The College of
Natural Sciences and Mathematics

University of Central Arkansas

# The 16th Annual Student Research Poster Symposium Abstracts

## April 23, 2010
## 2:00 - 4:00 pm

## McCastlain Hall Ballroom

COME MEET SOME OF OUR NATION'S FUTURE SCIENTISTS AND LEARN ABOUT THEIR RESEARCH PROJECTS!

Introduction from the Deans office.

This book contains the abstracts for the 16th Annual College of Natural Sciences and Mathematics Student Research Symposium. The symposium highlights graduate and undergraduate student research projects completed under the guidance of faculty in the departments of Biology, Chemistry, Computer Science, Mathematics, and Physics and Astronomy. This event has grown every year. This year's program includes 76 abstracts with 122 student authors and 44 faculty mentors. The opportunity to apply knowledge to real problems is an important component of the education that students receive at UCA. This symposium is an occasion to celebrate the scientific achievements of our students.

# Table of Contents

# Department of Biology

# Cloning by Yeast Gap Repair to Determine the Different Functions of the Homologous Proteins Mdv1 and Caf4 in Mitochondrial Fission.

***Justin Allen***
*Faculty Mentor(s): Kari Naylor*

Mitochondria are double-membrane organelles responsible for production of ATP- a cell's energy source. This function depends on the specialized structure of mitochondria which are tubular and highly branched, quite unlike the jellybean structure shown in textbooks. This specialized structure is maintained by two classes of membrane events, known as fusion and fission. Fusion is the merging of mitochondria, whereas fission is the division of mitochondria. If these events are not balanced, mitochondrial structure will be compromised, possibly leading to mitochondrial disease, such as blindness or hearing loss.

In *Saccharomyces cerevisiae*, our budding yeast model system, three proteins are required for mitochondrial fission: Dnm1, Fis1, and Mdv1. The dynamin-related GTPase, Dnm1, self-assembles into punctate structures that mediate mitochondrial division. Post-targeting, Dnm1-dependent division is controlled by the actions of the WD repeat protein, Mdv1, and the mitochondrial TPR-like outer membrane protein, Fis1. Analysis of Mdv1 indicates that not only does it function as an adaptor molecule but that dynamic interaction between Mdv1 and Dnm1 play a key role in division by regulating Dnm1 self-assembly.

A newly identified protein, Caf4, a homolog to Mdv1, may also to function as an adaptor molecule. Interestingly, Caf4 is not required for fission and over-expression experiments suggest that Caf4 may inhibit fission. To determine the role of Caf4 we have undertaken a structure-function approach by using Yeast Gap Repair to perform crude domain swapping between three domains (NTE, CC, WD) of Caf4 and their corresponding domains of Mdv1. Preliminary analysis of these constructs suggests that while Mdv1 and Caf4 are not redundant in function, Caf4 does have some fission activity in the absence of Mdv1. Interestingly, the junction between the NTE and CC domain in either Mdv1 or Caf4 appears to be important for fission activity. Completion of this analysis will provide additional insight into the molecular process of mitochondrial fission and a better understanding of the dynamics that maintain mitochondrial structure.

# A Study of Eukaryotic Mitochondrial Fission using *Dictyostelium discoideum*

***LaRhonda Apata and Dean Turbeville***
*Faculty Mentor: Kari Naylor*

*Dictyostelium discoideum* has emerged as an important model organism in the study of cytokinesis and other membrane scission events. *D. discoideum*'s optical clarity, high capacity for gene-marker tagging, and the simplicity of its life cycle make it a great eukaryotic model organism for our research studying mitochondrial fission. Previously in our lab, similar fission studies have been performed in yeast, but *D. discoideum* presents new challenges and questions. Our goal is to define and quantify fission events in *D. discoideum* and ultimately understand the mechanism of fission in all eukaryotes.

Our first task has been to visualize fission events, and quantify mitochondrial morphologies in real time using confocal microscopy. Staining the mitochondria with MitoTracker Red, we have been able to obtain high quality time lapse images, but fission events have yet to be identified. Typically the mitochondria of *D. discoideum* appear to "wobble" as if tethered to the cytoskeleton. The vast majority of mitochondria that have been visualized are spherical, with some varying degrees of elongation in a small number of cells.

# "Remnant" Cells Do Not Survive In The Brain, But Subplate Do

***S. Baldwin, A.L. James, K. Erbach, and A. Kilgore***
*Faculty Mentors: Barbara Clancy, George Bratton (UCA)*
*T.J. Teague-Ross (UAMS)*

Subplate neurons participate extensively in the development of the mammalian brain. Following development some undergo apoptosis, however some persist. Those that remain are often referred to as a remnant cell population. Yet supporting a vestigial population is metabolically expensive, and therefore unlikely. Our lab studies the persisting subplate cells across aging in rodents. These cells are located in advantageous positions below and above the white matter and project connections throughout the cortex. We reconstructed the subplate neural population from sections of rat cortex on postnatal days (P) 0, P7, P30, 6 months, and 1 year using three-dimensional software (Neurolucida, MicroBrightField). Subplate cell counts and overall volumes were collected (Stereo Investigator, MicroBrightField) and compared across ages. Preliminary statistical analysis (Analysis of Means; Minitab) indicates that despite the decrease in subplate

numbers that occurs at early ages, the subplate stabilizes and persists across maturity (6 months, 1 year). In fact, persisting subplate cells appear to be remarkably resilient across aging; such stability suggests a role in mature cortical function.

## Immune Responses to a Nickel-based Anti-Tumor Compound in Both Mercury Susceptible and Mercury Resistant Mice

***Autumn Bewley***
*Faculty Mentor: Ben Rowley*

The purpose of this study is to test immune responses to a Nickel-based compound in both mercury susceptible and mercury resistant mice. In vitro studies have previously exhibited cytotoxic activity of this novel nickel compound, [(dppe)Ni(CysEt)]Cl, in a human breast cancer cell line (MCF-7). A concern of utilizing metal molecule-based therapies in human beings, however, is allergic reactions and/or induction of immune system abnormalities. We want to determine if this compound might be safely used as an anti-tumor drug in humans. We are repeating our pilot study to confirm if this anti-tumor compound induces any autoimmune responses as a side effect in mice. In order to build upon the results of the pilot study, we have not only expanded the scope of the experiment, but also added groups of a mouse strain that is genetically resistant to heavy metal induced autoimmunity. This will indicate if the induction of autoimmune response is specific to the genetically susceptible mouse strain. The mice are injected with subtoxic doses of the nickel compound, and blood serum samples are extracted for analysis. Pan-IG-immunofluorescence will be utilized to label the antibodies with fluorescent dyes so they may be visualized with a microscope. Sera ELISA's will allow us to asses the total antibody levels in the serum samples. We will be looking at IgM, IgG1, and IgE. IgG1 and IgE levels tend to rise in response to heavy metals and IgM levels will provide additional information. We predict that autoimmunity will be induced in the genetically susceptible mice, but not in the genetically resistant mice. If autoimmunity is not induced in the resistant mouse strain this may mean that the compound could be used in humans if they do not have a heavy metal susceptible genotype.

## Segregation for Apomictic Seed Formation in Plants

***Halee Burrow, Claire Desrochers, Harry Richardson, and Shawn Brummett***
*Faculty Mentor: Richard D. Noyes*

Genetic analysis of traits relies on the variation in trait value. Apomixis, asexual seed production, is a naturally occurring phenomenon that is controlled by two genes. The goal of the experiment is to study apomixis trait variation, measured by estimating seed production, in hybrid F1s between three triploid (2*n*=27) apomictic pollen donors and a single common sexual diploid (2*n*=18) seed parent. Progeny show chromosome number variation ranging from diploid to triploid values. The frequency of seed makers at each chromosome number conforms closely to expected values based on genetic models. Work is ongoing to measure seed production quantitatively among the three F1 populations. These data will be used for mapping genes that control levels of apomictic seed production in plants.

## Determining the Role of FtsZ Proteins in Mitochondrial Division in *D. discoideum*

***Jordan Byrd and Kelly Dunning***
*Faculty Mentor: Kari Naylor*

Mitochondria are cellular organelles which carry out respiration and produce the energy needed to fuel almost every cellular process. Research on yeast and mammalian mitochondria emphasize the importance of the tubular structure in the function of the mitochondria, known to be maintained by Dynamin Related Proteins (DRPs). One mechanism of DRPs to maintain tubular structure is through division of the mitochondria.

Mitochondria evolved from prokaryotic bacterial ancestors. It is known that bacterial cell division is mediated by the FtsZ protein; however, it was thought this protein was lost during the evolutionary process that formed mitochondria. Until research of the eukaryotic organism *Dictyostelium discoideum* by Gilson and colleagues identified two FtsZ orthologs, *FszA* and *FszB* that may play a role in maintaining mitochondrial structure. Our goal is to determine the role of FszA and FszB in the mitochondrial fission process. In order to assay the fission machinery in *D. discoideum* we will create two deletion strains, *ΔfszA* and *ΔfszB,* and then analyze fission events in real time using Laser Confocal Scanning Microscopy.

Defects in mitochondrial structure hinder the process of apoptosis or programmed cell death, which has implication in a multitude of mitochondria-linked disorders. The outcomes of our work will lead to better understanding of the causes and treatment of mitochondrial diseases related to alterations in the tubular structure of

the mitochondria. This project is vital to further our understanding of the evolutionary relationship between mitochondria and prokaryotes and increase our knowledge of fission machinery in all eukaryotes.

## Analysis of B-cell Antibody Gene Segment Use in response to Mercury Treatment

***Heather J. Clarke***
*Faculty Mentor(s): Ben Rowley*

A.SW congenic strain mice have been used for three decades as a model of chemically-induced autoimmunity. When introduced with mercuric chloride ($HgCl_2$), a defined autoimmune response results in these mice, characterized by antinucleolar antibodies (ANoA) of the IgG1 and IgE isotypes. Although many studies have been conducted utilizing this mouse model, none have examined specific antibody light-chain gene segments of mature, circulating B-cell receptors (BCRs) which are selected in response to mercury treatment. Previous work in this lab has examined specific heavy-chain gene segments. As a continuation of this research and pilot project for future studies, we have refocused our efforts to begin examining light-chain segments. Using nested polymerase chain reaction (PCR), individually sorted B-cells from mercury-treated and sham-treated mice were examined for light-chain antibody rearrangements which could be amplified. This method was then followed by sequence analyses of gel-purified products in order to identify individual VJ gene segments used by B lymphocytes from treated and non-treated mice.

## Diet and Life History of the Bowfin (*Amia calva*) Collected in Eastern Arkansas near Brinkley, Arkansas

***Brandon Clemons, Michael Edmonson, and Brandon King***
*Faculty Mentor(s): Ginny Adams, Reid Adams*

The bowfin, *Amia calva*, is native to North America and abundant in many Arkansas waterways. In spring 2009, an eradication effort was made on the Big Piney watershed in eastern Arkansas by the Arkansas Game and Fish Commission (AGFC) on the invasive northern snakehead, *Channa argus*. This presented an opportunity to study a morphologically similar native species, *A. calva*, as well as comparing the effects of niche overlap between *C. argus* and *A. calva*. A gonadosomatic index (GSI) was calculated for males (n=32) and females (n=24). An average GSI of 3.03% was found for females and 1.18% for males; 20.8% of the females were gravid. The

average GSI calculated for all *A. calva* sampled was higher (3.03%) compared *C. argus* (1.29%), indicating an earlier reproduction in *A. calva*. Male to female ratio (1.3:1) was not significantly different from a 1:1 ratio (chi-square, P = 1.000). A digestosomatic index (DSI) was 8.1% for N=57. Comparisons of bowfin density and condition in relation to snakehead presence will be discussed.

## Identification of Novel MYB Transcription Factors Involved in Tomato Phenylpropanoid Biosynthesis in Response to Light

***Jennyfer Delvasto***
*Faculty Mentors: J.D. Swanson (UCA)*
*Stephen Grace (UALR)*

The leaves and fruits of tomatoes produce significant levels of phenylpropanoids which are an important step in the flavonoid biosynthetic pathway. Flavonoids are health-promoting components due to their high antioxidant capacity and ability to induce human protective enzymes. We are investigating the effects of high irradiance on phenylpropanoid metabolism in tomato plants. For this experiment we will be comparing (WT) wild-type plants with two monogenic mutant lines, *aw* (anthocyanin without) and *hp-2*$^{dg}$ (high pigment-2). Plants with the *aw* mutation synthesize flavonols but not anthocyanins while plants with the *hp-2*$^{dg}$ mutation display higher anthocyanin levels in light and have more deeply pigmented immature fruits. We are identifying which genes involved in phenylpropanoid metabolism are most responsive to light intensity. MYB transcription factors appear to play a key role in gene regulation of these pathways. Interestingly, the function of many MYB transcription factors in tomato is unknown. In order to identify new functional roles of MYB transcription factors involved in tomato phenylpropanoid biosynthesis we are BLASTing known MYB transcription factor genes in *Arabidopsis* and *Oryza* with the tomato genomic sequence. Using this information we will be making degenerate oligonucleotide primers PCR to amplify EST fragments of interest from tomato mRNA. We hope to isolate and characterize potential regulator factors and modifying enzyme in tomato based on orthologous gene sequences and identify a set of target genes that can be used for RT-PCR, northern blots, and in-situ hybridization.

# Changes in invertebrate community structure along a longitudinal gradient in Big Piney Creek, Arkansas

***Chris Fuller***
*Faculty Mentor(s): Sally A. Entrekin*

We measured changes in invertebrate community structure along a longitudinal gradient of ditches, streams, and wetlands in the Lower Mississippi River Delta Valley in Big Piney Creek watershed, Arkansas. The watershed is significantly altered from agriculture and associated hydrologic management. We hypothesized structural changes in the invertebrate community, along a longitudinal gradient from increased riparian inputs and shading, cooler water temperatures, and more complex habitat. Thus, we hypothesized that taxa richness and diversity of species would be highest in the wetlands, then streams, and lowest in ditches. Conversely, we hypothesized that invertebrate abundances would be highest in ditches, from greater primary production, and lowest in the wetlands. Preliminary data shows that abundance was higher at the ditch site (n=6) (mean±1SE, 1098±263), followed by the stream site (n=4) (567±271), and wetland site (n=4) (145±32) ($p=0.046$). Taxa richness was highest at the wetland site (18±1), followed by the ditch site (18±0.80), and stream site (11±1) ($p=0.002$). Simpson's Diversity was highest at the wetland site (4.36±1.27), followed by the ditch site (1.88±0.22), and the stream site (1.62±0.17) ($p=0.028$). The effects of agriculture on the physical environment, and consequently the invertebrate community, could have negative effects on higher trophic levels, like fish, due to changes in resource allocation and availability.

# The Transformation of Rubus and its Application to the Study of Plant Secondary Metabolites in Plant and Animal Cells

***Nadine Gates, Kayla Parker, Courtney Walker, and Natasha Skiver***
*Faculty Mentor(s): J.D. Swanson*

Transformation is the genetic alteration of a cell resulting from the uptake and expression of foreign genetic material (DNA). The ability to perform transformation is a technique that has yet to be accomplished in blackberry. To this end, we used *Agrobacterium*-mediated transformation techniques to transform the blackberry (*Rubus spp*) in tissue culture. A vector containing a GFP reporter gene was used to produce transgenic tissue. Results thus far have revealed the successful transformation of blackberry callus and studies are ongoing. We intend to use this system to aid in the study of secondary metabolites in *Rubus*. Plant secondary metabolites provide many leads for new therapeutics that are currently on the market, however, their mechanism of action is often not understood in either plants or animals. We hypothesize that phenolics (a class of secondary metabolites) represent a class of plant hormones that activate developmentally-regulated signal transduction pathways and are also able to activate mammalian signaling pathways by mimicking small ligands.

# Evolutionary History of Sexual and Apomictic *Erigeron tenuis* (Asteraceae)

***Dulcinea Groff***
*Faculty Mentor: Richard D. Noyes*

The evolutionary relationships of sexual diploid and apomictic polyploid populations of the flowering plant species *Erigeron tenuis* (Asteraceae) were studied. *Erigeron tenuis* is the presumed sister species to *E. strigosus* and it comprises diploid and polyploid populations. Phylogenetic analysis was conducted using sequence from the ITS and ETS spacer regions of nuclear ribosomal DNA (nrDNA). The phylogenetic analysis nests *E. tenuis* within *E. strigosus*, which implies that *E. strigosus* is paraphyletic. Cloning of polymorphic ITS and ETS spacer regions reveals that some sexual plants and most apomictic plants of *E*. *tenuis* combine sequences of both *E*. *tenuis* and *E*. *strigosus*. This indicates that hybridization between the two species has occurred. This result has implications for our understanding of apomixis in the group.

# Plant Diversity of Faulkner County as represented in the UCA Herbarium

***Liz Hawkins***
*Faculty Mentor: Richard D. Noyes*

A herbarium is a collection of dried preserved plants that records diversity through space and time. The herbarium at UCA was founded in the 1920s and contains approximately 20,000 preserved plant specimens. At the start of his project, the specimens representing Faulkner County were mixed in with collections from other counties of Arkansas. The goal of this project was to separate out Faulkner County specimens into archival quality folders and to evaluate the diversity present in the collection. The data shows that the UCA herbarium contains 5,084 specimens from Faulkner County, the oldest of which is a collection by Haas in 1924. A total of 974 different species are present, representing about 34% of the 2,894 naturally occurring species recorded for Arkansas. Of the Faulkner County species represented, 174 (18%) are introduced species. Seventeen species documented in the collection are native plants of conservation concern. These initial findings document the value of the UCA herbarium and will form the basis for computer data basing the collection in anticipation of a flora of Faulkner County.

# The effects of Chinese Privet (*Ligustrum sinense*) in riparian zones and streams of Woolly Hollow State Park in central Arkansas

***Oliver Herbst***
*Faculty Mentor(s): Katherine Larson*

Chinese Privet or *Ligustrum sinense* is a common invasive species in central Arkansas. It is most successful in the moist riparian areas surrounding streams and rivers where it forms dense thickets. Little is known about Chinese Privet and what makes it such a successful invader. The success of an invasive species is contingent on its ability to exploit resources more quickly than their competitors. Furthermore it is hypothesized that many invasives alter characteristics of their environment that promote further invasion. These characteristics are most readily observed in the alterations they cause to the nutrient cycle. To observe these alterations I plan to study decomposition, soil characteristics, and the nutrients stored in the plant tissue. To fully comprehend the changes made it is important to know what the original environment should have been. For this reason the study will be performed in Woolly Hollow State Park where two headwater streams have been located in close proximity to one another. These streams are similar except for the pronounced presence of Privet in only one of the two riparian zones. By comparing

decomposition we can gain an understanding how nutrients are restored from biomass back into useable plant nutrients. To determine if the presence of privet alters decomposition rate, I am measuring the rate of biomass lost from leaf litter bags placed in each of the two steam riparian zones. Litter bags will be collected in April, July, Oct 2010, and January 2011 and a decomposition rate calculated. Preliminary data from the April collection will be presented. I will also measure soil respiration using a soda lime $CO_2$ generation technique. The respiration rate of the soil community will be compared in the privet invaded area and the native area. Finally, because Privet is a riparian species and drops many of its leaves into the streams it surrounds, it could impact the aquatic invertebrate communities living in the streams. I will present data that quantifies the contribution of privet leaves to the decomposing leaves in the stream.

## The Molecular Investigation of Prickle Development Genes: A Model for Cell Communication

***Kayla Hill, Danielle Tippit, Ben Magie, and Meaghan Thompson***
*Faculty Mentor(s): J.D. Swanson*

Prickles are outgrowths of epidermal and sometimes cortical plant tissue that develop from a signaling cascade initiated by the head of glandular trichomes. These signals result in the division and growth of epidermal and underlying cortical cells. Due to the simplicity of their structure, prickle development is an ideal model to investigate how cells communicate to control growth, proliferation, and morphological differentiation. Understanding these modes of cellular communication could be a significant factor in all developmental pathways including mammals. We are currently analyzing gene candidates and their function in prickle development to better understand the role of trichomes in prickle development. We hypothesize that lignification marks the end of prickle development. *PAL 1* and *PAL 2* are known to play a role in the lignification pathway, and have been targeted for functional analysis in this study due to their potential as stop signals in prickle development. We have also hypothesized that GL1 and GIS are involved in promoting trichome initiation. To this end, we have identified orthologous ESTs (expressed sequence tags) from the trichome developmental pathway of Arabidopsis and other model species using a degenerate primer method. We have thus far identified several genes from raspberry and blackberry, our prickle development model plant. Using these orthologous EST sequences we are carrying out functional analysis using *in situ* hybridization. We have found that sectioning tissue for traditional *in situ* hybridization at the exact point of the occurrence of a glandular trichome is difficult; therefore, we have initiated the investigation of whole mount ISH allowing us to look at the entire epidermal surface of the tissue rather than sections. These data will provide some insight as to the potential signaling pathways involved in prickle development and may provide some clue to similar growth and developmental mechanisms in mammalian cells.

# Mate Choice in Mantids: Does Sexual Cannibalism Allow Females to Avoid Inbreeding

***Kyle Hurley and Nicholas Davis***
*Faculty Mentor(s): David Dussourd*

Female Carolina mantids, *Stagmomantis carolina,* often consume males before, during or after mating. The purpose of this behavior is unclear and observations of avoidance behavior by males suggest that a sexual conflict occurs. Males normally approach females from behind and freeze when the female turns in their direction. At approximately one body length from the female, the male jumps on top of the female and attempts to mate. Remarkably, the male abdomen can still attach to the female and apparently mate as the female consumes the male's head. Females of *S. carolina* receive nutritional benefits by consuming males, but little is known about how females decide which sperm to use. We plan to determine whether males cannibalized during mating are able to fertilize eggs as effectively as non-cannibalized males. We have collected egg masses from the Jewel Moore Nature Reserve at the University of Central Arkansas in Conway and the Railroad Prairie Natural Area near Hazen to ensure non-related groups. Virgin females from each location will be paired with either sibling males from the same egg mass or non-sibling males from the other location. Ootheca produced by each mating will be hatched and the number of nymphs and infertile eggs will be counted to give a fertilization ratio. Our goal is to compare the reproductive success of intact and cannibalized males and to determine if females detect kinship during cannibalism.

# Reliability of the MATE: the Measure of Acceptance of the Theory of Evolution

***Stephanie Jimmerson***
*Faculty Mentor: Mark Bland*

Evolutionary theory is regarded as *the* unifying theme in biology (National Research Council [NRC], 1996). Indeed, Darwin's theory of evolution by natural selection is among the most robust of scientific theories, is supported by a tremendous volume of evidence collected from numerous lines of inquiry, and has held up to the most intense scrutiny that science can bring to bear. Blackwell, et al. (2003) writes, "Without evolutionary theory, biology is divested of needed theme, coherence, understanding, and interpretation of relationships." And in the words of the prominent geneticist Dobzhansky (1973), "Nothing in biology makes sense except in the light of evolution." Despite this, studies reveal that many Americans not only have a poor understanding of evolution, but also reject it as a valid explanation of

the diversity of living forms, past and present (Gallup, 1993; National Science Board, 2000; Miller et al, 2006).

The Measure of Acceptance of the Theory of Evolution (MATE) is a survey instrument developed to quantify the acceptance of this scientific theory (Rutledge & Sadler, 2007). Rutledge has proposed that one way to measure the effectiveness of instruction in evolution is to assess changes in the acceptance of this theory, as opposed to belief in it. However, while reliability values have been obtained for this survey instrument for college students (Rutledge & Sadler, 2007), no reliability data has been generated for high school students. To assess the test-retest reliability of the MATE for this demographic, the MATE was administered to approximately 60 students enrolled in a rural Arkansas high school twice, with a two-week interval. The Pearson Product Moment correlation technique was utilized to analyze this data.

References

Blackwell, W.H., Powell, M.J., & Dukes, G.H. (2003). The problem of student acceptance of evolution. *Journal of Biological Education, 37*, 58-67.

Dobzhansky, T. (1973). Nothing in biology makes sense except in the light of evolution.
*The American Biology Teacher, 35,* 125-129.

Gallup, G. (1993). *The Gallup Poll.* Wilmington, DE: Scholarly Resources, Inc.

Miller, J.D., Scott, E.C., & Okamoto, S. (2006). Public acceptance of evolution. *Science, 313*(5788): 765-766. doi: 10.1126/science.1126746.

National Research Council. (1996). *National Science Education Standards.* Washington,
DC: The National Academies Press.

National Science Board. (2000). Science and Engineering Indicators 2000. (NSB-00-1).
Washington, DC: U.S. Government Printing Office.

Rutledge, M. L., & Sadler, K. C. Reliability of the Measure of the Acceptance of the Theory of Evolution (MATE) instrument with university students. *American Biology Teacher, 69*, 332-335.

# Recovery of a Lowland Fish Assemblage Following Large-scale Rotenone Application in Eastern Arkansas

***Clint Johnson***
*Faculty Mentor(s): Ginny Adams and Reid Adams*

During spring 2009, the Arkansas Game and Fish Commission and the United States Fish and Wildlife Service attempted to eradicate northern snakehead, *Channa argus*, from the Big Piney watershed by applying rotenone to approximately 640 km of stream. To examine long-term recovery of native fishes, we collected pre-disturbance community data at 45 sites during the eradication, 19 of which were re-sampled during fall 2009. Although most species had returned to the drainage by fall, other community characteristics, including evenness, were different. Fish densities were significantly higher in fall (9.4 fish/$m^2$) compared to eradication samples (0.5 fish/$m^2$; t-test, P=0.026), though some species declined or were not detected. Fall samples were dominated numerically by tolerant, generalist species such as *Dorosoma cepedianum, Ictiobus sp., Gambusia affinis*, and *Lepomis cyanellus.* Length-frequency histograms indicated population changes for several species. Early-colonizing fishes possessed life history traits conducive to rapid repopulation including mobile adults, high fecundity, and/or early reproduction. Collection of pre-disturbance data provides the unique opportunity to further quantify patterns of recovery. Future samples, including spring 2010 and fall 2010, will give insight into long-term recovery characteristics after severe disturbance, assisting managers in balancing benefits versus collateral damage when considering invasive species eradication.

# Movements and Habitat Use of a River Leviathan, Alligator Gar (*Atractosteus spatula*)

***Edward R. Kluender***
*Faculty Mentor(s): Reid Adams (UCA)*
*Lindsey Lewis (US Fish and Wildlife Service Arkansas Field Office)*

The Fourche LaFave River of west-central Arkansas accommodates a viable population of alligator gar. The relatively unaltered status of the river allows recruitment by maintaining connectivity with spawning locations in the tributaries, making it attractive as a model for the movements and habitat use of periodic fishes in a contiguous system. Over four trips, 32 adult alligator gar were captured with gill nets from a deep bend on the Fourche LaFave River and externally tagged with Advanced Telemetry Systems F2090B radio transmitters. They were also tagged with passive integrated transponder (PIT) tags and t-bar Floy tags. Lengths (147.0 cm – 224 cm) and weights (25.0 kg – 84.5 kg) ranged widely. Tracking began January 2009 and will continue until the summer of 2010. Basic descriptive analyses reflect seasonal differences in macrohabitat use, particularly between the main channel of the river and its tributaries. Further tracking

will add to the body of data describing movement patterns and habitat use and selection on various temporal scales. Microhabitat data have been collected throughout the project and use versus availability will be a strong focus during the remainder. Additionally, we will seek to analyze the patterns of movement from the larger space of the watershed into an identified over-wintering location. The majority of existing gar life history data are from lentic and estuarine populations; data describing riverine alligator gar are lacking. This study will also provide direction for future studies and stewardship efforts in Arkansas and similar regions.

## Fingerprinting Selected Blackberry Cultivars Using Microsatellite Markers

***Nicole Knox, Cynthia Rodriguez, and Tatum Branaman***
*Faculty Mentor: J.D. Swanson*

The United States is one of the top producers of blackberries and raspberries worldwide and national production of the fruit is currently increasing. Several varieties of blackberry have been developed to display different traits such as larger fruit or fewer prickles. The desire to incorporate these and other traits of commercial importance has led to greater interest in molecular marker analyses in blackberries.

Despite the increasing availability of SSR markers designed for crops related to *Rubus*, successful use of the technology in blackberry cultivars has not yet been published. Diversity among production clones is currently assessed through morphological and breeding records. Fingerprinting using microsatellite markers will aid in measuring genetic diversity and may also be used to compare varieties developed by breeders to commercially available varieties. We intend to screen previously reported SSRs for their polymorphic nature using 18 production cultivars from the University of Arkansas blackberry breeding program. This study is the initial step in developing the use of molecular marker tools for fingerprinting, diversity analysis, and quality control within the blackberry industry. We hope to use our findings to expand the identified markers to include additional cultivars from other breeding programs in the future.

# Pollen Size Variation and Reproductive Success for Apomictic *Plants*

***Signe Larson***
*Faculty Mentor: Richard D. Noyes*

Apomictic plants achieve reproductive success through their seed (produced asexually) as well as through pollen. Crosses between triploid apomicts and sexual diploids in *Erigeron* (Asteraceae) yield a bimodal distribution consisting mostly of diploid and triploid hybrids indicating that triploid apomicts produce reduced pollen that is mostly *n* and 2*n*. The hypothesis of bimodal pollen was investigated by examining the size variation and quality of pollen produced by triploid apomicts by plotting pollen diameter against pollen size controls. In contrast to expectation, the pollen produced by most triploids is unimodal and centers on 1.5*n*. This suggests that most pollen produced by triploids is wasted and that reproductive success comes from low amounts of pollen made at the tails of the distribution.

# The Effects of Natural Gas Drilling on Decomposition Rates in Headwater Streams in the Fayetteville Shale Gas Play

***Mike Lowry and Tyler Troutman***
*Faculty Mentor: Sally A. Entrekin*

The natural gas industry is flourishing in the Fayetteville Shale gas play of north central Arkansas where over 1500 wells have been drilled in the last 5 years. The drilling processes have the potential to alter stream catchments by increasing road density, land clearing, reservoir creation, pipeline construction, and the use of biocides and other components of fracturing fluids. Natural gas wells are in close proximity to small streams, but few studies have examined whether installation of gas wells affects stream biota and associated functions, such as decomposition. Our study quantified the relationship between well density and decomposition rates in six small stream catchments in the Fayetteville Shale region. Our hypothesis is streams with higher well density will have lower rates of decomposition due to the potential for increased sedimentation and possible contaminants associated with well drilling. However, other land cover types may also affect rates. Decomposition rates varied among sites, ranging from 0.0072 to 0.0193 $k \cdot d^{-1}$, but there was no relationship with well density ($r^2 = 0.03$). In fact, scrub-shrub ($r^2 = 0.69$) land cover explained the most variation in decomposition rates among streams.

## AFLP Markers for Mapping Genomes in Plants

***Darrell Martin Jr. and Michael Wild***
*Faculty Mentor: Richard D. Noyes*

Amplified fragment-length polymorphisms (AFLP) data were used to produce markers for genetic mapping in the flowering plants *Erigeron annuus* and *Erigeron strigosus* (Asteraceae). Crosses of triploid (3*n*=27) apomictic and diploid (2*n*=18) sexual parents gave rise to an F1 population 'N1' of 336 progeny. DNA was isolated from each individual and AFLP markers produced using 30 combinations of selective primers fluorescently labeled with NED or VIC fluorophores. Reactions were resolved via capillary gel electrophoresis on an ABI 3730 DNA sequencer at the University of Missouri DNA Core facility. Electropherogram analysis found informative segregating markers and a binary matrix for markers either present (scored 1) or absent (scored 0) was produced for the progeny. A master matrix of all markers (~400) will be analyzed using the program MapMaker to generate linkage groups representing the genome of the triploid parent.

## Responses in headwater streams to natural gas drilling in the Fayetteville Shale

***Lindsay Martindale***
*Faculty Mentor: Sally A. Entrekin*

Natural Gas in being drilled in the Fayetteville Shale of the Arkoma Basin. Gas companies are using a new method, hydraulic fracturing, to access the natural gas in the shale layers. Drilling occurs within close proximity to the stream channel and has the potential to increase sediment inputs from road development, pipeline installation, and pad clearing. Few studies have been conducted on the effects of hydraulic fracturing to the surrounding headwater streams. This project will have a field component as well as a Geographic Information Systems (GIS) component. We will study the effects of natural gas drilling to sediment transport in the surrounding headwater streams. We will measure the sediment transport in 6 stream catchments with high densities of wells and six sites with low densities of wells, all with similar land use/land cover within their catchments. The GIS component will quantify well proximity to stream channels in each watershed and riparian composition to examine relationships between well proximity to stream channels and the potential for stream riparian areas to act as buffers from potential sediment from the drilling process.

# Upregulation and trafficking of sodium/hydrogen exchanger isoforms 1, 2, and 3 may aid in MCF7 cell survivability in the solid tumor microenvironment via regulation of intracellular acidification

***Kevin McElhanon and Tara Havens***
*Faculty Mentor: Steven W. Runge*

Solid tumors consist of regions of diffusional hypoxia created by abnormalities in microvessel formation and increased diffusional distances, necessitating a metabolic switch from aerobic to anaerobic respiration. As oxygen tension decreases and metabolism becomes glycolysis dependent, the tumor microenvironment becomes acidic due to metabolic production of lactate. Apoptosis is induced by intracellular acidification in normal cells and a selective pressure is created favoring cells most able to adapt to the adverse environmental conditions that lead to intracellular acidification.

Questions still remain as to how apoptosis is circumvented by cancer cells subject to these extreme conditions. We hypothesize the Sodium/Hydrogen Exchanger (NHE) family of antiporters plays a central role in the ability of cancer cells to proliferate in an acidic and hypoxic environment. This study is designed to discern the function of NHE1, NHE2, and NHE3 in intracellular pH regulation in MCF7 cells (human breast adenocarcinoma) and how cells are utilizing these isoforms.

The NHE1, 2, and 3 isoforms exchange internal $H^+$ for external $Na^+$ with 1:1 stoichiometry in an ATP independent manner and are extremely efficient at maintaining intracellular pH, thus making likely candidates for pH regulation in the tumor microenvironment. Whole cell and membrane bound NHE abundance will be analyzed after exposure to acidic and/or hypoxic conditions in order to determine total protein abundance and possible trafficking to the plasma membrane. This study will allow our lab to elucidate a basic understanding of the role sodium/hydrogen exchange plays in intracellular pH regulation, and ultimately tumor cell survival in this harsh microenvironment.

## Do girdles and saliva promote growth in notodontid caterpillars

***Deborah Moon***
*Faculty Mentor(s): David Dussourd*

Caterpillars in the family Notodontidae often chew furrows around leaf petioles or stems. This girdling behavior has been reported in seven notodontid species feeding on six families of economically important trees, including species of oak, birch, pecan, willow, cherry and elm. The function of girdling by notodontids is still unknown. Girdles may benefit caterpillars by disrupting the vascular tissues or by allowing caterpillars to introduce salivary components into the wound. Caterpillars have been observed rubbing the tip of the labium where the salivary glands empty onto the surface of the girdle. To test if girdles increase caterpillar growth rates, and specifically if saliva improves growth, we plan to compare larval growth over 3 days on control birch stems, birch stems with natural girdles (cut by another cohort of caterpillars), and birch stems with artificial girdles. If girdles and oral secretions enhance growth, we predict that larvae too small to cut their own girdles will grow faster on the girdle treatments and fastest on stems with natural girdles.

## Effects of *Ligustrum Sinense* Eradication on Avian Abundance and Species Richness in Central Arkansas

***Jessica Needham***
*Faculty Mentor: Katherine Larson*

*Ligustrum sinense* is one of the most common exotic and invasive plant species in Arkansas forests, and in many locations, it is being actively managed through cutting, spraying the stumps with herbicide, and burning. However, little is known about the effects of *L. sinense* and these management strategies on avian abundance and species richness. The main goal of this study is to determine if cutting and spraying *L. sinense* affects avian abundance and species richness. This study tests the hypothesis that areas where *L. sinense* has been cut and sprayed but still lies in piles will have higher avian abundance and species richness than areas where *L. sinense* remains untouched. Species richness was found to be higher in the cut *L. sinense* plot, but there was no difference in abundance. The urban nature reserve where this study is being conducted contains remnants of native prairie as well as *L. sinense* invaded areas. A secondary goal of this study is to test the hypothesis that the urban nature reserve containing native vegetation has higher avian abundance and species richness than a nearby urban nature reserve lacking native vegetation. We found little effect on daily species richness and abundance, however, more total

species, including one of conservation concern, were observed in the nature reserve with native vegetation.

## The effect of hydroperiod and invertebrate feeding on leaf decomposition rates in intermittent Ozark streams

***Kasey J. Nix***
*Faculty Mentor(s): Sally A. Entrekin*

Intermittent streams have a hydroperiod that is regulated by the relatively predictable climate of a region. However, predictions based on global climate change indicate less frequent precipitation and greater severity, resulting in an overall increase in variability and unpredictability of intermittent stream flow. These changes in the regularity of the hydroperiod may directly affect the organisms living in the stream and cause significant changes in stream processes, such as leaf decomposition. We hypothesized that the rate of leaf decomposition would be greater in areas with longer periods of inundation and crayfish feeding would increase the rate of leaf decomposition compared to feeding by other invertebrates. Leaf bags were placed in different habitats within the same stream with different hydroperiods (pools and riffles) and leaf bags were prepared to include and exclude crayfish. We found that the rate of leaf decomposition was faster in areas with longer periods of inundation (pools: $k=0.0051\ d^{-1}$ vs. riffles: $k=0.0028\ d^{-1}$). Also, the rate of leaf decomposition was faster in riffles when crayfish were excluded ($k=0.0037\ d^{-1}$) versus crayfish included ($k= 0.0028\ d^{-1}$). Changes in hydroperiod length and invertebrate community composition may interact to cause significant changes to nutrient and energy flow through intermittent streams.

## Acute effects of atrazine and nitrate on *Hyalella azteca* (Amphipoda) in laboratory exposures

***Ram Pandey***
*Faculty Mentors: Laurie Warren and Ginny Adams*

Pesticides and other chemical contaminants rarely occur in the environment as single compounds but rather as mixtures. Atrazine is one of the most commonly detected herbicides found in mixtures with other contaminants such as nitrates. Atrazine application in agricultural areas often coincides with fertilizer use, resulting in the presence of both atrazine and nitrate in surface and groundwaters. Atrazine toxicity data are available for many organisms but combined effects of atrazine and nitrate have not been investigated with any invertebrates. This study examined combined effects of atrazine and nitrate with the freshwater amphipod *Hyalella azteca* using survival as the toxic endpoint. The results obtained in laboratory exposures reveal that atrazine does not

alter the toxicity of nitrate. The 96-hour LC50 (concentration that kills 50% of organisms) values with and without the presence of atrazine are 69.8 and 87.2 mg/L $NO_3$-N respectively. Post-test growth and behavioral observations (10-day period) conducted with adult *H. azteca* following 96-hour exposure suggest that nitrate and atrazine at these concentrations do not result in long-term effects on *H. azteca* under our experimental conditions.

# Analysis of signal transduction in Mercury-treated EL4 T lymphocytes

***J. Leigh Reno***
*Faculty Mentor(s): Ben Rowley*

Mercury (Hg), is a widespread environmental toxin encountered in a range of situations. Mercury has well-documented neurotoxic and immunological effects on humans and mice, which has led to in-depth research about its mechanisms of action and consequent cellular responses.

This study will be concerned with the effect of Hg on lymphocyte signal transduction, particularly that of EL4 T lymphocytes. The effects of mercury (Hg) on signal transduction are of particular interest because of its prevalent low-level ecological deposition and well-established toxicity - this study is significant because of the concern with low, biologically relevant levels of Hg that have not been researched before. This study will test a Hg concentration of 1 μM. Preliminary studies have been performed to determine which concentrations (5μM-0.01μM) may induce either apoptosis or necrosis within exposed cells.

The goal of this study is to investigate the impact of acute (12 hour) and chronic (96 hour) exposures to low concentration inorganic Hg on EL4 T cell signal transduction. It has been found that such exposures lead to an inappropriate activatation of EL4 T cells. Analytical flow cytometry was used to assess intracellular activation-induced phosphorylation events in the presence or absence of mercury.

# Niche Breadth and Diet Analysis of the Northern Snakehead in Brinkley Arkansas

***Harry Richardson and Kyle Meek***
*Faculty Mentor(s): Ginny Adams and Reid Adams*

The Northern Snakehead fish species, *Channa argus,* is indigenous to parts of Asia, but has recently been introduced to eastern parts of Arkansas. *C. argus* is invasive, creating competition and threatening the livelihood of native fish fauna. In spring of 2009 the Arkansas Game and Fish Commission (AGFC) attempted to eradicate the species from the Big Piney Watershed near Brinkley, Arkansas. *C. argus* was collected by University of Central Arkansas volunteers after rotenone was applied to the watershed. The stomachs from 488 *C. argus* specimens were removed for analysis of gut contents and diet preference. In its native habitat, *C. argus,* preys strictly on invertebrates before switching to a piscivorous diet at a mature size. This did not correspond to the diets of *C. argus* specimens collected in the Big Piney watershed. Using Levins (1968) niche breadth equation, a niche breadth for *C. argus* was calculated and then standardized on a scale of 0 to 1.0 and showed to be 0.458. This shows that *C. argus* showed some selection towards specific food categories, but not any one in particular. An index of relative importance (IRI) was calculated for each food category to show which food categories were preferred. Unidentifiable sunfish showed the highest IRI of 33.13 followed by crayfish with 25.4 and mosquito fish showing an IRI of 16.9 showing *C. argus* showed preference for these three food categories. The data reflects the significant competition C. argus creates for native fish species. Their lack of competition and opportunistic diet poses a threat for ecosystems where they are introduced.

# Unigene markers for mapping genomes in plants

***Aaron Roberds and Rebecca DiGiacomo***
*Faculty Mentor: Richard D. Noyes*

Many different classes of genetic markers can be used for mapping genomes. The only requirement is that segregating alleles must be present. In this experiment we evaluated length differences of intronic regions of genes for potential use in genetic mapping in plants. PCR conditions were optimized for 19 primer pairs published for intronic regions of unigenes in the plant family Asteraceae. Products were visualized on an ABI 3730 capillary sequencer using fluorescently tagged universal primers. The preliminary results demonstrate differences in the length of intronic regions within and among individuals. Segregation for this putative allelic variation will be evaluated among progeny in controlled crosses and used to facilitate production of genetic maps.

# Effects of the protein kinases, CaMKII, PKA, and PKG on the sarcoplasmic reticulum $Ca^{2+}$-ATPase pump expression

***Stuart Sherwood, Andreya E. Reed, and Tramaine Shepard***
*Faculty Mentor: Brent Hill*

A high cytoplasmic $Ca^{2+}$ concentration in coronary artery smooth muscle cells induces arterial constriction which can limit blood flow to the heart. The lack of blood flow to the heart can induce a heart attack if the coronary arteries have already demonstrated atherosclerotic plaque formation. The sarcoplasmic/endoplasmic reticulum $Ca^{2+}$ ATPase pump (SERCA) is used by the cells to help reduce cytoplasmic $Ca^{2+}$ levels and relax the arteries. SERCA activity is known to be increased by the protein kinases, $Ca^{2+}$/calmodulin-dependent kinase II (CaMKII), protein kinase G (PKG), and protein kinase A (PKA). Our lab has previously demonstrated that estrogen (E2) independently increases SERCA2b, PKA, PKG, and CaMKII expression. The purpose of this study is to determine if E2 increases SERCA expression via the protein kinases. The distal portion of right coronary arteries obtained from female porcine hearts were cut into longitudinal strips and incubated for 24 hrs in 1 nM E2 and the EtOH solvent for E2. When appropriate, the specific inhibitors for CaMKII, PKG, and PKA were added during the incubation period. Western blot analyses suggest PKG is responsible to the increase in SERCA expression, while PKA appears to have no effect. Preliminary data also indicates that CaMKII may mediate the increase in SERCA expression.

# An Assessment of the Impacts of Natural Gas Drilling in the Southern Arkansas Ozarks

***Loren Stearman***
*Faculty Mentor(s): Ginny Adams and Reid Adams*

Natural gas exploration has increased recently in the Fayetteville Shale region of the southern Ozark Mountains and Arkansas River Valley of central Arkansas. Potential impacts of natural gas drilling include increased sedimentation and loss of in-stream benthic habitat, loss of the riparian buffer zone, potential stream morphology homogenization and the accidental leaking of toxic fracturing fluid. However, few studies have measured the response of aquatic ecosystems to the combined effects of drilling on headwater streams, despite their lowered resistance compared to larger streams. Two study designs are being employed to measure the effects of drilling on headwater streams. A pre-post drilling study will assess fish community structure in streams, and a second will compare fish community structure in twelve streams with a gradient of well densities. Initial pre-drilling sampling of five stream stations indicated a rich fish fauna for monitoring (approximately 28 species), with greater than fifty percent of the species categorized as sensitive (e.g., *Notropis boops*, *Etheostoma zonale*, and *Noturus exilis*) by EPA standards. The coupled study design of pre-post drilling and a gradient of well

densities will provide a thorough assessment of potential effects of drilling on the diverse fish assemblages in headwater streams of north central Arkansas.

## Does Evolution Instruction Elicit an Emotional Response in Students?

***Stephanie Testerman and Josh Allen***
*Faculty Mentor: Mark Bland*

Brain research suggests that emotional stimuli can interfere with cognitive processes. Further, participants' reasoning centers did not show increased activity when they were shown positive and negative statements about their choice of 2004 presidential candidates, but their emotional centers did. We hypothesized that if learners respond to evolution on an emotional level, then physiological indices of these learners will reflect varying degrees of emotional responses to images and statements about evolution, with "religious" students responding more strongly than "non-religious" learners. The current study was designed to assess whether students enrolled in a non-majors biology course experience a detectable emotional response upon exposure to evolutionary themes.

Physiological data, such as heart rate and galvanic skin response, was collected from students while they were exposed to varying images and text representing evolutionary themes, neutral themes, and religious-based themes. Additionally, a survey was administered to students enrolled in the same two sections of non-majors biology classes from which student participants were recruited. Among other things, this survey was used to identify the learners as either "religious" or "non-religious". Physiological data was compared with paper survey responses to determine whether correlations exist between participants' physiological responses and their survey responses.

# Movement Patterns and Environmental Influences of Two Cyprinids in an Intermittent Reach of an Ozark Stream

***Richard Walker***
*Faculty Mentor(s): Ginny Adams and Reid Adams*

Previous research in perennial headwater systems has shown the majority of fishes exhibit restricted movement; however, few studies have tested the restricted movement hypothesis in an intermittent stream where resource availability is often patchy relative to perennial streams. Our objectives were to examine movement patterns of southern redbelly dace (*Chrosomus erythrogaster*) and creek chub (*Semotilus atromaculatus*), two small-bodied fishes common in a 5958m reach of an intermittent headwater stream and to determine the environmental factors influencing these movement patterns. A total of 4744 *C. erythrogaster* and 406 *S. atromaculatus* were tagged with elastomer over the first two sample trips. Capture efficiency was high for both *C. erythrogaster* (97%) and *S. atromaculatus* (94%) and recapture rate varied from 23% to 10%, respectively. Mark-recapture results indicated a high percentage of recaptures during the Fall season remained within the original pool of capture (68% for *C. erythrogaster* and 42% for *S. atromaculatus*). However, some individuals did move long distances: 5,732m for *C. erythrogaster* and 1,088m for *S. atromaculatus.* These long exploratory movement behaviors may be a means of evaluating alternative habitats for additional resource requirements. Mark-recapture data relating environmental parameters with movement and persistence of individuals will be discussed further.

# Mercury causes inappropriate activation in WEHI-231 B lymphocytes

***Kara Weigand***
*Faculty Mentor: Ben Rowley*

B lymphocytes are immune cells that fight extracellular infection. When an antigen binds to an immunoglobulin receptor imbedded in the plasma membrane it crosslinks the cytoplasmic tails of the receptor. This crosslinking initiates the signal transduction cascade which consists of a series of molecules obtaining a phosphate group. Once activated, these cells differentiate into plasma cells that secrete antibodies and clear out the antigen. Mercury, which is a widespread environmental contaminant, is known to affect the immune system by increasing the potential for autoimmunity. The mechanisms induced by low-level mercury exposure that cause an organism's immune system to attack its own tissues are currently unclear. Populations of WEHI-231 B cells were exposed to multiple low-level concentrations of $HgCl_2$ for either 12 or 96 hours to mimic acute and chronic subtoxic exposure.

Flow cytometry was used to detect the presence of fluorescent-labeled antibodies bound to phosphorylated forms of multiple activation molecules in the signal transduction cascade. In the absence of antigenic stimulation, increased levels of activation molecules were present within WEHI-231 cells following acute and chronic exposure to low-level mercury. This increase of phosphorylated signal transduction molecules indicates inappropriate activation of these cells by the mercury alone.

## Expression of Mdv1 and Caf4 Chimera Proteins in *Saccharomyces cerevisiae*

***Abby Wyant***
*Faculty Mentor(s): Kari Naylor*

The mitochondrion is a cellular organelle that produces energy required for cell survival. This function is highly dependent upon the maintenance of its reticular structure; any compromise in structure is a detriment to function. Fission and fusion are the events responsible for mitochondrial structure upkeep and we aim to study the former. Three proteins in budding yeast, Dmn1, Mdv1, and Fis1 are essential for the fission process. A fourth protein, Caf4, is not required for fission to occur but we hypothesize it functions to ensure that mitochondrial division does not occur in excess. Caf4 is homologous to Mdv1; their structures are very much alike, though their functions are not. To determine the inherent functional differences between Mdv1 and Caf4, five GFP tagged chimeras in the model organism *Saccharomyces cerevisiae* were constructed. Each chimera protein was then expressed in three different background strains, wild-type, *Δmdv1,* and *Δcaf4*. To determine the affects these chimeras have on fission we must first determine if these constructs express full-length chimera proteins. Protein was extracted from each chimera expressing strain, separated by SDS-PAGE, and transferred to nitrocellulose, where the proteins were probed with anti-GFP. Preliminary data confirms protein expression in two constructs, #1 and #5. Western blots will continue to be employed to confirm expression of all chimera proteins. Once confirmed, Mdv1 and Caf4 function can be determined, thus mitochondrial morphology and its affect on function can be more readily understood.

# Department of Chemistry

# Reactions of $Zn^+(^2S)$ with $CF_3X$ and $CH_3X$ (X=Br, I)

***Kimberly M. Berry, Charles M. Nichols, and Benjamin K. Ward***
*Faculty Mentor(s): William S. Taylor*

State-specific reactions of $Zn^+(^2S)$ with $CF_3X$ and $CH_3X$ (X = Br, I) have been carried out in a selected-ion drift cell apparatus. Under near-thermal reaction conditions, these reactions exhibit association in competition with bimolecular product channels indicative of C-X bond activation. Branching ratios indicate that association predominates under these conditions, but that product distributions are dependent on the identity of the reactant neutral. All bimolecular processes are largely consistent with known thermochemical and quantum mechanical requirements as determined using density-functional theory; however, some noteworthy discrepancies are observed between calculated values and available published results. Reaction outcomes indicate that the bimolecular chemistry of $Zn^+(^2S)$ with some neutrals is markedly different from that which we have previously reported for $Cu^+(^3D)$, suggesting the possibility of a mechanism requiring the formation of a bond-insertion intermediate rather than direct abstraction.

# An Unexpected New Heteroscorpionate and Isomerism in its Nickel(II) Complexes

***Brian M. Besel and Adam L. Corken***
*Faculty Mentor(s): Patrick Desrochers and Richard Tarkka*

Scorpionates are a widespread class of tridentate nitrogen-donor ligands, incorporating three pyrazole rings that bind transition metals with a very high affinity. We have been working to attach this popular ligand class to a heterogeneous support, thereby improving the utility of nickel-scorpionates developed in our lab for applications ranging from small molecule and selective amino acid sensors as well as protein purification. While testing an alternate synthetic method for preparing a supported version of the ligand (Tp*) we found a new direct route to prepare a mixed scorpionate (Tp´) in which one of the three pyrazole rings is cleanly replaced by a benzotriazole functional group. This result is appealing for two reasons. First, the synthesis is a direct preparation of a derivative of a very useful ligand from relatively inexpensive starting materials. Second, the benzotriazole moiety offers a possible route to heterogeneous scorpionate attachment using simple azide/alkyne “click” chemistry. To demonstrate the functionality of Tp´, its nickel(II) complexes were prepared, purified, and characterized by an array of solution and solid phase spectroscopies. These properties are expected to serve as baseline comparisons for eventual supported nickel-scorpionates.

# Screening of proteins to test for correlation of phosphate collapse around cationic protein residues and DNA bending

***Elizabeth Dourlain and Bryce Grant***
*Faculty Mentor(s): Lori Isom*

Protein/DNA complexes in the Protein Data Bank were screened to select for complexes that could be used to test the theory that cation interactions with DNA phosphate groups, which are negatively charged, will result in partial charge neutralization. These interactions may possibly induce DNA bending and minor groove narrowing. X-ray crystal structures of protein/DNA complexes provide the best structural information for DNA and proteins to quantify the effect of monovalent cation binding on DNA structures. DNA/protein structures were screened based upon having a resolution of 2.5 Angstroms or higher. In the case of duplicates, the higher resolution was retained. Structures with at least ten base pairs (one full helical turn), continuous, and unmodified were also retained. Structures that would involve additional interactions were excluded, such as histones, where there is DNA/protein interaction and DNA/DNA interaction. To be considered continuous, the DNA phosphate backbone of the strand could not be broken and the base pairs could not be sticking out. The strands also had to possess a parallel and antiparallel side. The protein could not be an endonuclease, DNA polymerase, or a restriction enzyme because of their nature to cut the phosphodiester bonds in DNA. The proteins that met the preceding criteria can potentially be used to determine the relationship between cation interactions with DNA phosphate groups.

# Amino Acid Radical Precursors

***Daniel Fields III, Darrell J. Martin, and Cory B. Stogsdill***
*Faculty Mentor(s): Nolan Carter*

Protein radicals are produced by ionizing radiation as well as endogenous mechanisms related to metabolism. Radical damage pathways often involve a complex sequence of reactions initiated by reactive oxygen species such as hydroxyl radical which react by hydrogen atom abstraction to produce protein-centered radicals. The study of this process is complicated by the fact that hydroxyl radical is nonselective and can attack a particular amino acid at multiple sites, leading to multiple protein-centered radicals. To aid the study of this type of reaction pathway, we have designed photolabile amino acid radical precursors that generate specific radicals upon photolysis. Results of experiments using a valine radical precursor will be discussed. Progress toward the synthesis of a novel tyrosine radical precursor will also be presented. These studies are intended to provide insight into the biologically significant issue of radical-mediated protein damage.

# Isoelectric focusing as a method for dendrimer purification

***Anthony T. Hightower and Ashley M. Scroggins***
*Faculty Mentor(s): Kyle W. Felling*

Isoelectric focusing (IEF) has been used for many years as a valuable technique in protein purification. In this study, the technique of preparative, liquid-phase IEF is utilized in order to separate structural impurities from varying generations of poly(amidoamine) (or PAMAM) dendrimers. Generations -0.5 to +0.5 PAMAM dendrimers are fractionated using a Bio-Rad Rotofor electrophoretic system via both carrier ampholyte and ampholyte-free procedures. Twenty IEF fractions are collected and analyzed by many spectroscopic methods including LC/MS. Analysis of this data clearly identifies separation of the “pure” dendrimer from any structural defects produced during synthesis. This study demonstrates the usefulness of this purification technique as a low cost, quicker alternative to commonly used approaches toward dendrimer purification, such as column chromatography.

# Investigating the interaction between $Mg^{2+}$ and the crystal dehydrating agent 2-methyl-2,4-pentanediol (MPD) and its role in DNA bending

***Courtney Huff, Tori Dunlap, and Jade King***
*Faculty Mentor: Lori Isom*

This project focuses on explaining the mechanism by which MPD affects DNA bending and, specifically, investigates whether MPD chelates $Mg^{2+}$ ions. If DNA bending is induced by cation binding, then chelation of $Mg^{2+}$ by MPD could sequester the ions away from the DNA, thereby decreasing its curvature. To test this hypothesis, competition experiments between MPD and an indicator, Eriochrome Black T (EBT) for $Mg^{2+}$ ions, have been used to test for the MPD-$Mg^{2+}$ chelation. Samples containing EBT/ $Mg^{2+}$ with varying amounts of MPD were prepared and analyzed using UV spectroscopy. An absorbance wavelength maximum shift corresponding to the color transition from pink to blue indicates competitive removal by MPD of $Mg^{2+}$ from EBT. This transition has been detected and quantified by monitoring absorbance values at various MPD concentrations at two wavelengths: 550 nm (pink, EBT/$Mg^{2+}$) and 650 nm (blue, MPD/$Mg^{2+}$).

# Metabolic Profiling of 9-*cis*-Retinoic Acid in Human Immune Cell Lines

***Andrea Kirkpatrick***
*Faculty Mentor(s): Melissa Kelley*

Vitamin A and its analogs, retinoids, are essential for many critical life processes including vision, proliferation, and immune function. Biological active retinoids, all-*trans*-retinoic acid (*t*-RA) and 9-*cis*-retinoic acid (9-*cis*-RA), are ligands for retinoic acid receptors and retinoid X receptor that are involved in regulating immune function. *t*-RA and 9-*cis*-RA augment cellular adhesion in the human B cell lines RPMI 8866 and U937, but not in human cell lines Jurkat or Daudi. In the current study, we examine 9-*cis*-RA metabolism in RPMI 8866, U937, Jurkat, and Daudi immune cell lines. Retinoid metabolites were profiled using liquid-liquid extraction and reverse-phase HPLC with photodiode array detection. Our data reveal that U937 and RPMI 8866 cells are retinoid responsive with respect to cellular adhesion and proliferation and that the retinoid responsible is 9-*cis*-retinoic acid. Our study demonstrates retinoid availability plays a role in governing cellular adhesion and proliferation in immune cell lineages.

# 9-*cis*-Retinoid Acid Induces Integrin-Independent Adhesion while Dampening Proliferation in Select Human Immune Cells

***Kaitlin S. Merrell***
*Faculty Mentor(s): Melissa Kelley and Lance Bridges*

Immune cell adhesion and proliferation is essential for proper immunity. Imbalanced adhesion and/or proliferation can lead to chronic inflammation or immuno-suppressed states. 9-*cis* Retinoic Acid (9-*cis*-RA), a derivative of Vitamin A, alters gene expression and impacts cell proliferation, differentiation, and adhesion. In this study, we investigated the adhesive and proliferative effects of 9-*cis*-RA on multiple human immune cell lines. Our results establish that 9-*cis*-RA robustly promotes immune cell adhesion. These results appear to be specific to the human cell lineage exposed to 9-*cis*-RA and the substrate tested. In addition, the observed 9-*cis*-RA dependent adhesion was not altered by function blocking integrin inhibitors such as monoclonal antibodies or EDTA. The same cell lines shown to have adhesive effects also dampen cell proliferation upon 9-*cis*-RA exposure. These data demonstrate that 9-*cis*-RA plays a central role in immune biology by prompting novel integrin-independent adhesion while simultaneously altering cellular proliferation

# The Importance of Retinoic Acid Dosage on Lymphocyte Adhesion and the Permanence of its Effect Over Time After Removal

***Jabin Miller***
*Faculty Mentor(s): Melissa Kelley and Lance Bridges*

Cellular adhesion is a key event in a spectrum of biological processes, including gamete fusion, wound healing, immune response and inflammation. Within immune cells, adhesion and proliferation are known to be affected by retinoic acid (RA) treatment. Our previous studies have demonstrated that exposure of human lymphocytes to 1.0 μM 9-cis RA augments cell adhesion. In this study, we examined the adhesion effects of a range of physiologically relevant doses of 9-cis RA from 1.0 μM to 10.0 nM. All of the concentrations tested resulted in similar effects on adhesion. We also examined if the adhesion effects persisted after the RA stimulus was removed. We report here that while adhesion persisted for a brief time after RA removal, subsequent generations of cells did not exhibit elevated levels of adhesion. Our results are the first to define concentration ranges of RA that bestow lymphocyte adhesion, and that upon removal of RA exposure, RA adhesion diminishes over time.

# The Impact of Silver Nanostructures on the Thin Film Formation of Halogenated Benzoic Acids

***Liz Schiefer, Scott Cordova, Ashley Bonde, Taylor Razor, Mallory Roberson, and TsungYen Chen***
*Faculty Mentor: Donald Perry*

Adsorption properties of nanofilms of halogenated benzoic acids deposited from volatile solvents with varying protic/aprotic and polar properties on vacuum-evaporated silver films and silver powders are being studied with surface-enhanced infrared absorption (SEIRA), surface-enhanced Raman spectroscopy (SERS), and density functional theory (DFT). The adsorption properties are characterized as a function of increasing adsorbate coverage. SERS preferentially enhances monolayer Raman shifts, while SEIRA can enhance the infrared absorbance of the monolayer and a multilayer. SERS demonstrates that all of the benzoic acid isomers adsorb as benzoate ions in the monolayer, and the combination of SERS/SEIRA shows polar properties of the adsorption solvent alter the degree of molecular ionization, orientation, and intermolecular interactions in a multilayer. In particular, deposition of the halogenated benzoic acid from an alkane solvent with nonpolar bonds results in the formation of a significant number of benzoate ions in the multilayer. DFT calculations are revealing that there is a competition between halogen bonding and C-H--O hydrogen bonding going from a substituted F- through Cl- and Br- to I- in a multilayer of a halogenated benzoate ion. These studies will contribute directly to the understanding of the fate of halogenated compounds in the environment and will impact material, synthetic, biological, and nanotech. chemistry where the chemistry of halogenated organics is important.

# GC/ECD analysis of organic contaminants in Missouri cave streams using POCIS & SPMD samplers

***Martin P. Sharum and J. Tyler Fox***
*Faculty Mentor(s): Karen Steelman and Ginny Adams*

This water quality study evaluated the habitat of the grotto sculpin (*Cottus carolinea*), a high priority candidate fish species listed under the US Endangered Species Act, only found in five cave systems within Perry County, Missouri. Using gas chromatography with mass spectrometric and electron capture detection, our laboratory analyzed extracts from polar organic chemical integrated samplers (POCIS) and semi-permeable membrane devices (SPMD) deployed during May and June 2008. These solid-phase extraction devices effectively sample a wide variety of chemicals that are often missed by instantaneous water sampling techniques.

Twenty chemicals were quantified at ng/L levels from agricultural, industrial, and residential sources. Triazine and organochlorine pesticides and their degradation products were the most commonly detected classes of chemicals, followed by chloroacetanilide pesticides and polycyclic aromatic hydrocarbons. Two bioaccumulative compounds, dieldrin and heptachlor epoxide, exceeded EPA criteria for the protection of aquatic life. These results will feed directly into improving land-use practices.

## Exchange equilibria of variable nitrogen-donors at nickel(II)-scorpionates

***Kristin A. Thorvilson, Ade Osinowo***
*Faculty Mentor: Patrick Desrochers*

Nickel(II) demonstrates a high affinity for nitrogen-donor bases. Accordingly, Tp*$Ni^{+}$ reversibly binds N-donors according to the reaction: Tp*NiX + 3 N-donor $[Tp^*Ni(N\text{-donor})_3]X$, where N-donor = imidazole, acetonitrile, or ammonia and X = $Cl^-$, $Br^-$, $I^-$, and $BH_4^-$ and Tp* = the scorpionate hydrotris(3,5-dimethylpyrazolyl)borate. For all N-donors studied, this reaction is exothermic, reflecting the exchange of stronger nickel-N-donor for weaker nickel-X bonds. Variable temperature $^{11}B$ NMR of the Tp*NiX/acetonitrile systems yielded thermodynamic parameters for these equilibria. We also describe reversible ammonia binding at $Tp^*NiBH_4$, an interesting case because the product, $[Tp^*Ni(NH_3)_3][BH_4]$, incorporates reactive hydridic B-H and protic N-H groups in a single solid. This is reminiscent of magnesium based hydrogen-storage materials incorporating a similar $Mg\text{-}NH_3—BH_4$ arrangement (Soloveichik, et al. *Inorg. Chem.* **2008**, p. 4290). These materials are expected to have applications to solid-state ammonia storage and ammonia sensors.

## Qualitative Differentiation between Strong and Weak Acids via Hydrogen Gas Collection

***Michael Wild and Matthew Huber***
*Faculty Mentor(s): Faith Yarberry*

The difference between a strong acid and a weak acid is a difficult concept for students to comprehend. Our goal was to develop a laboratory method that would allow students to qualitatively observe the difference between acid strength. The method used involves the collection of hydrogen gas produced by reacting the acid with magnesium over a specific time interval. This method permits only qualitative determination because of the effects of Le Châtelier's principle for a reaction at

equilibrium. Our results confirmed that acid strength could be illustrated by the difference in the quantity of hydrogen gas produced. This method, therefore, will permit the distinction between strong acids and weak acids containing the carboxylic acid functional group.

# Department of Computer Science

# General Purpose K-means Clustering Algorithm for Interval Typed Data

***Abhinav Reddy Atla, Benjamine Nordin, and Matthew Johnson***
*Faculty Mentor: Chenyi Hu and Bernard Chen*

K-means is a well known clustering algorithm for grouping the data into different feature groups. Interval typed data is commonly used in scientific computational analysis as it has been shown to produce more reliable results, however, to date there is no proven algorithm for clustering interval typed data. In answer to this we introduce an Interval k-means algorithm, which uses interval arithmetic concepts to generate the clusters. We test the efficacy of the algorithm on scientific data that has been shown to be notoriously difficult to cluster and that also allows the generated cluster quality to be easily analyzed. This is done by comparing the homology of the clusters generated by this approach. In this paper we analyze protein sequence data using the already proven k-means algorithm and our introduced interval k-means algorithm for comparison purposes.

# Fractal Dimension of Dermoscopy Images

***Brendan Lee***
*Faculty Mentor: Sinan Kockara*

The medical imaging and image processing techniques, ranging from microscopic to macroscopic, has become one of the main components of diagnostic procedures to assist dermatologists in their medical decision-making processes. Automated assessment tools for dermoscopic images have become an important research field mainly because of inter- and intra-observer variations in human interpretations. In this study, we investigate whether the fractal dimension is one important parameter to characterize dermoscopy images. The fractal dimension is a quantity that spatially measures self-similarity in the number of disjoint regions that the data set can be divided into. In dermoscopy images, fractal dimension gives statistically sound combined information about the spatial distribution of lesion, volumetric content, and bulk density. Results indicate that fractal dimension is an important parameter to categorize dermoscopy images.

# Interval Time Series Prediction Using Interval Stochastic Models

***Pavan Roy Marupally and Devendar Singireddy***
*Faculty Mentor: Chenyi Hu*

Distinctive and unique problems in statistical modeling and inference are generated through an analysis of experimental data that have been observed at different points in time. The applicability of many traditional statistical models is severely limited, as they assume adjacent observations to be independent and identically distributed. This research proposes two techniques for predicting an interval time series. The first method is based on exploiting correlation as a phenomenon that may be generated through linear lagged relations leading to Interval Auto Regressive Moving Average (IARMA). The second is based on handling nonstationarity in interval time series giving rise to Interval Auto Regressive Integrated Moving Average (IARIMA). In the proposed approach, we try to regressively fit the midpoint and radius of interval values assumed by the interval time series in the data set. A combination of the predicted midpoint and radius of the interval values is in turn utilized to forecast the lower and upper bounds of the interval time series. The proposed models are evaluated on the basis of estimating the average behavior of the mean absolute and the mean square error in the framework of interval data extracted from the CISL Research Data Archive.

# Joint H.264/SVC-MIMO Rate Control for Wireless Video Applications

***Christopher Rhodes***
*Faculty Mentor(s): Yu Sun*

The demand for high-quality mobile wireless communication services is increasing at an explosive rate primarily due to significant growth of multimedia data usage. As one of the most significant breakthroughs in wireless communications, Multiple Input Multiple Output (MIMO) technology can provide higher level data throughput with extremely low latency. Meanwhile, as the latest advance of video compression technology, the emerging H.264 Scalable Video Coding (H.264/SVC), has improved coding efficiency and provided a higher degree of scalability. Therefore, integrating H.264/SVC technology with MIMO wireless system can significantly enhance the overall performance of real-time wireless video transmissions and thus offers a unique solution for miscellaneous wireless video applications. However, the state-of-the-art techniques in these two areas are largely developed independently. In this research, with the objective to deliver the optimal visual quality and accurate rate

regulation for wireless video applications, we investigate the joint design of H.264/SVC-MIMO rate control. We propose a system architecture for H.264/SVC compression and transmission over MIMO systems. Our simulation results demonstrate that our proposed architecture is very effective, which forms a solid foundation for our research of joint H.264/SVC-MIMO rate control.

## Tool against Key Logging

***Devendar Reddy Singireddy, Sri Rama Satya Krishna Bobba***
*Faculty Mentor(s): Vamsi Paruchuri*

A key logger, sometimes called a keystroke logger, or system monitor, is a hardware device or small program that monitors each keystroke a user types on a specific computer's keyboard. A key logger program does not require physical access to the user's computer. It can be installed on purpose by someone who wants to monitor activity on a particular computer or it can be downloaded unwittingly as spyware and executed as part of a root kit or remote administration (RAT) Trojan horse. Key loggers can be potentially very harmful leading to Identity theft, personal usage monitoring and stolen passwords and financial / sensitive data.

Most of the anti key logging software's provide security up to certain level but cannot be 100% secured and more over anti key logging software's are more commercial based which doesn't help normal user. Other way to prevent key logging is using a virtual key board, but most of these are domain based i.e. only used for a particular website and which increases maintenance cost.

It is hard to track the mouse movement, thus prevents from key loggers to detect what are the keys pressed. The key advantages are lower maintenance costs, no necessity to have a special anti key logging software's which are expensive, it is not restricted to web page or domain or a single application.

Key loggers can be extremely dangerous pieces of software from an identity theft point of view. Since key logger programs log everything you type, criminals get a record of Web sites you visit, every user name and password you use and even sensitive personal information that you might submit on a Web form. We propose to develop a tool against key logging using an on-screen keyboard which randomly changes i.e. the keys are shuffled randomly.

# Modeling Uncertainty of Growth Rate with Interval Time Series

***Naveen Singireddy, Rahul Tada, Sri Ram Bobba***
*Faculty Mentor: Chenyi Hu*

Uncertainty plays a major role in the field of economics and finance. This happens mainly due to measurement inaccuracy and incomplete knowledge of factors that makes it difficult to accurately predict the results of different investments. Conventionally, uncertainty in finance and economics is described by statistical models. One of the primary limitations of the traditional probabilistic approach is that the exact point values of all the relevant probabilities have to be known before hand. However in economics and finance, we do not have enough statistics to precisely determine all the needed probabilities as the situation changes dynamically with time. In this work we propose a new approach for interval time series analysis. This approach accepts the possible values of probabilities in an interval ($\underline{p}$, $\overline{p}$). As we do not have the exact point value of the probability p. Further, if the possible probability of a given quantity is unknown, the approach only considers the interval ($\underline{X}$, $\overline{X}$) i.e. the possible values of quantity X. An evaluation of the proposed interval based approach is demonstrated by modeling the interval uncertainty in growth rates of population, financial and economic data sets.

# Interval Prediction for the SCAN Clustering Algorithm

***Vincent Yip and Sait Suer***
*Faculty Mentors: Chenyi Hu and Sinan Kockara*

In many application domains, a graph presentation of voluminous dataset may compose of thousands even millions of nodes and edges. Clustering these nodes and edges can play an important role in discovering knowledge. To achieve this, a number of community detection approaches have been proposed. These include modularity based algorithms, min-max cut, normalized cut, and the Structural Clustering Algorithm for Network (SCAN). Among them, SCAN is capable of detecting hubs and outliers in addition to cluster members. The term hub means node with ability of collecting and delivering information among clusters while outliers are considered as noise in the data. Currently, researchers use exhaustive search to determine the structural similarity threshold value (ε) in the SCAN. This paper reports a new approach of using interval ε value to narrow the searching domain for proper threshold value ε for the SCAN. The approach first adopts computational results produced by the Fast Modularity and the Walktrap algorithms to bound the number of clusters of a network and then determine the interval ε value. For each of our test datasets, the interval prediction reliably bounds the true number of clusters. More importantly, the proposed prediction method helps users to eliminate an average of 67.7% of inappropriate ε values used to generate clusters.

# Concept Discovery for Pathology Reports using an N-gram Model

***Vincent Yip***
*Faculty Mentor: Sinan Kockara*

A large amount of valuable information is available in plain text clinical reports. New techniques and technologies are applied to extract information from those reports. One of the leading systems in the cancer community is the Cancer Text Information Extraction System (caTIES), which was developed with caBIG-compliant data structures. caTIES embedded two key components for extracting data: MMTx and GATE. In this paper, an n-gram based framework is proven to be capable of discovering concepts from text reports. MetaMap is used to map medical terms to the National Cancer Institute (NCI) Metathesaurus and the Medical Language System (UMLS) Metathesaurus for verifying legitimate medical data. The final concepts from our framework and caTIES are weighted based on our scoring model. The scores show that, on average, our framework scores higher than caTIES on 848 (36.9%) of reports. Furthermore, 1388 (60.5%) of reports have similar performances on both systems.

# Department of Mathematics

# Dynamic Output Feedback Controllers for Store-Operated $Ca^{2+}$ Entry

***Jing Voon Chen***
*Faculty Mentor: Weijiu Liu*

Calcium ions play a central role in controlling cellular activities including muscle contraction, cell proliferation, and cell death. The store-operated $Ca^{2+}$ entry (SOCE) is proposed to be the main process that regulates calcium uptake into a non-excitable cell across the plasma membrane. Recent experimental studies revealed that SOCE is controlled by two major proteins, STIM1 and Orai1. Upon depletion of an intracellular calcium store, the endoplasmic reticulum, STIM1 binds directly to Orai1 to activate SOCE channels for calcium entry. In addition, experimental studies showed that the interaction of STIM1 and calmodulin with Orai1 inactivates the $Ca^{2+}$ release-activated $Ca^{2+}$ channel. In this research, we design a dynamic output feedback controller for both SOCE and the $Ca^{2+}$-dependent inactivation, validate the model by published experimental data, and provide theoretical insight into SOCE.

# Nonclassical Symmetries of a Nonlinear Burgers' System

***David Ekrut and Jackson Fliss***
*Faculty Mentor(s): Danny Arrigo*

The nonclassical symmetries of a class of nonlinear Burgers' system involving two arbitrary functions is considered. This study was initialized by Cherniha and Serov, *J. Math. Anal*. **282**, (2003) pp. 305-328 with a restriction on the form of the nonclassical symmetry operator. Here we remove this restriction and completely solve the determining equations to show that (1) a new form of Burgers' system exists that admit a nonclassical symmetry and (2) a class of Burgers' system that is linearizable.

# Fractals and Plane Symmetries

***Hayley Miller***
*Faculty Mentor(s): Fred HIckling*

M.C. Escher's art is familiar to most people, less familiar is that much of it is based on the Wallpaper groups. A group is a mathematical object that describes the symmetries of something. In much of Escher's art, he tiles the plane with repetitive pictures (e.g., Angels and Devils). These pictures are so constructed that various rotations and translations brings the tiles back onto themselves. The collection of all such rigid motions is the group associated to the tiling. Though there are an infinite number of different tilings each tiling is associated to only one of 17 different groups, the Wallpaper groups. The plane can be tiled with fractal shapes. Tiling with fractals, besides allowing for translations and rotations, also allows for symmetries that rescale the picture. We propose to explore the possible symmetry groups associated to tiling the plane with fractal shapes that can be rescaled.

# Spatial Modeling of Arkansas Deer and Turkey Populations

***Jason Morris and Jonathan Johnson***
*Faculty Mentor(s): Patrick Carmack*

The Arkansas Game and Fish Commission keeps track of the number of deer and turkeys taken for each hunting season at the county level. We apply spatial modeling to exploit the inherent spatial relationships in the data to obtain high resolutions estimates of these two populations via a technique known as kriging. The particular implementation employed makes use of novel non-parametric semivariogram methods researched by the Mr. Morris, Mr. Johnson, and Dr. Carmack. Such applications can be used to track shifts in animal populations over time, and could be used to guide hunting policy decisions.

# Engaging Students in Realistic Mathematics: Police Station Problem

***Dennis Show***
*Faculty Mentors: Long Le and Carolyn Pinchback*

The city of Conway, AR just built a new police station located at the corner of Prairie St. and Front St., but, is it the best location to minimize the response time to a call when one comes in? This is the question that we will answer using a technique called method of random search. By analyzing the district breakdown of the city of Conway, the frequency of calls to each district, and the gridding of the city, we can answer that burning question, and begin to see how teaching secondary mathematics can be more meaningful, more engaging, and ultimately, more real.

# Counting on Our Future: Are Educational Technologies Effectively Allowing Math Teachers to Prepare US Students for the World of Tomorrow?

***Jon Sumners***
*Faculty Mentor: Jean J. McGehee*

According to a 2010 study conducted by the Organization for Economic Co-operation and Development (OECD), US students rank 19th in math and 14th in science out of 31 countries. In addition, an article in the *New Jersey Mathematics Teacher* maintains that the "United States is currently facing a severe shortage of mathematicians, scientists and engineers" and is having to import foreign professionals to meet these voids.

During a speech at a January 2010 Educate to Initiate meeting at the White House, President Obama warned, "Our future is on the line. The nation that out-educates us today is going to out-compete us tomorrow. To continue to cede our leadership in education is to cede our position in the world." Hence, math educators have essentially issued a national call to arms by rallying for intermediate through high school math teachers to implement a curriculum that integrates math, science, and technology in hope of motivating students to pursue careers in these fields. As a result, a technological boom has ensued within American schools. Essentially, school districts are spending large sums of money on educational technologies without exploring literature pertaining to these technologies or investigating the few scientific studies available about the effectiveness of these technologies.

By compiling a brief literature review over the effectiveness of interactive whiteboards and graphing calculators, we can investigate whether or not these

technologies are useful in the classroom setting. Through the results of an Arkansas statewide survey, we can analyze the correlation between technology use and student performance on statewide End-of-Course assessments in order to examine the effectiveness of these technologies.

## Reducing Sonic Boom for Supersonic Wings

***Mark VanDerLugt***
*Faculty Mentor(s): Clarence Burg*

The Concorde's first flight in 1969 changed intercontinental travel with its ability to cruise at Mach 2, however it is unable to cruise at supersonic speed over land due to the sonic boom its wings produce. We began trying to produce a wing design that does not produce this sonic boom. We concluded that there is no way to create a wing with an upward lift without some downward sonic boom (i.e., Newton's Laws of Motion). We then decided to try to reduce the sonic boom, while having a decent lift to drag ratio. The Concorde's lift to drag ratio was approximately 7; our current design has a lift to drag ratio of over 5, with a much reduced sonic boom.

# Department of Physics and Astronomy

# Quantitative X-Ray Analysis with ZAF Corrections using an SEM/EPMA

***Saroj Adhikari***
*Faculty Mentor(s): Rahul Mehta and Scott Austin*

Scanning Electron Microscope (SEM) and Electron Probe Micro Analyzer (EPMA) are important tools for research in material science, biophysics, chemistry and geology. SEMs are used to produce high-resolution images of various samples; EPMAs are additionally equipped with detectors and spectrometers for various qualitative and quantitative chemical analysis. A SEM/EPMA was used to perform quantitative x-ray analysis of a few samples containing Cu, Mg and Au. Characteristic x-rays of these elements were analyzed beforehand qualitatively to make sure that the samples contained the elements under consideration. In the SEM/EPMA, an electron beam of about 20 keV was directed on the samples; an SEM image was taken and the x-ray intensities at various wavelengths were measured. Then, to first approximation, the mass concentration of the elements in the samples were calculated by simply taking the product of the ratio of the measured x-ray intensities and the mass concentration of the known standard sample of the elements under consideration. Finally, ZAF corrections were applied to account for the effects that occur due to atomic number (Z), x-ray absorption (A), and x-ray fluorescence (F).

# Gamma Ray Emissions in Beta Decaying Elements*

***Pete Bland, Dustin Morris***
*Faculty Mentor: Rahul Mehta and Stephen Addison*

After an element undergoes beta decay, gamma ray emission follows as the element transitions to its ground state. The gamma ray emissions of various elements were studied using a sodium iodide detector which was thallium activated. The system was calibrated using known gamma ray energies of cobalt ($^{60}$Co) and cesium($^{137}$Cs). Using a isotopic chart of gamma ray energies, elements of manganese, zinc and barium were identified. The calibrated system was used to study gamma-gamma coincidence using gamma emitting isotope of sodium ($^{22}$Na). The source undergoes positron emission which then annihilate, emitting two gammas of 0.511MeV energies at an angle of 180° to one another. One detector was held fixed while a second detector was rotated around the source from -20° to 20°. The area of the 0.511MeV peak was studied. It was determined that the positron emission and subsequent annihilation results in two gamma ray emissions at a 180° angle to one another.

*Acknowledgements: Lucas Phinney and Dr. J.L. Duggan, University of North Texas

# X-Ray Fluorescence: Identification of Unknown Samples*

***Renee Brock and Josh Lieblong***
*Faculty Mentors: Stephen Addison and Rahul Mehta*

X-Ray fluorescence is a modern-day trick used to identify different elements by the energy they emit as x-rays. A certain, unknown, sample is placed near a detector and is bombarded with photons from either a radioactive or an x-ray source. Upon contact with the sample, the sample will emit characteristic x-rays with certain, predictable energies. These energies appear as peaks on a graph of relative intensity versus x-ray energy (measured in keV). In order to generate these graphs, a computer software Maestro is used. The use of this software allows the data to be analyzed and compared. This method has many practical applications. For instance, it may be used to test a sample and determine if the sample is above the safe range (elemental composition) for humans. Multiple samples were tested and the graphs were compared to known values to determine their elemental composition.

*Acknowledgements: Dr. Jerome Duggan and Lucas Phinney of University of North Texas

# Using Doppler Ultrasound to Measure the Motion of a Double Pendulum

***Joshua Lieblong***
*Faculty Mentor(s): Carl Frederickson*

Doppler ultrasound is being evaluated as a tool for characterizing human motion. A high frequency sound wave is transmitted toward a moving object, which then reflects frequencies shifted from the transmitted frequency due to the velocity of the object. A double pendulum model has been used to model the behavior of a leg. The double physical pendulum's characteristics are being examined to determine if the current experimental apparatus can be used as a model. The current apparatus can be used as a model for future experiments. The same techniques could be applied to measure a gait signature. The comparison can be used to model anything from an individual's walk to distinguish that person's mood, mass, or even as a type of identification system for oscillatory human motion.

## Spectroscopy of Cepheid Variable Stars

***Jeremy A. Lusk***
*Faculty Mentor: Scott Austin*

Cepheid variable stars are large, hot stars that undergo dramatic pulsations with a regular period. This study uses the University of Central Arkansas Observatory Meade 14-inch aperture LX200R GPS telescope and fiber-fed bench spectrograph to examine the stellar spectra of Cepheid variable stars for variations in the oxygen absorption triplet line at 7774 Angstroms. Previous studies have indicated that the equivalent width of this feature should vary with the luminosity phase of the star, but lacked confident phase values for the maximum and minimum feature strength. Observations taken on different nights should reveal these variations, and their corresponding phase values.

## Behavior of a Helmholtz Resonator Driven at High Amplitudes

***Dustin Morris***
*Faculty Mentor(s): William V. Slaton*

The acoustic behavior of a Helmholtz resonator was studied when driven by a compressed air source. The resonator consists of a 55 gallon drum with 4" diameter necks of different lengths. Compressed air from a 0-15psi regulator is introduced into the resonator using an electronic valve controlled by a signal generator. A pressure sensor was used to study the acoustic behavior of the resonator as it was driven over the resonance frequency with the compressed air source. By closely examining the resonant peaks, the quality factor of the system could be determined for different drive pressures. The measured resonance frequencies are compared to two theoretical models. The resonator's quality factor (energy stored in resonance/energy lost per cycle ) is shown to decrease with drive amplitude indicating increased losses with higher amplitude.

# The Effect of A Helmholtz Resonator's Neck Geometry On The Aero-Acoustic Excitation of Resonance

**Asami Nishikawa**
*Faculty Mentor(s): William V. Slaton*

The aero-acoustic excitation of a Helmholtz resonator with different neck geometries has been examined with an improved measurement technique. A Helmholtz resonator consists of a volume connected to a duct and has a well defined resonance frequency which depends on the length of the duct, the volume of the resonator and the cross sectional area of the duct. In the system used during this experiment, two Helmholtz resonators have been positioned at opposite sides of a junction in a wind tunnel. The air speed in the wind tunnel can be varied over the range 0 to 28 m/s. The air flowing over the junction openings to the Helmholtz resonators can excite the acoustic resonance of the system. This is similar to blowing over an empty bottle's opening and creating a tone. The excitation of the resonators as a function of flow speed in the wind tunnel has been recorded. The effect of the resonator's geometry has been seen in the measured acoustic amplitude and frequency in the resonator and will be presented.

# Energy Loss of Alpha Particles in Copper Foils*

***Brandon Stocks, Trey French***
*Faculty Mentor(s): Rahul Mehta and Stephen Addison*

The purpose of this experiment was to find the energy loss (dE/dx) of alpha particles as they passed through Copper foils of known thickness. The alpha source was Americium-241. A Silicon Surface Barrier Detector, plated with Gold on one side and Aluminum on the other, was located above the source and foils. The area where the detector and source were located needed to be evacuated so the detector would function properly and so the alpha particles wouldn't lose energy passing through air. A bias of 50 volts was applied across the detector. Copper foils were then stacked one at a time to measure the energy loss of the alpha particles. Maestro, a software designed to work with the detector, showed a graph of Counts vs. Energy. The energy peaks and alpha intensities were displayed through the software. As expected, the intensity of alpha radiation decreased with increasing thickness of foils.

Acknowledgements: Duncan Weathers, University of North Texas

# Determination of Thin-Film Sample Thickness Using a $He^+$ Ion Beam

***Alec Watson and Asami Nishikawa***
*Faculty Mentors: Stephen Addison and Rahul Mehta*

When an ion beam of known energy is incident on a thin-film sample, the energy of the scattered particles can be measured and used to determine the thickness of the thin film. This study used a linear alpha particle accelerator to bombard a sample that consisted of a silicon chip coated with a thin film of some metal combined with a detector that measured the energies of the scattered particles. As the positively charged alpha particles travel through the thin metal film, they lose energy as they interact with the negatively charged electrons surrounding the nuclei of the metal. The energies of the incident ions and scattered ions are then compared. Since each metal has a different atomic number and hence different nuclear charge, each metal will exert a slightly different Coulombic force on the ions. The behavior of the alpha particles in different metals is accounted for in calculating the thickness of the sample using constants that are specific to each metal.

Acknowledgement: We would thank to the IBMAL Lab's instructors, Mongel Dhoubadel, Jerry Duggan, and Venkata Kummari.

# Changes in the Elemental Composition of Rat Leg Bones Subjected to Hind-Limb Suspension

***Alec Watson***
*Faculty Mentor: Rahul Mehta*

Hind–limb suspension, or HLS, is a NASA validated model of simulated weightlessness. This study examines whether the exposure of rats to HLS for a period of 1 or 2 weeks affects the relative ratios of elements in the leg bone tissue of the rats, with emphasis on the levels of calcium phosphate in the bones, one of the primary constituents that provides the 'hardness' of the bones. To determine the elemental composition, x-rays produced by a 20keV beam of electrons by a scanning electron microscope (SEM) were analyzed by computer software that recognizes the unique signature of x-rays produced by different elements. Changes in the ratios of elements in control vs. experimental rats were then determined. Results suggest that calcium phosphate is produced at the same rate in both groups, but without the minute amount of wear each step causes on bones in the HLS rats, there is an imbalance of calcium phosphate in the bone tissue, especially around the knee.

## Index:

The student presenter's names are in **bold** font.