along with undergoing invasive procedures. Cases involving community-associated MRSA (CA-MRSA) occur in healthy people unexposed to a hospital setting. Skin abrasions can allow CA-MRSA distribution to happen more readily, with individuals in athletic settings at a higher risk. A gymnasium is an area with many individuals sharing machines and during peak hours cleaning of the machines after every user is not feasible. CA-MRSA, along with other bacterial pathogens, can infect individuals in a situation like this and without preventive measures in place, the risk of an outbreak increases. Therefore, proper assessment of current equipment cleaning methods implemented in a gym should be tested for effectiveness against representative bacterium from four general groups (Gram positive and negative coccus and bacillus). The goal of this study is to determine to what degree current cleaning methods are efficient, specifically cleaning solution and physical cleaning methods effects on general bacterial types isolated from the gym.

Estrogen Induces Coronary Arterial Dilation via Downregulation of Voltage-gated Ca^{2+} Channels

Edouard Niyonsaba[1], Mohamed Idrissa Moussa[1], Robin J. Dalton[1]
Faculty Mentors: Brent J. F. Hill[1], Nancy J. Rusch[2]
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[2]Pharmacology & Toxicology, University of Arkansas for Medical Sciences, Little Rock, AR

Gender studies have suggested that the female sex protects against abnormal vascular tone. Our lab has shown that estrogen (E2) can downregulate voltage-gated L-type Ca^{2+} channels (VGCCs) to prevent excessive vasoconstriction. The aim of this study is to determine the mechanisms associated with this E2-induced downregulation. The right coronary artery was obtained from hearts of female pigs. The right coronary artery was sectioned into longitudinal strips (Western blots, real-time PCR) or rings (isometric tension) and incubated for 24 hrs in 1nM E2 or EtOH (E2 solvent). The role of the endothelium was evaluated by removing the endothelium of the artery with a toothpick before the 24 hr incubation period. E2 decreased the expression of pore-forming α_{1c} subunit of the VGCC by 35%, but did not affect the mRNA encoding of the α_{1c} subunit. This decrease was not affected by the presence of endothelium. Isometric contractions were also measured to the VGCC agonist, FPL64176, in endothelial intact and denuded rings. Although E2 decreased the FPL41176 contraction by 50%, the presence of endothelium had not effect. To determine the role of estrogen receptors (ER), the arterial strips were incubated with either an E2 α/β antagonist (ICI 182,780), or a G-protein-coupled ER antagonist (G-15). Using western blots, only ICI 182, 780 prevented the E2-induced decrease in the α_{1c} subunit expression. Overall, our result suggest that E2 posttranscriptionally downregulates VGCCs via the activation of ER α/β; the downregulation is endothelium-independent.
Support: Grant #P20 GM103429-11.

Exploring the Use of Isotropic Fractionation in the Nine-Banded Armadillo

John Patterson, Bethany Verkamp, Lindsey Heflin
Faculty Mentor: Jeff Padberg

In order to gain insight into the constraints upon and factors affecting mammalian brain organization, one must look at many mammalian lineages. To date, however, much of the focus has been on two mammalian superclades—Euarchontoglires (e.g., primates, rodents) and Laurasiatheria (e.g., felines). We propose to examine the brain of the nine-banded armadillo, a member of superclade Xenarthra, using state-of-the-art neuroanatomical methods. Quantitative neuroanatomy, usually performed using unbiased stereology is time consuming, however a newly employed technique, the isotropic fractionator method (IF), has recently been used to rapidly quantify numbers of neurons in different animals, including humans. Our group has been working on learning this technique in order to adapt it for use in the nine-banded armadillo.

In addition to neuroanatomical investigations, it is important to determine whether our animals are carriers for *M. leprae* the bacterium that causes Hansen's disease. We routinely test samples from our animals using polymerase chain reaction (PCR). We modified our protocol in order to more efficiently determine the status of our animals by using ear samples. We performed PCR runs on six tissue samples from armadillos we currently have in our lab. In these runs we tried different temperatures for denaturation and annealing and different times for annealing and extension steps. We changed steps to PCR protocols in a range from the typical denaturing, annealing and extension steps to match that of another lab that tests for leprosy as well that add longer annealing and extension steps before starting the cyclic steps (Donoghue, 2001). We found that using a higher annealing temperature, 60°C, helps clear away a lot of residual "ghost bands" we had at our lower temperature runs of 52-53°C. Our future goal for this project is to have a revised protocol that provides a cleaner PCR banding pattern from ear samples.

Seasonal Fluctuations in Testosterone and Estradiol in the Ouachita Map Turtle, *Graptemys ouachitensis*

Luke Pearson
Faculty Mentor: William B. Cash

Animal conservation has become increasingly important in the fight to preserve species diversity and richness. However, efficient conservation strategies can only be implemented with sufficient life history and physiological knowledge of the organism. *Graptemys* is the most specious genera of freshwater turtle in the United States, yet is one of the least studied. On the Arkansas River, I captured *Graptemys ouachitensis* in baited three-and four-ring hoop nets and basking traps. Blood samples were acquired within ten minutes of capture. Monthly (September 2013 – November 2014) testosterone and estradiol concentrations of sexually mature male (n = 115) and female turtles (n = 26), respectively, were measured using enzyme-linked immunosorbent assays (ELISA). Testosterone concentrations varied seasonally, with the reproductive season (September 2013 and 2014, and October 2013) having significantly higher concentrations compared to the non-reproductive season (May – July). Testosterone concentrations did not differ from the 2013 reproductive season to the 2014 reproductive season. Because of the low numbers of sexually mature females captured, estradiol concentrations did not vary seasonally. Due to the cautious nature of large females and the differing habitat preferences between females and males, low female sample size is an obstacle for research conducted with *Graptemys* species. By learning more about the life history and physiology of these understudied freshwater turtles, more effective conservation strategies can be implemented to protect the diminishing population numbers during important times of the year (mating and nesting seasons).

In Vivo Regulation of β1, 2, 3, & 4 Subunits of Ca_L Channels in Response to Ovariectomy and Estrogen Replacement Therapy in Mice

Krystal Pham
Faculty Mentor: Brent Hill

17β-estradiol (E2), the primary female sex hormone, functions as a vasodilator and plays a significant role in maintaining vascular tone via voltage-gated L-type calcium channel (Ca_L) regulation. The intracellular component of Ca_L, the beta subunit ($Ca_v\beta$) is essential in maintaining the gating properties of these calcium channels through regulation of various cell signaling molecules (G proteins, kinases, GTPases, etc.). In postmenopausal women, E2 levels decline and susceptibility to cardiovascular disease (CVD) increases. Furthermore, recent studies demonstrate various detrimental effects in $Ca_v\beta$ knockout models towards cardiovascular health in postmenopausal women. Therefore, the purpose of our study is to understand the mechanisms of Ca_L, specifically the beta-subunit isoforms 1-4, in maintaining healthy arterial blood pressure. Mice will be menopause-induced via ovariectomy, sacrificed 4-weeks post-surgery, and aortas will be excised and analyzed. This study intends to measure protein level and mRNA expression of each beta subunit in mice aortas via western blot and qRT-PCR analysis, respectively. Additionally, we plan to examine the restorative effects of hormone replacement therapy to β subunit regulation in ovariectomized mice.

Prey Preference and Prey Handling in Two Populations of *Nerodia rhombifer*

Samantha Pike
Faculty Mentor: Matthew Gifford

Behavior plays a major role in the adaptation of populations to unique environments. My objective is to uncover the similarities and differences in prey preference and prey handling behaviors between two distinct populations of the Diamondback water snake, *Nerodia rhombifer.* In a population of water snakes near Lonoke, Arkansas, diet is very generalized, with frogs making up a substantial portion of ingested prey. The Lonoke site has a high abundance of both frogs and baitfish. In a second population in Keo, Arkansas, the diet appears to be predominantly fish, which mirrors the dominant prey type at the study site. Prey preference of a snake can be determined by counting the number of tongue flicks the snake directs toward a prey scent that is presented on a cotton swab. Neonate snakes from the two populations are expected to show innate differences in prey preferences because of the unique, steady diet of each population. Prey handling between the Lonoke and Keo populations is another behavioral aspect that will be examined. Specialist populations (Keo) are typically expected to deal with specific selective pressures that can strengthen their ability to capture a single type of prey. Generalist populations (Lonoke) operate under a different set of selective pressures because their diets consist of multiple prey types. Juveniles from the two populations are expected to differ in prey handling time and in the number of jaw walks utilized during ingestion, both aspects that may indicate efficiency at capturing and ingesting a given prey type.

Toward Capabilities-Based Environmental Leadership: A Case Study in Kanembwe, Rwanda

Brandon R. Rogers
Faculty Mentor: Leah Horton

This project aimed to develop an understanding of how residents in Kanembwe, Rwanda perceive their current reality with respect to capability opportunities and failures, explore the role the environment plays in influencing individual capabilities, and investigate whether an alternative cooking method, in the form of rocket stoves, took less time/energy than traditional 3-stone fires. The quantitative experiments taking place at the University of Central Arkansas revolve around the time/energy efficiency of site-built rocket stoves compared to that of traditional 3-stone fires. By using the rocket stoves built on campus, we will conduct two tests—the Water Boiling Test (WBT) and the Standard Cooking Test (SCT)—using the 3-stone fire and the rocket stove. We will then collect such quantitative data as time required to boil water, mass of wood consumed to achieve boiling, cooking time for beans and potatoes, and mass of wood consumed during cooking. The knowledge obtained during these experiments will serve as a preliminary source of information regarding the efficiency and necessity of the methodology that will be used for field-testing in Kanembwe, Rwanda.

Change in Land Use and Fish Assemblages in Sylamore Creek Over a Thirty-Nine Year Period

Heather A. Saco
Faculty Mentor: Ginny Adams

Long-term studies evaluating land use and fish community structure are often lacking but necessary to further the understanding of anthropogenic influence on local fish assemblages. Land use is known to influence the health of aquatic ecosystems, and alterations may result in negative impacts including increased sedimentation, nutrient enrichment and loss of habitat. Sylamore Creek is a tributary of the White River in Stone County, Arkansas. During June 2014, we sampled fishes at10 sites within the Sylamore Creek watershed. Sites, dates and sampling methodology were consistent with a historical data set collected during 1975. Fish assemblages will be compared with historical data using Morisita-Horn similarity indices and non-metric multidimensional scaling. Fish metrics (species richness, percent tolerant, percent intolerant, etc.) will be analyzed in relation to change in land use type. Land use change will be determined using current GIS technology as well as remote sensing for historical data. Results from this comparative study will be a valuable contribution to the long-term evaluation of fish community structure in Sylamore Creek. Further comparative investigations of additional Arkansas upland stream systems will follow.

Exploring Biomedical Issues Using A Time Translation Model

Atikatou Amadou Sadou, Anthony Cardillo, Sarah England, Ha Ram Kim
Faculty Mentor: Barbara Clancy

Previous work in our lab established a web-based tool that employs statistical modeling to convert the timing of brain development in experimental species to corresponding dates in human development, *http://www.translatingtime.net*. We currently use this tool to understand how studies accomplished in non-human species can best be applied to developing humans. Surprisingly, many questions regarding cross-species comparisons have never been sufficiently addressed, as laboratories typically use untested proportions ("dog" years) or unconfirmed rules of thumb (rat brain at 1 week = human brain at birth).

We mined the empirical literature for data points that chronicle events of interest and applied our statistical model to test if studies in experimental species used developmental times appropriate for human applications.

Current analyses include:

- A recently proposed relationship between the developing gut microbiome and nervous system, focusing on a proposed correlation between gastrointestinal dysfunction and autism.
- The suggestion that there are adverse effects of maternal caffeine consumption on developing fetal brains, possibly due to impact on inhibitory brain receptors, another system implicated in autism.
- A serious unresolved issue in pediatric surgery that indicates potential harmful effects of anesthetics on developing brains.

We are also seeking a better understanding of how hearts develop when compared to brains. This is a critical question as medical interventions might impact both developing hearts and brains, yet typically these organs are not studied in tandem.

Pilot analyses suggest that many studies done in experimental species have been accomplished at times that may be inappropriate if we hope to make comparisons relevant to humans. We also find that hearts of humans and experimental species follow similar patterns of development, indicating mammalian heart development is highly conserved, and that animal models of heart development could be applied to human development if accomplished at appropriate times.

Wetland Connectivity: The Impact of Urbanization on Material Transport and Transformation in the White Oak Bayou Watershed

Stephanie Stoughton
Faculty Mentor: Sally Entrekin

The movement of energy and matter link ecosystems through space and time. Wetlands represent a land-water interface where material is physically, chemically, and biologically transported and transformed from the terrestrial uplands to the downstream river network. Land-water connections are understood in intact ecosystems; however, the urbanization could alter connectivity. Intact wetlands are sources, sinks, and refuge for nutrients and biota. Wetlands store nutrients temporarily, operating as a lag, and transform energy and matter. In contrast, urban land development often inhibits transformation by decreasing wetland holding capacity and reducing carbon inputs that mediate nitrogen storage and uptake. The White Oak Bayou Watershed (Pulaski County, Arkansas) experienced a nine percent increase in urban development from 1999 to 2006. My study will quantify changes in material transport and transformation from the urban tributaries to the wetlands and into the main stem of the Bayou. I predict that transport rates will be greatest with more urban development, while transformation rates will be greatest in more-forested catchments. I will further develop the ecological theory, testable hypotheses, and methods for presentation.

Formation Of Hormone-Induced Nodule-Like Structures In The Model Grass, *Brachypodium Distachyon*

Jacklyn Thomas, Ryan Hiltenbrand
Faculty Mentor: Arijit Mukherjee

Availability of nutrients, especially nitrogen, is a major constraint for crop productivity and sustainable agriculture. Over the last decades, there has been an excessive dependence on nitrogen fertilizers. Unfortunately, this has caused many negative consequences at the economic and environmental level. One option for improving crop yields while maintaining the sustainability of our agriculture systems is to take advantage of naturally occurring beneficial plant-microbe symbioses. For instance, legumes (soybean, alfalfa, peas) can form a beneficial symbiotic association with soil bacteria, rhizobia. In this process, the rhizobia fix atmospheric nitrogen for its host plant inside specialized root structures called nodules. Unfortunately, this symbiosis is very species-specific and is restricted to plants from the legume family. Therefore, important agronomic and biofuel crops like rice, corn, wheat etc. are still heavily dependent on fertilizers for their growth and yield. Several studies in legumes have shown that plant hormones play an important role in regulation of plant-microbe symbioses. For instance, addition of auxins can induce nodule-like structures (NLS) in legume roots even in absence of rhizobia. Interestingly, we have been able to induce similar NLS structures in roots of rice. Besides rice, we are investigating formation of these hormone-induced structures in another model plant for grass structural and functional genomics, *Brachypodium distachyon*. Brachypodium is a widely recognized model plant, and the first species of the grass subfamily Pooideae with a sequenced genome. Due to its amenability to experimental manipulation and compact genome, Brachypodium research is moving forward rapidly. In this project, we optimized the experimental conditions to induce NLS formation in Brachypodium roots in response to 2,4-D, a synthetic auxin. Our goal is to determine the host plant genes that are controlling the formation of these hormone-induced structures in Brachypodium roots. Towards that goal, we are currently preparing our samples for an RNASeq experiment.

Molecular Cloning to Improve Mitochondrial Fission and Fusion Assays in *Dicytostelium discoideum.*

Olivia Vogel and Ericka Vogel
Faculty Mentor: Kari Naylor

In our lab we are studying the process of mitochondrial fission and fusion to understand the mechanisms for these processes within eukaryotic cells. We quantify the rates of fission and fusion in wild-type and perturbed conditions to determine the role different proteins play in these processes. In order to study the mitochondria, we must be able to view them under a fluorescent confocal microscope. We currently use MitoTracker Red- a vital dye - to label the mitochondria. However, this dye has proven inefficient due to the fact that it can wash out under certain experimental conditions and only stains healthy mitochondria**.** The purpose of this project is to create a fusion protein that fuses the first 35 amino acids of the mitochondrial protein TopA with the red fluorescent protein mCherry. This fusion protein, once expressed in the cell, will target and fluorescently label the mitochondria. This construct will prove more efficient in the visualization of *Dictyostelium discoideum* mitochondria by staining all mitochondria, and will not be washed out. These fluorescently labeled mitochondria may then be studied to answer questions about mitochondrial dynamics, such as the rate of fission, fusion, and motility.
The cloning process we used can be divided into four main steps: polymerase chain reaction, digestion, ligation, and transformation. In our research, we have currently performed all steps and created a construct. Upon screening our colonies we identified three positive clones. However, after sequence analysis it became apparent that we did not clone the correct mitochondrial targeting sequence. Instead, a primer dimer had been inserted. To eliminate this problem, we ordered complementary oligonucleotides of 129 bases and annealed the pieces together. Once annealed, the pieces were digested and ligated into the vector along with mCherry.

Basic Science Literacy in Arkansas

Patrick Ward
Faculty Mentor: Mark W. Bland

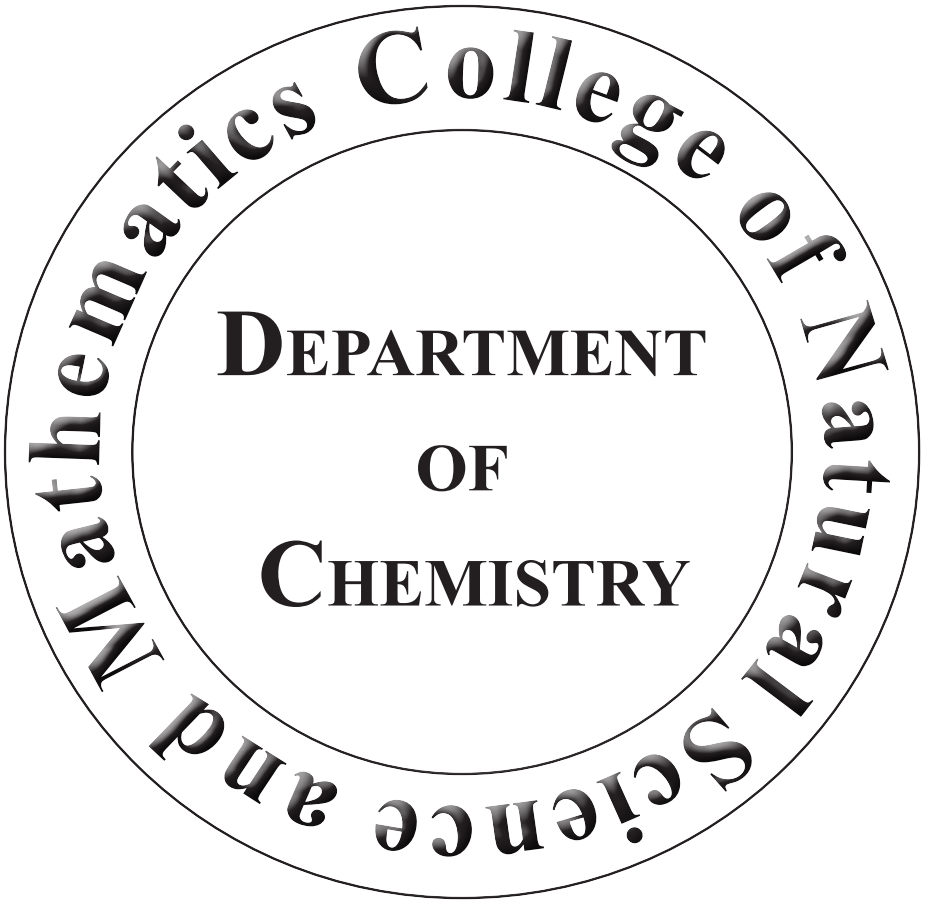
Basic scientific knowledge research conducted by the National Science Foundation (NSF) in 2012 revealed that 26 percent of Americans answered incorrectly when asked, "Does the Earth go around the Sun or does the Sun go around the Earth?" In the same study, only 39 percent of adults correctly responded to the item, "The universe began with a huge explosion," and 48% percent responded "true" to the item, "Human beings, as we know them today, developed from earlier species of animals." To determine whether high school students enrolled in public high schools in rural Arkansas would perform better than participants in the NSF study, we chose to administer a similar instrument in selected schools in Arkansas. Participants enrolled in 13 rural public high schools in Northern Arkansas (N=828) were administered the NSF instrument, which included five additional questions. Scores for individual questions ranged from 93.4 percent (Question 1, "The center of the Earth is very hot.") to 37.3 percent (Question 7, "The universe began with a huge explosion."). Notably, answers to questions 7 ("The universe began with a huge explosion.") and 11 ("Human beings, as we know them today, developed from earlier species of animals.") were lowest, with scores of 37.3 and 37.6, respectively. Results of regression analyses regarding socioeconomics, population size, school size, and religious affiliation are presented, and implications are discussed.

The Role of The Cytoskeleton in Mitochondrial Dynamics

Laken Woods
Faculty Mentor: Kari Naylor

Mitochondria are highly specialized eukaryotic organelles responsible for producing a majority of the cell's ATP and play a vital role in many other cellular processes. The organelle's morphology and distribution play an imperative role in cellular health and overall cellular function. Mitochondrial morphology and distribution are maintained by the membrane events fission and fusion and motility. Using time-lapse confocal microscopy and kymograph analysis in the model organism *Dictyostelium discoideum*, we were able to determine fission and fusion rates, mitochondrial velocities, and the number of mitochondria moving within the cell in deletion strains and cells treated with microtubules and/or actin inhibiting drugs to determine the role of the cytoskeleton in mitochondrial dynamics. It has been suggested that Dynamin-Like Proteins, or DLPs, interact with actin filaments at dividing mitochondria because of their co-localization at the cleavage furrow. We have shown that lack of the DLPs increased velocity of moving mitochondria and the rates of fission and fusion. On the other hand, the protein CluA is speculated to be an intermediary protein between mitochondria and microtubules. Cells lacking the protein have decreased fission, fusion, and mitochondrial motility.

To determine if there is an interaction between the cytoskeleton and the mitochondria, the microtubules inhibiting drug nocodazole and actin inhibiting drug latrunculin B were used. All strains treated with nocodazole had significantly lower fission and fusion rates, velocities, and percent of mitochondria moving than untreated strains. When actin was inhibited, there was no significant difference in fission and fusion rates or motility. In an effort to determine if there was a synergistic effect, fission and fusion rates were calculated for the cells treated with both nocodazole and latrunculin B. We found that fission, fusion, and motility were again significantly highly reduced in the double drug treated cells. Our findings suggest that the cytoskeleton, specifically microtubules, plays a major role in mitochondrial dynamics within a cell, which provides more insight into the molecular mechanism of mitochondrial dynamics.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Radiocarbon Dating of Rock Paintings at Eagle Cave, TX

Trinidy Allen
Faculty Mentor: Karen Steelman

Our laboratory determined the age of three Pecos River Style paintings in Eagle Cave, a rockshelter in southwest Texas. Utilizing the properties of oxygen plasma reactions involving electrically excited oxygen gas ignited with a radiofrequency generator, we extracted organic carbon from the paint layers to obtain direct accelerator mass spectrometry radiocarbon dates on the paintings. For overlying and underlying accretion layers, calcium oxalate was identified using Fourier Transform Infrared Spectroscopy. After isolation with acid washes and collection onto quartz filters, the calcium oxalate layers were cleaned with plasma oxidation prior to combustion for accelerator mass spectrometry radiocarbon dating. This process allowed us to obtain minimum and maximum ages for the production of the art using the collected carbon dioxide. Conducting two different analytical methods on the different materials provides more secure dating of the paintings. We expect chronological stratigraphy for the overlying accretion layer, paint layer, and underlying accretion layer. Significantly, Pecos River Style paintings produced by hunger-gathers contain a sophisticated mythology and are thought to be 3000-4000 years old.

Characterization and Analysis of Metal Containing Aerosols Generated from Candle Burning

Logan W. Bevill
Faculty Mentor: Kristin S. Dooley

It has long been known that indoor air quality is often poor due to gas and particle emissions inside the home. Inadequate ventilation that dilutes the pollutants with clean outside air can cause the concentrations to rise even further. A contributor to this pollution is the fine particulate matter emitted from burning household candles which often contain various metals in their wicks. This study characterizes the particulate matter emitted from several candles by size and by metal composition. The size distribution of the particulates are important as the health effects of particulates are size dependent. The particulate matter emitted by various candles was coarsely size selected using a multi-stage impactor. Gravimetric analysis of the particulates collected allowed us to characterize the proportion of the particulate matter that fell below the 1 micron size cutoff often used to determine if particulate matter is small enough to go deep into lung tissue making it more harmful when inhaled. Atomic Absorption spectroscopy was then used to determine the concentration of various metals in the particulates. Size and metal concentrations are compared for various candle brands and burn times.

Measurement of Aerosol Optical Properties Using Pulsed Laser Cavity Ring-Down Spectroscopy (Crds).

Logan Bevill, Julio Castillo, and Jay Pittman
Faculty Mentor: Kristin Dooley

Accurate measurements of optical extinction coefficients and scattering parameters for atmospheric aerosols are needed in order to quantify the effects aerosols have on climate change. Although this field was once dominated by Fluorescence FAGE and long-path absorption spectroscopy DOAS, cavity ring-down spectroscopy (CRDS) has emerged as a cost-effective, accurate alternative technique that has numerous advantages. CRDS is an optical absorption technique based on Beer's Law that allows for the characterization of extremely low concentration target samples by using two highly reflective mirrors to create an optical cavity with a pathlength thousands of times longer than its meter long laboratory footprint. System ring-down information will be monitored and collected using LabView, a program capable of quantifying sensory data and associated ring-down measurements. Well-characterized laboratory generated aerosols of various sizes and compositions will be used to characterize the instrument.

NMR Study of the Active Form of the Polymerization Catalyst Formed Between Tp*Rh(COD) and 4-Ethynyltoluene

Hannah Blakely
Faculty Mentor: Richard M. Tarkka

Tp*Rh(cod) is a catalyst that can be used to polymerize phenylacetylene derivatives. It contains a rhodium ion and a boron centered scorpionate ligand in which three dimethylpyrazole rings are attached to the boron atom. We are interested in determining the effect of scorpionate ligand structure on the efficacy of the catalyst. The purpose of this study is to use ^{13}C NMR spectroscopy to determine the active form of the catalyst that forms between Tp*Rh(cod) and 4-ethynyltoluene. These studies show that only a small fraction of the catalyst molecules in the reaction mixture participate in the reaction. Most are inactive. In the catalyst molecules that do react, cyclooctadiene is detached from rhodium ion.

Impact Analysis of Pre-Requisite Incorporation Toward Student Success in Freshman-Level College Chemistry Courses

Seth Cornish
Faculty Mentor: Faith Yarberry

At the Spring 2012 American Chemical Society National Meeting, it was reported that there was a direct correlation between the success rate of students in freshman-level college chemistry courses and the score they earned on the mathematics portion of the ACT Exam. The evaluation of the data suggested improved student success if a prerequisite of a Mathematics ACT score of 21 for the General Chemistry in Health Sciences course, and a Mathematics ACT score of a 24 for the College Chemistry course was implemented with a college mathematics course co-requisite for those that did not meet the necessary requirement. A course prerequisite was instituted to reflect these findings. Students entering either course are required to have a Mathematics ACT score of 21 or a prerequisite/co-requisite of College Algebra. In the research presented here, we will be reporting the findings associated with the incorporation of these prerequisites on student success rates.

Synthesis and Characterization of Iron Heteroscorpionates

Katherine Demaree
Faculty Mentor: Patrick Desrochers

The heteroscoropionate Tp' was developed in our lab following a simple pyrazole-for-triazole substitution strategy. Tp' represents the scorpionate chelate hydrobenzotriazolyl-bis(3,5-dimethylpyrazolyl)borate, a monoanion. Scorpionates are aggressive tridentate chelates with broad applications encompassing nearly every metal ion on the periodic table. Heteroscorpionates (where one of the three nitrogen donor groups is varied) introduce interesting asymmetry in the complexes prepared. For the present work, new iron complexes, $(Tp')_2Fe^{n+}$, will be described. The iron(II) form (n = 0) and iron(III) form (n = 1, as its PF_6^- salt) of the ligand were synthesized, both of which have been characterized by paramagnetic ^{11}B NMR as well as through infrared and electronic spectroscopies. The orange iron(II) form can been chemically oxidized to the deep purple iron(III) form (this change is reversible), mirroring the chemical behavior of ferrocene. These syntheses demonstrate the utility of this scorpionate with earlier transition metals; presently only late metals, nickel and copper, have been employed with Tp'. Iron and even-earlier metal ions introduce interesting redox and magnetic properties that may be exploited on resin-supported analogs.

Surfaced Enhanced Infrared Absorption on Optimized Copper Nanostructures

Will Henry, Taylor Huntington, Caleb Denton, Bakarie Branch, and Brandon Wilde
Faculty Mentor: Donald Perry

The goal of this research is to develop optimal copper metal nanoparticles (MNPs) for applications in surface-enhanced infrared absorption spectroscopy (SEIRA). Various optimized MNPs are formed by oblique angle deposition (OAD) through metal evaporation onto CaF_2 substrates at angles ranging from 75^0 to 80^0. These nanostructures are characterized with AFM, SEM, and UV/Vis-NIR spectroscopy. A monolayer of *p*-nitrobenzoate ion was deposited onto the copper nanostructures to determine the degree of vibrational enhancement in SEIRA. These optimized MNPs show SEIRA enhancement factors up to x50 better than MNP grown at incident. We observe SEIRA enhancement factors of ~x200 for optimized silver MNPs and enhancement factors of around x100 and x25 for optimized gold and nickel MNPs, respectively. This work will influence a range of biological, medical, catalytic, environmental, and nanotechnological applications.

Synthesis and Characterization of Transition Coordination Polymers for CO_2 Capture from Post-Combustion Flue Gases

Clement Mugenzi
Faculty Mentor: Lei Yang

The urgent need to control CO_2 concentrations in atmosphere has promoted global efforts to develop new materials for CO_2 capture from post-combustion flue gases of the conventional coal combustion, which is one of the major sources of anthropogenic CO_2 emissions. In Arkansas, the coal-fired electric power plants contribute over half (~53%) of the state's electricity in 2013.[1] Although fruitful results have been achieved, great challenges, such as low partial pressure of CO_2, high temperature, presence of other components (e.g. N_2 and H_2O), and the high energy cost of regeneration, still remain. Inspired by these challenges, our goal in this project is to develop new metal-organic frameworks (MOFs) for selective CO_2 uptake from post-combustion flue gases. Our initial work based on the pyridylamide ligands and transition metal ions have led to the isolation of some very interesting polymeric compounds characterized by single crystal X-ray diffraction. The three-dimensional architecture exhibited by our MOFs showed excellent thermal and moisture stability, which are ideal properties for the potential application of these materials in CO_2 capture.

Synthesis and Characterization of Transition Metal Clusters/Polymers Supported by Pyridylamide Ligands

Magnus A. Pauly
Faculty Mentor: Lei Yang

Absorption and storage of CO_2 by transition metal polymers have attracted considerable interest due to the high selectivity and efficiency of these materials. In our effort to discover the new generation of transition metal polymer materials, a serial of pyridylamide ligands functionalized with multiple donors were synthesized and applied in the construction of polymeric porous structures with first row transition metal ions. Various coordination polymers/clusters with different nuclearity have been prepared and characterized by X-ray crystallography, IR, UV-vis and elemental analysis. The interesting structural and spectroscopic features of these compounds will help us obtain a deeper understanding on ligand design and polymer construction, which are major factors to impact the adsorption properties of these materials.

The Effect of Retinoid Receptor Agonists on K562 Cellular Adhesion, Proliferation, and α5β1 Integrin Cell Surface Expression

Raynin Phomakay
Faculty Mentor: Melissa Kelley

Establishment and maintenance of proper immunity requires a precise balance between cellular adhesion and proliferation. A disruption in either event culminates in a variety of pathologies encompassing immunosuppression, auto immunity, and cancer. Retinoids, profoundly affect immune function by mediating cellular adhesion and proliferation in certain leukocytes. Retinoids, by binding to retinoid receptors (RARs or RXRs), modify the expression of a variety of signaling proteins involved in immune cell proliferation and adhesion including, integrins. Integrins are a family of transmembrane heterodimeric receptors consisting of non-covalently linked α and β subunits that are considered to be the principle receptors involved in attachment to the extracellular matrix and provide adhesive interactions that control cellular proliferation. Currently, the contributions by retinoids in immune cell adhesion and proliferation have been independently examined; however, in retinoid responsive immune cell lines there appears to be a potential synergism between cellular adhesion and proliferation, which may be mediated through integrins, specifically the α5β1 subset. In this study, the effect of all-*trans*-retinoic acid agonists on K562 cellular adhesion, proliferation, and α5β1 integrin cell surface expression was investigated. RARgamma agonist exposure increased K562 cellular adhesion to RGD containing extracellular matrix proteins fibronectin and FN-120. Cell surface expression of both the α5 and β1 integrin subunits was increased in the presence of a RARgamma agonist; however, RARgamma agonists decrease K562 cellular proliferation. In the presence of the RARbeta agonist, K562 cellular proliferation was increase, while α5β1 cell surface expression was decreased. The RARalpha agonist was comparable to the control in K562 cellular adhesion, proliferation, and α5β1 integrin cell surface expression. Our study is the first to demonstrate that specific RAR agonists alter cellular adhesion, proliferation, and intergrin cell surface expression.

State-Specific Reactions of $Cu^+(^1S,^3D)$ with SF_6 and SF_5Cl: Thermochemical Control Over Product Formation

Xavier S. Redmon, Benjamin A. Scheuter
Faculty Mentor: William S. Taylor

Reactions of the gases SF_6 and SF_5Cl with the ^1S ground state and ^3D excited states of Cu^+ were carried out in order to examine parameters influencing S-X (X=F,Cl) bond activation. Experiments were conducted using a selected ion drift cell apparatus. Both Cu^+ states were prepared in a glow discharge utilizing Ne as the working gas. Ion mobility spectrometry (IMS) revealed state-specific product formation for both gases. $Cu^+(^1S)$ reacts with both SF_6 and SF_5Cl to yield association products and is not observed to induce any bimolecular chemistry. Conversely, $Cu^+(^3D)$ reacts with both compounds to yield SF_3^+, and with SF_5Cl to form $CuCl^+$. SF_3^+ does not appear to react further with either neutral reactant, whereas $CuCl^+$ reacts in an efficient secondary process with SF_5Cl to yield SF_5^+. Additional higher-order fragmentation products were observed to occur in trace amounts with both substrate molecules. Thermochemical requirements for fragmentation products in both reactions indicate that the neutral byproducts must involve some degree of bond formation to proceed exothermically. Candidates for possible product channels were evaluated on the basis of energetics and conservation of electron spin. State-specific kinetic measurements show that both Cu^+ states are consumed efficiently by SF_5Cl, whereas SF_6 reacts with $Cu^+(^1S,^3D)$ slowly. This suggests that the rate-determining step in the SF_5Cl reaction involves activation of the weaker S-Cl bond.

Using an Inter-Chapter Relations Grant to Increase Chemical Outreach

Amber D. Rolland, Julio Castillo, Hoda H. Agrama, Jalyn D. Henderson, Johnathon G. Schmidt
Faculty Mentors: Kristin S. Dooley, Faith Yarberry, Karen L. Steelman

Our chapter has an avid interest in interacting with our community to develop a public appreciation for chemistry and science. To share and learn from other chemistry clubs, we applied for and received an ACS Student Inter-Chapter Relations Grant to host Demo-Palooza, an afternoon of demonstrations by UCA's Jerry Manion and Louisiana Tech's Bill Deese. With over 60 attendees from our own campus, local community, and four other nearby universities, the demonstrations and explanations of their chemistry concepts educated and delighted the audience. Our chapter plans to implement what we learned into our regularly scheduled events, such as Science Nights at local schools, a community-wide environmental EcoFest, and Kids' Club at UCA football games. Performing these demonstrations and participating in these events has not only contributed to our community, but benefited club members via volunteer opportunities, professional growth in organizational and communication skills, as well as networking with our peers.

Pre-Cursor Research for the Development and Implementation of an Online Chemistry/Mathematical Tutorial

Enock Rwamuza
Faculty Mentors: Faith Yarberry, Lisa Christman

College chemistry I and II are freshman-level chemistry courses offered by the Department of Chemistry at the University of Central Arkansas. College Chemistry I is offered as part of the UCA Core and College Chemistry I and II are required by many science majors in the College of Natural Science and Mathematics. According to the literature, Chemistry is frequently considered to be a gate-keeper course for many students. Additionally, the literature, as well as research performed in our group, has shown that there is a direct correlation between mathematical skill and student success in chemistry. Therefore, we believe that the lack of basic mathematical knowledge makes it difficult for students to pass these classes.

The goal of the research presented is to identify specific mathematical concepts that students struggle with in College Chemistry I and II as a pre-cursor for the development of a Chemistry/Mathematical tutorial to be implemented in these courses beginning in the Fall of 2015. We have evaluated chemistry examination questions from College Chemistry I involving mathematical concepts missed by students and will be evaluating questions from College Chemistry II. As part of the research, a table of results has been generated outlining the mathematical errors employed by students on these questions and the number of students that committed that error. Finally, the results from these tables were compared and the concepts with which students most struggled identified. These concepts will be addressed in the Chemistry/Mathematical tutorial being developed in the future.

Gas-Phase Reactions of Cu^+ (^1S, ^3D) with CF_3CH_2Cl, $CF_3CH_2CH_2Cl$, and $CF_3CH_2CH_2Br$: Proximity Effects in Substrates with Competitive Reactive Sites

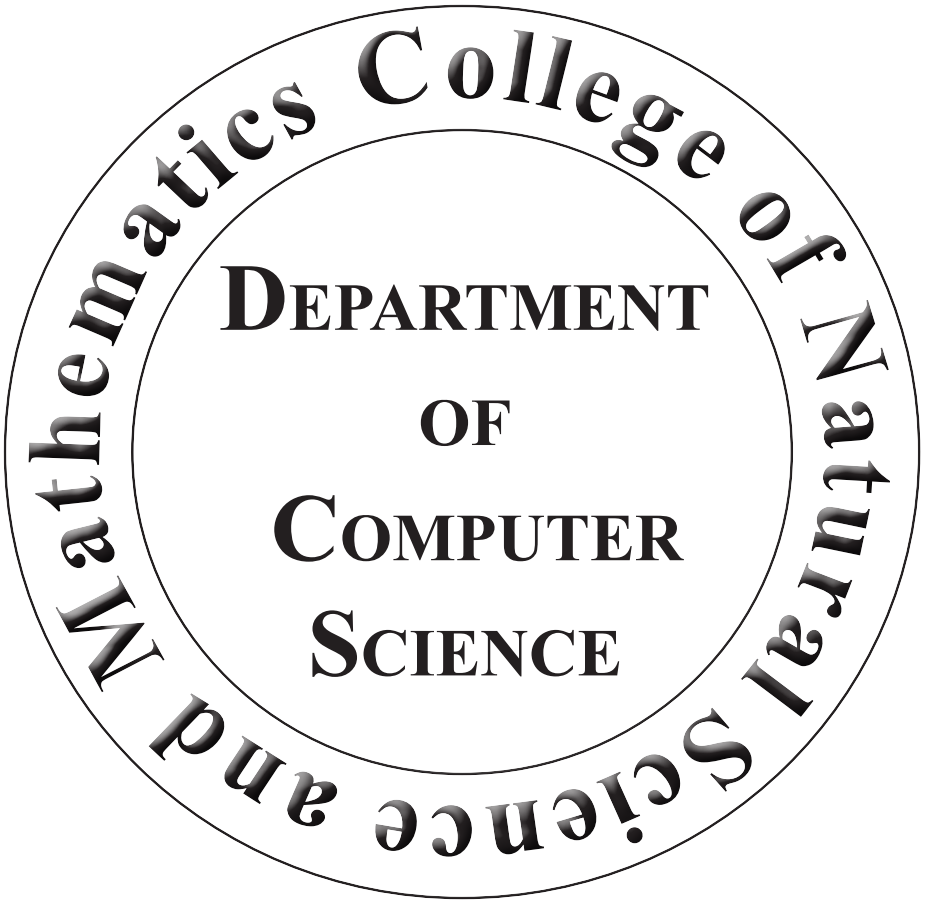
Benjamin Scheuter, Xavier Redmon
Faculty Mentor: Dr. William Taylor

Effects of chain length were explored in the gas-phase reactions of Cu^+(^1S, ^3D) with halogenated short chain organic compounds. Reactions of $CF_3(CH_2)_n$–X (X = Cl, Br; n = 1, 2) with Cu^+ ions formed in a sputtering glow discharge were carried out under near-thermal conditions using a selected ion drift cell. In this work, we sought to study the effects of separating the *preferred association* site (the more electronegative –CF_3 end) with the *preferred reaction site* (the –X end). State-specific product formation was characterized using ion-mobility spectrometry. These results show that association products are formed primarily via Cu^+(^1S), whereas Cu^+(^3D) initiates a number of bimolecular processes. These include halogen abstraction, HX abstraction, and several products indicating that the metal induces other, more complicated rearrangements of the substrate. State-specific kinetic data were obtained for all three neutrals, which reveal that the overall reactions are very efficient, with rate constants for both copper states on the order of 10^{-9} $cm^3 \cdot molec^{-1} \cdot s^{-1}$. Preliminary findings indicate that product branching ratios remain the same for processes exhibited by more than one reactant neutral. This implies that changes in proximity of the preferred association site to the preferred reaction site do not influence efficiency of the reaction or branching ratios.

Synthesis of Photolabile Aryl Selenides

Daniel A. Shrum and Johnathan A. Marasco
Faculty Mentor: Nolan Carter

Proteins are subject to damage by reactive oxygen species such as hydroxyl radical. Since hydroxyl radical is nonselective, it can react with any amino acid and at multiple sites within the same amino acid. Due to this non-specificity, evaluating the role played by specific radical intermediates in protein damage is difficult. To facilitate the study of this process, we have worked to synthesize photochemically-reactive aryl selenides that generate specific amino acid radicals upon exposure to UV light. These amino acid radicals are intended to serve as models for radicals formed within a protein. The photolabile compounds required for these studies are not commercially available and must be synthesized. In the present work, different types of reduction methods are being evaluated to convert an intermediate oxime into the corresponding amine. This is a key step in the synthesis of an aryl selenide radical precursor compound.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The Robotic Maze Runner

Kwadi Higgins, Paul Morrison, Justin Duff, Kendall Mason
Faculty Mentor: Yu Sun

In every aspect of our lives, we are required to react to stimuli within our environments. Navigating is essential to this process. In order to represent the process of having to react to different stimuli within an unknown environment, in this project we have researched using an EZ-Robot to navigate a maze. Within this maze, the robot will encounter several symbols and it will need to react accordingly to those symbols. Detecting each symbol, performing the correct reactions to those symbols, and navigating the maze is the end goal for this specific project. The robot we will use is called JD. The robot has servo motors that enable it to have a wide range of motions, a built in camera, an ultrasonic sensor, led lights for eyes, and voice recognition. We have developed an algorithm to have JD recognize colors and also perform proper rotation. Currently, we are working with the ultrasonic sensor and building the maze in order to complete the project successfully.

Autonomous Robotic Exploration

Guofu Huang, Reese Childers, Joe Hilton, and Brandon Hyslop
Faculty Mentor: Yu Sun

Robots have gained an ever increasing role in the lives of humans by allowing more efficient and exacting completion of tasks, ranging from healthcare to manufacturing. One area that robots have not been fully utilized in is autonomous exploration of areas. In this project, we developed methods to use multiple robots collaboratively to complete exploration tasks more efficiently than a single robot is capable of. For this, the robots are given the task of finding a specific object from a series of rooms. One of the robots will scout an area while the other robot will both scout an area and pick up an object if it locates one. If the scout robot locates the object, then the scout will report the room that the object is located in by sending the room number between the robots. The robots navigate the room by following its path. The methods proposed are still being developed. So far, our robots can successfully traverse a room and can retrieve objects that we request. In addition, we also implemented efficient communications between the robots, and the retrieval robot is capable of room exploration and object retrieval.

Classifications and Wine Informatics

Hai Le
Faculty Mentor: Bernard Chen

This research seeks to classify wines based on sensory data derived from Wine Spectator Magazine wine reviews. In the new data science field of Wine Informatics, our research serves to support the validity of classification based upon organoleptic properties versus physiochemical analysis as a creditable source for wine classification. Our research included using three classification algorithms, Naïve Bayes, Decision Tree, and K-nearest neighbors. Our data set included a 1000 wine data set with 500 scored as 90+ and 500 scored as 90-. The data set was normalized using a Computational Wine Wheel for preprocessing. We used the 5-fold cross validation to validate the performance of our algorithms with results of 85.7% accuracy prediction achieved using the Naïve Bayes algorithm with $k = 2$.

Optical Character Recognition via Neural Networks

Jason Moix
Faculty Mentor: Victor S. Sheng

As technology advances and as augmented reality continues to become a bigger part of the world we live in, methods for developing self-learning systems that perform such tasks as optical recognition become of great importance. With the ability of neural networks to map complex mathematical models and recognize patterns of both linear and non-linear data, neural networks are uniquely suited for the analysis of character data acquired from images. This paper examine the use of a neural network in order to classify handwritten characters by analyzing data acquired from both contour representations of characters and skeletal representations of characters. Then, the two methods are analyzed for efficiency.

The Step Project - A Study in Algorithmic Traversal for EZ Robots

Jason Moix, Chris Carney, Sheikh Faal, Alex Williams, and MK Shamburger
Faculty Mentor: Dr. Yu Sun

Every day we see greater advances in robotic technologies appearing around us. From the creation of military robots built to travel across hostile territories to the implementation of drones in a domestic setting by Amazon.com, these robots continue to become a more important part of our lives everyday. Due to this fact, the importance of investigating new methods for ensuring the safe travel from one location to another grows as well. In the spirit of researching these methods, the "Step Project" aims to develop the functionality for a robot to climb a set of stairs. The robot being used for this project is manufactured by EZ Robot and is provided with its functionality through the execution of scripts and animations created in an integrated development environment. Using this development environment, we develop the algorithm to allow the robot to successfully climb a set of stairs.

Improved Insertion Sort Algorithm

Michael Newton
Faculty Mentor: Sinan Kockara

Sorting is an often used operation in computing environments, whether sorting numbers to be used in a specific order, to sorting names for formatting, various sorting algorithms will always need to be used to accomplish this. Sorting algorithms are mostly judged based on their average speed and their maximum speed. Insertion sort on average takes a long amount of time compared to many algorithms, but performs very well when the list is already in a nearly sorted state. This paper will discuss a way to perform operations an a list to make it nearly sorted very quickly. This allows insertion sort to run close to its best case scenario each time. The result is an algorithm that runs much faster than insertion sort in most scenarios.

Label Noise Correction Methods

Bryce Nicholson
Faculty Mentor: Victor S. Sheng

A main concern in data preprocessing is ensuring that the data in question is clean. In real-world applications, label noise is an unavoidable phenomenon. The important task of correcting label noise is addressed infrequently in literature. The difficulty of developing a robust label correction algorithm leads to this silence concerning label correction. To break the silence, we propose two algorithms to correct label noise. One utilizes self-training to re-label noise, called Self-Training Correction. Another is a clustering-based method, which groups instances together to infer their ground-truth labels, called Cluster-based Correction. We also adapt an algorithm from previous work, a consensus-based method called Polishing that consults with an ensemble of classifiers to change the values of attributes and labels. We simplify Polishing such that it only alters labels of instances, and call it Polishing Labels. We experimentally compare our novel methods with Polishing Labels by examining their improvements on the label qualities of binary and multi-class data sets, and ultimately conclude that all three methods significantly improve label qualities. Our Cluster-based Correction method performs the best.

Noise Correction of Image Labeling in Crowdsourcing

Bryce Nicholson
Faculty Mentor: Victor S. Sheng

The overabundance of data that characterizes the modern world necessitates techniques to gain knowledge from it. A promising field that proves helpful in the pursuit of this knowledge is crowdsourcing, the distribution of tasks by requesters to non-expert workers in a web-based environment. These workers process, categorize, or label the data in ways that a machine cannot, since they view the data from a human perspective rather than a mechanical one. When many annotations have been acquired and consensus has been done, the data will still contain misclassified, or noisy, instances. Fortunately, there are mechanical remedies to the problem of noise, such as noise filters. The noise reduction technique we will examine in this paper is noise correction, the systematic alteration of instances' classes in an effort to improve the accuracy of the data. We investigate the methods of improving data quality, in terms of label accuracy, in the context of image labeling in crowdsourcing. First, we look at three consensus methods for inferring a ground- truth label from the multiple noisy labels obtained from crowdsourcing, i.e., Majority Voting (MV), Dawid Skene (DS), and KOS. We then apply three noise correction methods to correct labels inferred by these consensus methods, i.e., Polishing Labels (PL), Self-Training Correction (STC), and Cluster Correction (CC). Our experimental results show that the noise correction methods improve the labeling quality significantly.

Remote Surveillance Using Raspberry Pi

Oliver Roundtree, Calaeb Williams, Alex Schwartz, Jeremy Clark, Brandon Mitchell
Faculty Mentor: Yu Sun

The Raspberry Pi is a new, small, lightweight, and powerful piece of hardware that has a lot of research potential due to its modular nature and very low cost. In this project, we develop a Raspberry Pi remote surveillance system which will be very useful for home use and can be easily extended to fit many other kinds of real-world applications by using more sensors to collect various forms of data. The components used in the Pi are inexpensive, allowing the Pi to be configured easily to meet a user's diverse needs. We are currently working to set up a Raspberry Pi as a headless device with a simple USB webcam attached via servo motors. By using a Wi-Fi connection, the Pi will stream its video and send it to a remote user who can use a graphical web interface to pan and tilt the camera. This can be accomplished without any special hardware, using only the Pi's built in GPIO functionality and Python codes. As of now, the Pi is able to stream video to an outside source using the webcam. We are currently developing the servo control codes so that the Pi can pan and tilt the camera when receiving a command from the website. We believe that this Raspberry Pi system will be very useful.

Analysis of Stock Market prices

James Robert Stamps
Faculty Mentor: Chenyi Hu

Due to the huge interest in stock market prices, statistical analysis of stock market data has and will always be researched. The Dow Jones is used as a measurement of the strength of the United States economy and in this research I will perform a statistical analysis and scientific computing methods of two quarters of the components of the Dow Jones. I find the general trends of prices and how stocks affect each other.

Semi-Active Learning

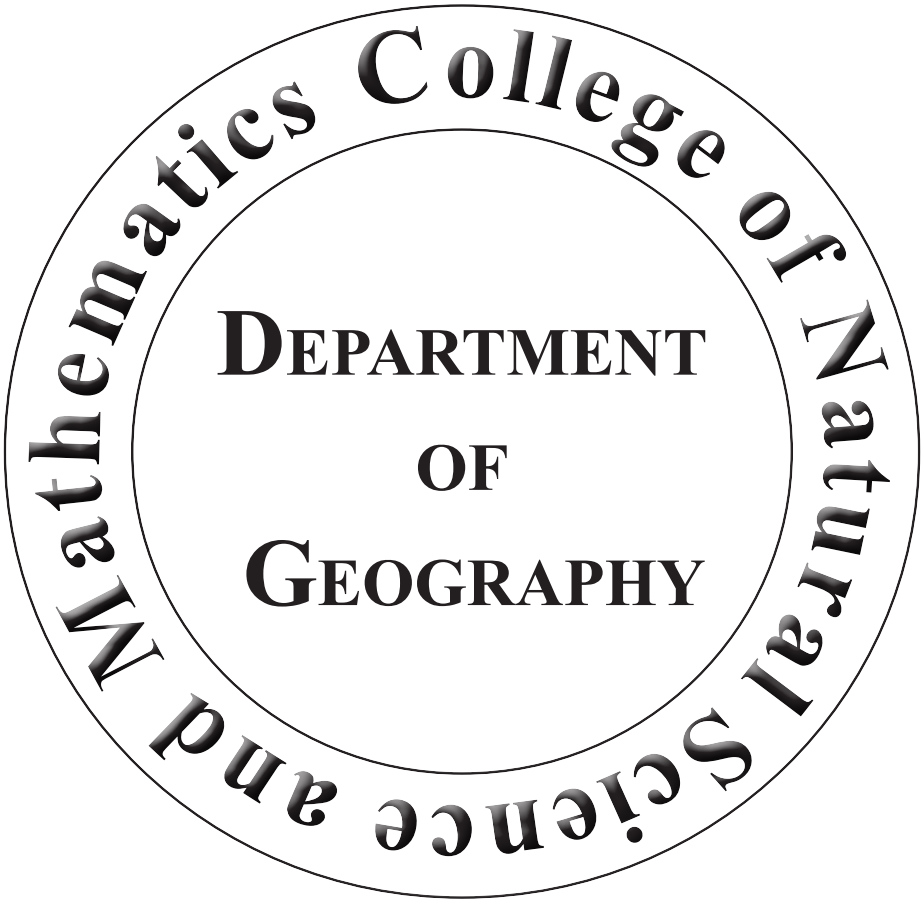
James Robert Stamps, David Fink
Faculty Mentor: Victor S. Sheng

Often active learning is used to increase the accuracy of low confidence instances for other algorithms such as semi-supervised learning algorithms. The goal here is to use active learning as the base algorithm and apply other algorithms to lower the cost of "querying the oracle." Two of the ways in which we will lower the cost of active learning; one is to make better selections in which instance to query, and the other is to lower the number of instances needed to create a good model. To begin a few things are needed a data set of labeled and unlabeled instances, a model to evaluate with, and a bases for selecting unlabeled instances to label.

Semi-supervised Multi-label Learning

James Robert Stamps
Faculty Mentor: Victor S. Sheng

Semi-supervised learning is a commonly used learning method that has proven itself quite useful for single label data. It produces high quality models, while being extremely cost efficient. This efficiently makes semi-supervised learning a major interest in industry because it reduces the cost of building highly effective classification models. Because the cost of building multi-label classification models is high, semi-supervised learning appears to be a way to fix its main problem. I will be exploring the adaptation of three different semi-supervised learning methods on multi-label data. Some major adaptation is needed for the later methods but overall the results do show some promise in the future of semi-supervised learning on multi-label data.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Predictive Habitat Modeling for Ivory Billed Woodpeckers in Arkansas and Louisiana

Russell T. Rogers
Faculty Mentor: Mary Sue Passe-Smith

The Ivory Billed Woodpecker once ranged over the majority of the Southeastern United States, where it would dwell primarily in the swampy bottomland hardwood forests that had a large canopy of old growth trees. Since the 1800s logging and agriculture has reduced the bird's habitat from 24 million acres down to only 4.4 million acres of scattered forests. With the great majority of the forests being replaced by farmland there was a large increase in pollution in the remaining habitat in the form of pesticides, fertilizers and sediments. Due to this many believe the bird to be extinct or at the very least critically endangered. The goal for this project was to find the optimum locations where the Ivory Billed Woodpecker may still be found by utilizing GIS layers representing favorable habitat locations, inclusive of determining which habitat areas are a reasonable distance from the dangerous pollutants found near farmland.

The eSports Commodity: How Recreational Viewership of eSports has Evolved Over Time.

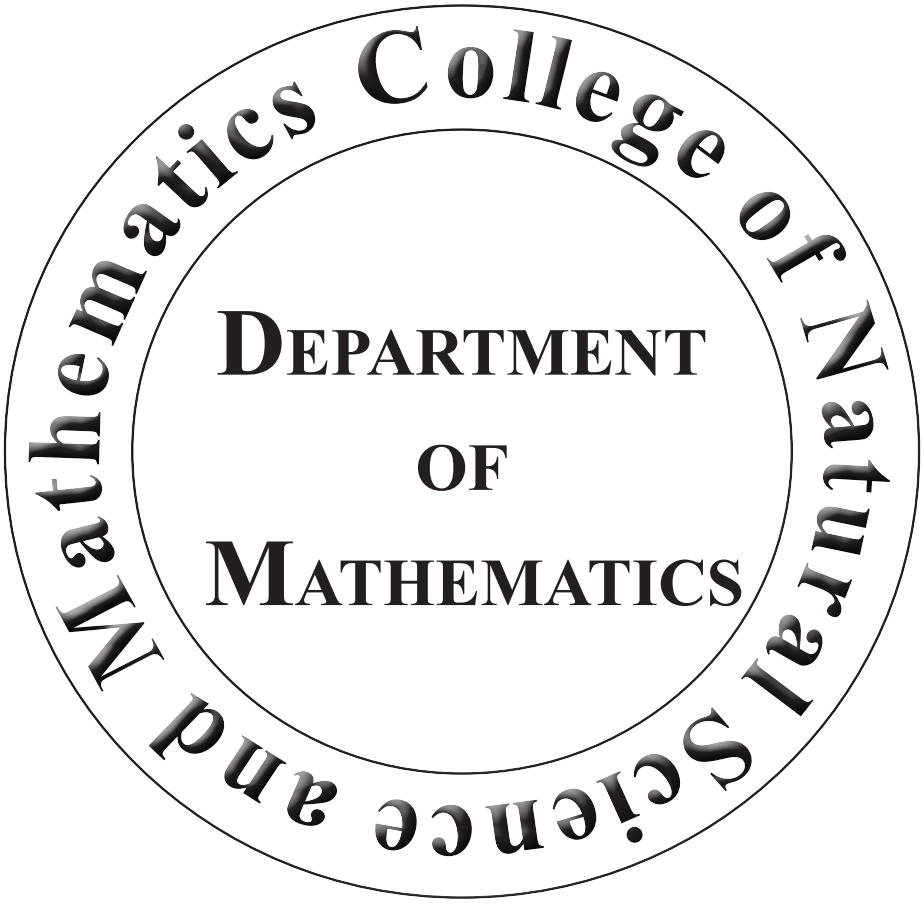
Mason Sims
Faculty Mentor: Stephen O'Connell

The purpose of this research is to take an in-depth look at the increase in popularity of eSports over the last few years. More specifically, the focus examines the growing number of spectators who participate in eSporting events. This research will analyze patterns of attendance at live events, where people travel to convention halls in order to watch players in a physical setting. The analysis of these live events will investigate changing patterns of size of venues (how many people can a venue host) and cost of attendance for a spectator. As well as provide a comparison of eSport conventions to other, more traditional events. Additionally, this research will analyze the off-site viewership of these events and briefly examine patterns in virtual attendance of spectator events. This will include reviews of participation in online streams of events, a brief explanation of the phenomenon known as "barcraft", and estimations of total participation in viewing events. The research will conclude with a demography through which statistical patterns dealing with age, gender, ethnicity, and nationality of the spectators will be addressed.

Environmental Injustice: How Race and Income can Affect Your Health

Frank Zuniga
Faculty Mentor: Mary Sue Passe-Smith

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies, according to the EPA. Utilizing GIS proximity and geographic statistical techniques, I will test the hypothesis that race and/or income come into play regarding which individuals are located in the adjacent to such sites: are nonwhites or poorer persons more likely to be within the "toxic mile" surrounding such sites?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Symmetries of the Gross-Pitaevskii Equation

Kyle Barker
Faculty Mentor: Danny Arrigo

We consider the classical and nonclassical symmetries of the Gross-Pitaevskii equation (GPE). We will show that the nonclassical symmetries are more general than the classical symmetries. We further consider first order compatibility and the GPE and show a class of compatible equations exists that are not obtainable by the symmetry method.

Effects of Interactive Images on Student Understanding in Calculus

Katie Burden, Cyrus Koch, Sarah Zimmerman
Faculty Mentor: Jason Martin

Conceiving of and relating pertinent measurable attributes of objects or phenomena is known as quantitative reasoning. This reasoning can be used to continually refine and generalize a student's personal mathematical model so that the associated mathematical concepts may be applied across varied contexts. Reasoning quantitatively while modeling mathematical concepts is especially important with calculus concepts as these concepts are frequently applied to a wide range of contexts across the spectrum of STEM fields.

Project CLEAR Calculus is a research-based effort to develop calculus curriculum that is conceptually accessible to students while simultaneously increasing the coherence, rigor, and applicability of the content learned. First year results indicate substantial gains in students' conceptual understanding but there is room for improvement. Recent studies indicate that interactive images may support additional gains in conceptual understanding.

To capitalize on recent advances of technology, virtual manipulatives (computer based interactive representations) and animations were constructed to support Project CLEAR Calculus. In this study we asked the questions, "What effects do interactive images have on student understanding?" and, "How do students conceive of and relate quantities differently with graphical and contextual representations?"

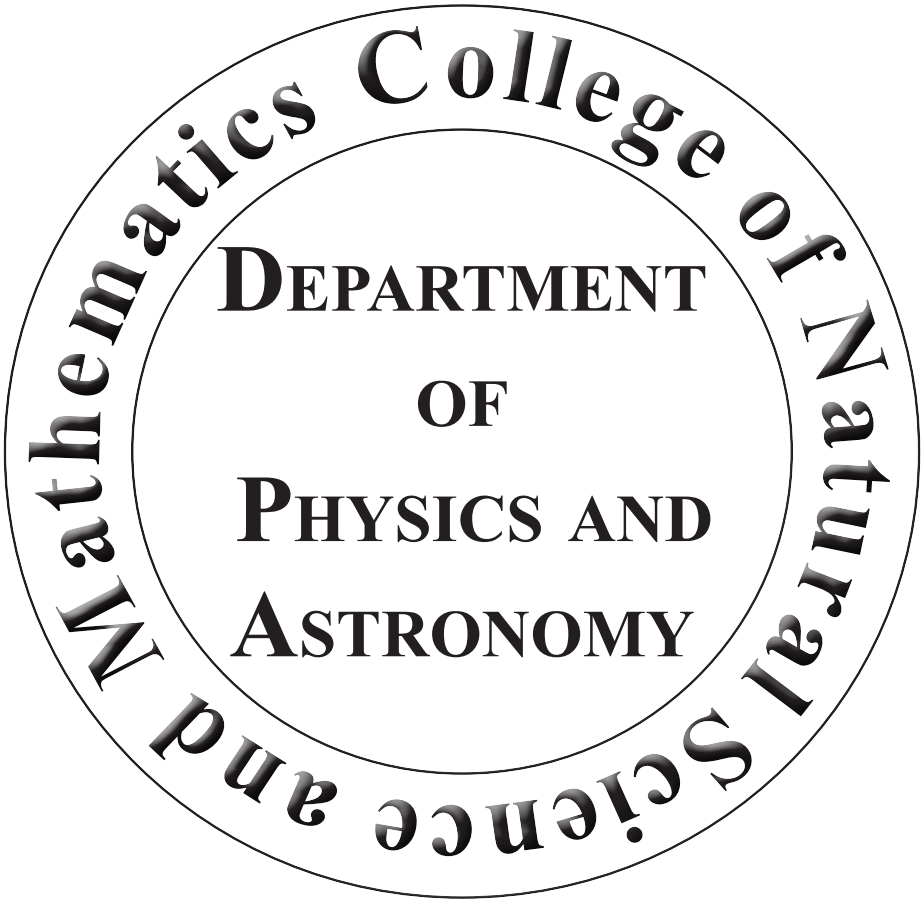
During clinical interviews, individual students were shown contextual and graphical representations with differing levels of interactivity, including static images, animations, and virtual manipulatives. They were asked a series of questions to gauge whether a more interactive representation aided their understanding of the concept and their ability to reason quantitatively. Students' interactions with the images were recorded and analyzed with a focus on determining when the students began reasoning quantitatively.

Early results indicate that students first attended to general shapes and patterns and that the transition from static to animated representations tended to correlate with a recognition of changing quantities.

Mathematical Modeling of a Smoking System

Alma Malibekova, Diana Morales
Faculty Mentor: Long Le

Our research focuses on mathematical modeling of smoking in a population. The study focuses on four different groups that consist of a potential, exposed, smoking, and quitter individuals. A set of differential equations is derived for the system whose equilibrium points are found and analyzed for their stability. Our results determine whether the system will eventually reach stability and whether smoking will become nonexistent or more prevalent within the system.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Identification of AGB Variable Stars in the KELT Survey

Robert A. Arnold[1]
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This research investigated the time-series photometric properties of asymptotic giant branch (AGB) stars using data from the KELT survey. KELT is an exoplanet transit survey run by astronomers from Ohio State University, Vanderbilt University, Lehigh University, and the South African Astronomical Observatory. KELT uses small robotic telescopes, one in Arizona and one in South Africa, to survey roughly 60% of the sky to record light curves in search for exoplanet transits. For this research, objects observed by KELT were cross-matched to the WISE and 2MASS catalogs in order to collect colors in multiple filters. This information was used to create a two color diagram, and the AGB stars were identified using criteria taken from Tu and Wang (2012). The AGB stars were then tested for coherent photometric variability using Stetson analysis. The periodicity of the stars having a high Stetson L statistic was determined using the Lomb-Scargle method. After identifying 21,279 candidate AGB stars observed by KELT, we find 300 of them showing strong periodic behavior. Further work will be done to search for relationships between physical properties of the stars such as color and atmospheric chemistry and light curve parameters such as period and amplitude. The data from the KELT telescopes make it possible to analyze large numbers of Miras and other red giant variables and will hopefully provide astronomers with a useful catalog for better understanding the properties of these stars.

Acknowledgment: This work was supported by the NSF grants PHY-0849416 and PHY-1359195

Changes in Elasticity of Rat and Mice Bones Under Simulated[+] Space-like Conditions

Lawrence M. Benzmiller and Hayley N. Heacox

Faculty Mentors: Rahul Mehta, Azida Walker,
M. Dobretsov and P. Chowdhury**

The aim of this study is to determine the changes in elasticity and lattice structure in bones of rats and mice, which are matured under space-like conditions of simulated microgravity and cosmic radiation. The microgravity was simulated through Hind limb Suspension (HLS) of the animals before they were sacrificed. The animals were also exposed to a total radiation of 10 Grays over ten days. The non-irradiated and/or the unsuspended animals provided the control data. A Scanning Electron Microscope (SEM) was utilized to image bone cross-sections in order to study the changing bone lattice structure.
The leg bones (tibia and femur) were bent with applied forces, and the corresponding strain was measured via two different methods. The first method consists of a LASER based bending setup (Cantilever); the second method includes a three-point bending technique with a force sensor. This method involves a machine that moves the bone a certain distance vertically, and consequently, a force is exerted on the bone. For both methods, an analysis of stress versus strain provided the elastic modulus of the bones. In some cases, the fracture limit was also measured. Analysis of the results demonstrated that the bones had a Young's modulus between 6 and 18 , and the relative comparison showed that this modulus for the control group was approximately 2.5 times larger than that for the bones of the HLS group. This clearly points to a less elastic nature of leg bones exposed to HLS compared with control bones. In addition, the trend of the stress versus strain graph (beyond the linear range) indicated a substantially lower breaking point for HLS leg bones. The elastic modulus and lattice structure changes indicated a weakening of the bones under space-like conditions of microgravity. The changes were even larger when radiation effects were taken into account**.**

[*]University of Arkansas for Medical Sciences
[+]This work is supported by Arkansas Space Grant Consortium

Metacognition and Epistemic Games in IPLS Group Problem Solving

Charles Bertram
Faculty Mentor: Andrew Mason

In order to improve how physics is being taught in introductory physics for life sciences (IPLS) courses, an effort is being made to understand how non-physics majors learn physics from a problem solving perspective. A metacognitive exercise in problem solving was given to an IPLS class at UCA over the course of the Spring 2014 and Fall 2014 semesters. This exercise was presented to the class at the beginning of the lab period and the students were allowed an allotted period of time to work in groups to solve a context rich problem relevant to that day's lab activity. The exercise featured scaffolding in the form of a rubric that students could use to note where they struggled in a group problem solving effort. One of the concerns was that students who are not physics majors do not necessarily have the same epistemic framework as physics majors would for the classroom. As such, we examine written artifacts from the students' reflection activities and audio-visual data recorded from the various groups working on the activity for evidence of different epistemic games. We also describe a comparison of written artifacts to pre-post data from the FCI and CLASS surveys.

Sound Absorption and Resonance of Venturi Resonator Systems

John P. Ferrier, Jr
Faculty Mentor(s): William V. Slaton

Venturi resonators allow for sound absorption in wind pipes while introducing minimal flow damping to the system. Utilizing this technology, it is possible to create sound abatement technologies for use in larger scale applications without utilizing volume outside of the pipe. To test this, a 3D printer was used to create Venturi resonators, and microcontroller systems were developed for data acquisition, in order to test for flow excitation and absorption to verify the acoustical theory.

Pearcey Function Modeling of the Transverse Cusp Caustic

Nicholas Frederickson
Faculty Mentor: Carl Frederickson

The transverse cusp caustic is an acoustical phenomenon in which sound rays form a focal envelope after being reflected off a curved surface. The amplitude of the waveform is highest along the edge of this envelope, lower on the inside of the envelope, and nearly nonexistent outside of the envelope. The diffraction pattern associated with the transverse cusp caustic is given by the Pearcey function. Inside the cusp caustic there are three specular reflection points on the curved surface. At the caustic two of these points merge. Outside the caustic there is only one specular reflection. In propagating from the surface to an observation point inside the caustic, some of the specular ray paths will touch the caustic surface. The shapes of these pulses will be changed during this encounter.

To look for these ray paths, a reflective surface of the necessary shape was created using a MakerBot 3D printer. Sound bursts from a 50 kHz source were directed at the surface and the reflected wave front is measured at certain points inside and outside of the expected caustic. Measurements of the shapes of the reflected signals show the expected shape changes. In order to test Pearcey function modeling of the transverse cusp caustic diffraction pattern, MATLAB code was written to evaluate the function based on the source, reflective surface, and observation positions. Quasi-static signals will be used to develop a picture of the acoustic wavefield that will then compared to the model generated by the Pearcey function.

Construction of a Sub-Sonic Wind Tunnel

Samuel A. Johnson
Faculty Mentor: Carl Frederickson

The sub-sonic wind tunnel is a staple piece of equipment for all forms of aerospace engineering. Even with computers allowing increasingly accurate models, wind tunnels are still needed to verify predictive models and also visualize fluid flow about a specific design. An operational wind tunnel will provide another tool to allow experimentation conducive to engineering fields. The tunnel was designed with three parameters in mind: cost, wind speed, and laminar airflow. A tunnel with variable wind speeds and laminar airflow is a good emulator of objects moving through the atmosphere. At the highest of three speeds the tunnel is expected to have winds approach 100 mph. So long as the airflow at this speed is both laminar and continuous, the proposed tunnel will allow for the study of basic fluid flow principles (like air drag) and design of parts for cars, aircraft, and spacecraft.

Impedance Tube Measurements of Acoustic Properties of Porous Materials

Forrest McDougal
Faculty Mentor: Carl Frederickson

An impedance tube has been used to make measurements of the acoustic impedance of porous samples. Micron-scale sized glass beads were tested for their characteristic impedance. Software was developed to make the data acquisition process more robust. Unidentified issues with previous measurements were discovered due to the new process. The measurements taken were compared to previous measurements and calculated values. The end goal is to develop a system that can be used with 3D printed porous materials to test porous material acoustic propagation models.

The Killing Equation and Isometriesof the Metric

Brandon Miller
Faculty Mentor: Balraj Menon

Though it is often not mentioned, physics is done on manifolds—usually $\mathbf{R}^3$, but also in Minkowski spacetime in $\mathbf{R}^4$, the state spaces in thermodynamics, and the configuration spaces in mechanics, and even more exotic manifolds in M-Theory. Often these manifolds have a tensor field defined on them: The metric tensor, which gives the notion of distance on the manifold. One can ask the question "what are the transformations that are allowed by this metric such that the metric (the measure of distance) does not change?" and this is equivalent to finding the vector fields that generate these transformations, known as Killing vector Fields, and these are solutions to Killing's Equation. These vector fields and their associated transformations are closely related to conservation laws on the manifold. Conservation laws are very important in physics, and conserved quantities (such as energy, momentum, charge, etc.) are useful in describing many physical situations. Killing's Equation was solved to obtain the Killing vector fields admitted by various metrics, including the Euclidean metric, the Minkowski metric, the metrics on the 2-sphere and 3-sphere, and the Roberston-Walker metric.

A Study of Concrete and Determining Elastic Moduli of Materials Using Resonance

Gerard Munyazikwiye
Faculty Mentor: William Slaton

The objective of this multidisciplinary study was to determine elastic moduli of materials; especially concrete, using a resonance technique. Therefore, a separate study of concrete was initially done to learn necessary skills that are required for one to work with concrete. In order to determine elastic moduli of rods; their mass, length and density were obtained experimentally. The torsional, longitudinal, and transverse resonance modes for the rods were recorded by a multichannel analyzer which swipes the current through coils that were wrapped around on both ends of the bar. Both ends of the bars were placed in a magnetic field that was created by two PASCO magnets in which the two bar ends were placed. Hence, an electromagnetic force caused the bar to vibrate with different frequencies from which a resonance frequency can be obtained. These resonance frequencies are related to the elastic properties of the materials; Young's moduli and Shear moduli. Therefore, by measuring these quantities the strength of the material were determined. Preliminary tests as proof of principle were conducted with aluminum, brass, wood and plastic rods and the results supported the claim. Data and experimental techniques for determining the elastic moduli for concrete using this procedure will be presented but more work need to be done for the final conclusion to be made.

Effects of Microgravity and Radiation on Elastic Modulus of Rat Femurs Using 3-Point Bending*

Otis Perkins[1],
Faculty Mentors: A. Walker[1], R. Mehta[1], M. Dobretsov[2], P. Chowdhury[3]
1 Department of Physics and Astronomy, University of Central Arkansas, Conway, AR, 72035, USA
2 Department of Anesthesiology, University of Arkansas for Medical Sciences, Little Rock, 72205, USA
3 Department of Physiology and Biophysics, University of Arkansas for Medical Sciences, Little Rock, AR, 72205, USA

The aim of this study was to determine the changes in elasticity and lattice structure in leg bone of rats which were: 1) under Hind-Limb Suspension (HLS) by tail for 2 weeks and 2) were exposed to radiation of 10 Grays in 10 days. The animals were sacrificed at the end of 2 weeks and the leg bones were surgically removed, cleaned and fixed with a buffered solution. The mechanical strength of the bone (elastic modulus) was determined from measurement of bending of a bone when under an applied force. Two methodologies were used: i) a 3-point bending technique and ii) classical bending where bending is accomplished keeping one end fixed. Three point bending method used a captive actuator controlled by a programmable IDEA drive. This allowed incremental steps of 0.047mm for which the force is measured on the bone suspended in a harness which was specifically designed and generated using three-dimensional printing to allow minimal force in any direction other than directly downward on the midpoint of each bone. The data is used to calculate the stress and the strain. In the second method a mirror attached to the free end of the bone allowed a reflected laser beam spot to be tracked. This provided the displacement measurement as stress levels changed. Analysis of stress vs. strain graph together with solution of Euler-Bernoulli equation for a cantilever beam allowed determination of the elastic modulus of the leg bone for (i) control samples, (ii) HLS samples and (iii) HLS samples with radiation effects. To ascertain changes in the bone lattice structure, the bones were cross-sectioned and imaged with a 20 keV beam of electrons in a Scanning Electron Microscope (SEM). A backscattered detector and a secondary electron detector in the SEM provided the images from well-defined parts of the leg bones. Elemental compositions in combination with mechanical properties (elastic modulus and lattice structure) changes indicated weakening of the bones under space-like conditions of microgravity and radiation.

*Acknowledgements to the Arkansas Space Grant Consortium Grant #RID14141

Atomic Force Microscopy to Quantify Adhesive Force between Silicon Tip and Silicon Surface in the Presence of Graphene

Brandon Rogers, Lucus Ratz, and Forrest McDougal
Faculty Mentors: Radwan Al Faouri and Dr. Azida Walker

Graphene, a single-layer, two-dimensional form of carbon in a hexagonal lattice in which one atom rests at each vertex[1], can be used for many biomedical applications including *in vitro* intracellular delivery of anticancer drugs[2] and its use as a biosensor to detect numerous biomolecules.[3] The opportunities provided by this material emerge from its electrical, optical, mechanical, and chemical properties. The size of graphene is highly debated mainly due to its distribution dependence on the solvent. In theory, the definition of graphene refers to a single layer of carbon with an atomic thickness of 0.345 nm[4]; however, graphene flakes gather in small areas as a result of the liquid exfoliation process and solvent used to coat the silicone sheet. An atomic force microscope (AFM) method measured the adhesive force between a silicon surface and a silicon tip in the presence of graphene to quantify the differences in adhesive forces. The apparatus mapped graphene patterns on acetone-washed and deionized water-washed silicone foundations overlaid with either functionalized or non-functionalized graphene. These methods could be used to better understand the interaction of graphene with cellular structures.

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Computational Investigation of the Surface Tension of Supercooled Water

T. Ryan Rogers
Faculty Mentor(s): Feng Wang (University of Arkansas, Department of Chemistry and Biochemistry)

It has been debated whether or not a second inflection point (SIP) exists in the surface tension of water as its temperature drops below the freezing point. Prior experimental and computational analysis pointed toward the existence of the SIP; while recent data suggest a linear relationship. We employ the accurate WAIL potential for water [E. R. Pinnick, S. Erramilli, and F. Wang, J. Chem. Phys. **137**, 014510 (2012)], which was derived purely from electronic structure information, to determine the surface tension of water in the temperature range from 223K (-50°C) to 298K (25°C). Preliminary results could either be fit with or without a SIP with the linear fit giving slightly better weighted sum of square residuals. The fit with a SIP gives its location at -13°C, also in agreement with prior experimental estimate. The WAIL model agrees better with experimental extrapolation at lower temperatures.

Determining Black Hole Mass of Active Galactic Nuclei Using FWHM of the Hβ Emission Line and Luminosity Relations

Hunter Ward, Stephen Clark, Lucus Ratz
Faculty Mentor(s): Debra Burris, Balraj Menon

Our research is a joint project with Dr. J. Kennefick and others at the University of Arkansas. There they hope to determine a correlation between the spiral galaxy pitch angle and the mass of the super massive black hole (SMBH). Our goal is to provide independent mass determination of these black holes in order to conclude if correlations exist. We will do this by looking at the emission lines from the Active Galactic Nuclei (AGN) which contains the Balmer Hβ emission lines. From these Hβ lines, the velocity of the gas can be determined. The luminosity of the black hole can be determined by applying the extinction correction to the spectral files. The extinction correction accounts for the amount of light that our own galaxy absorbs, giving the true luminosity of the AGN. With both of these key components, the mass of the black hole can be calculated. Now we have recently begun using IRAF to measure the FWHM of the Hβ lines for a group of AGN selected by Dr. Kennefick. From here we hope to continue with the research until a correlation with the spiral galaxy pitch angle and the mass of the black hole can be made.

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