*The College of*
*Natural Sciences and Mathematics*

**University of Central Arkansas**

Biology * Chemistry * Computer Science * Mathematics * Physics & Astronomy

# Abstracts

# The 19th Annual Student Research Poster Symposium

## April 19, 2013
## 2:00 - 4:00 pm

## Student Center Ballroom

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

## Introduction from the Dean's office

This book contains the abstracts for the 19th 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 87 abstracts with 134 student authors, 1 external student author, 48 faculty mentors, and 5 external 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.

# Biology

## Investigating the Specificity of Neurotrophism and Neurotropism of Neural Crest Derived Precursors

***Faviola Aguilar, Christian Haney, Lauren Hyde, Megan Hammond, Derek Karr, Ashley Long, Marcus Loudermilk, Miki Lindsey, Casey Pulliam, Tara Parish, Laken Woods, and Yao Xu***
*Faculty Mentor: Bhupinder P. S. Vohra*

The notion of neural crest cells and their impeccable ability to differentiate into many different cell types of the developing embryo is becoming more and more researched and delved into in the world of regenerative research in the biological and medical field. Neural crest cells, migrate throughout the body to form structures such as facial structure, pigmentation in skin cells, sensory ganglia organs and the skull. In order to form these structures, however, the neural crest cells have to migrate to their destination, be it the cranial region, the cardiac region, the vagal and sacral region, or the trunk region. In addition, neural crest cells can also migrate into the gut through the vagal neural crest cell pathway. More specifically once the neural crest cells are past the somites, cells from the vagal neural crest enter into the foregut, and spread to most of the digestive tube. Once in the developing gut, the vagal neural crest cells are attracted to the digestive tube by Glial-Derived Neurotrophic Factor (GDNF), which is a paracrine factor produced by the gut mesenchyme that binds to its receptor, Ret (Receptor Tyrosine Kinase), and this is supported by the fact that vagal crest cells have more Ret receptors (and GDNF) than the sacral rest cells do, because vagal cells have GDNF that bind to Ret, and the sacral neural crest cells generally do not. In fact, it is the vagal cells that will eventually become the enteric nervous system. The purpose of our experiment was to look at the different neurotropic and neurotrophic factors that exist in the differentiated dorsal root ganglia cells and the enteric portions of the gut of the mouse. Neurotropic factor, are the factors whose purpose lies in allowing the mouse cells to have the affinity for neurons. WE have performed the experiments to investigate the neurotrophic and neurotropic specificity of neural crest derivatives, which are going to form dorsal root ganglion and enteric nervous system.

## Mussel Diversity Survey in the Sylamore Ranger District, Arkansas

***Loren Biggs, Joshua Bregy, Neil Holaway, and Heather Humphrey***
*Faculty Mentor: Ginny Adams*

As biological indicators of a healthy habitat, freshwater mussels play a critical role in riverine ecosystems as they regulate energy and nutrient flow via filtration (Pouldal 2012). Additionally, mussels serve as biodiversity regulators within ecosystems (Pouldal 2012). Studies suggest that

mussels become increasingly more pivotal in an ecosystem as they increase in biomass (Spooner 2007). However, freshwater mussel populations have recently been in decline, sparking an increase in research and conservation methods from the scientific community. Since mussel biodiversity and distribution are heavily reliant on environmental conditions such as aquatic chemistry, physical characteristics of watersheds, and even biota present (Burlakova et al. 2011), declines in populations can be attributed to changes in environmental conditions. Several studies indicate that habitat destruction is a major cause for mussel decline due to siltation as well as heavy metal and pollutant contamination (Bogan 1993; Downing et al. 2010). Other causes for mussel population decline stem from the loss of host species, which play an integral role in mussel lifecycle, or the introduction of nonnative species, which can outcompete native species (Bogan 1993; Downing et al. 2010). Our research focuses on mussel communities in the Sylamore Ranger District (SRD), where little research on mussel diversity exists. Our study will evaluate mussel diversity and habitat along multiple riverine ecosystems located within the SDR. Selected riverine sites will be visually scanned along the banks for dead and live mussel shells. The different mussel species found will be counted, collected (dead shells only), identified, and tagged with GPS coordinates. EPA habitat assessments of survey sites will be conducted to determine if any correlation exists between mussel diversity and habitat. Sampling a variety of stream habitats should allow us to better explain and evaluate the mussel community by examining richness, abundance, and disbursement along riverine environments in the SRD.

## Water Conservation in Pima Cotton During Drought Possibly Due to Increased Thermotolerance

***Tyler Button***
*Faculty Mentor: John Choinski*

Young Upland cotton (*Gossypium hirsutum*) leaves are warmer and have a higher photosynthetic thermotolerance than more mature leaves because of the limited evaporative cooling ability of their undeveloped stomata. This project addresses the question: What might the plant responses of the young and mature leaves be under water stress? To answer this question, Upland cotton and a known water stress resistant (and presumably thermotolerant species), Pima cotton, (*Gossypium barbadense*) were grown in a greenhouse under the same conditions; after approximately 50 days after planting, five plants of each species were artificially water stressed by adding the water absorbing carbohydrate, polyethylene glycol (PEG) to the soil while five of each species was watered normally. Photosynthesis was estimated using two chlorophyll fluorescence parameters: maximum quantum yield ($F_v/F_m$) and actual quantum yield ($\Phi_{PSII}$) and transpiration (evaporative cooling) rates were estimated by measuring stomatal conductance (g) using a humidity difference porometer. We found that mature Upland leaves decreased their g by 37% when water stressed while mature Pima leaves decreased their g by 71% when water stressed. We concluded that the thermotolerance of young and mature Pima cotton leaves allowed them to conserve water because they did not have to transpire to keep cool to avoid heat damage while mature leaves of Upland (of necessity) exhibited evaporative cooling at a higher rate. Being able to conserve water allowed the young leaves of PEG treated and watered Pima cotton to show no significant difference in $F_v/F_m$ unlike Upland cotton; the young PEG stressed Pima leaves also had a statistically higher $F_v/F_m$ value than did young stressed Upland cotton leaves.

# Upstream Migration of Yellow-Phase American Eels *(Anguilla rostrata)* at Norrell Lock and Dam, Arkansas River Navigation System

***Casey Cox***
*Faculty Mentors: Reid Adams and Ginny Adams*

The American eel *(Anguilla rostrata)* has experienced a decline from historical population sizes in parts of its range. Previous studies focus on Atlantic river systems, however limited data exists on the species within the Mississippi River Basin. It is hypothesized that the American eel has experienced similar declines in the Arkansas River. Limited recruitment into the Arkansas River could explain a declining population within the system. Our objective was to describe the upstream migratory phenology of yellow-phase eels in the Arkansas River Navigation System. A concrete sill below Norrell Lock and Dam, the first obstacle fishes migrating upstream from the Gulf of Mexico encounter, was sampled by backpack electrofishing from 22 March 2012 to present. Nineteen yellow-phase eels (mean length = 487mm, $\pm$ 97mm) were collected below Norrell dam. Seventeen were collected from 7 April 2012 to 21 May 2012, two others were collected on 13 January 2013 and 23 February 2013. Maximum eel abundance corresponded to increasing river flow and temperatures ranging from 22-27° C. The presence of eels below Norrell dam for a limited period and within a certain temperature and flow regime possibly indicates migratory yellow-phase eels are seeking entry into the Arkansas River.

# Characterization of Gym Surface Microorganisms

***Jade Crumley and Marcus Loudermilk***
*Faculty Mentor: Ben Rowley*

With the rising cost of healthcare and increasing threat of Community MRSA (C-MRSA), it is important to investigate and determine if local university facilities are harboring harmful bacteria and potentially putting students using the facilities at risk of infection. We obtained surface swab samples from our local university gym to determine if potentially harmful bacteria were present. Gram-staining and a variety of biochemical tests and culture media were used to identify the bacteria obtained. While most surfaces do typically harbor some forms of bacteria on them from time to time, our study has found instances of both *Staphylococcus epidermidis* and *Staphylococcus aureus* on the 20 pieces of gym equipment sampled. We also tested the effectiveness of cleaning products used in this gym setting against the bacteria obtained by both serial dilution/growth and flow cytometric viability assay methods. This study will help to determine if current bacterial control methods in this gym are working effectively.

## Creating Mitochondrial Targeted mCherry

***Andrea Eades and Olivia Vogel***
*Faculty Mentor: Kari Naylor*

The purpose of our research is to create a mitochondrial targeted red fluorescent protein. This will enable the mitochondria to be visible *in vivo* with the use of a fluorescent microscope. These fluorescently labeled mitochondria may then be used in further research studying mitochondrial dynamics.

The cloning process we used can be divided into four main steps: (1) polymerase chain reaction, (2) digestion, (3) ligation, and (4) transformation. Thus far in our research we have performed all four steps to create our construct where we linked a 35 amino acid mitochondrial targeting sequence to the red fluorescent protein, mCherry and inserted this into the *Dictyostelium discoideum* expression vector pDXA-3H. Now we must screen our colonies for the correctly assembled construct. If our initial cloning experiment is determined to be unsuccessful, then sources of possible error will be considered, the procedure will be modified accordingly, and additional attempts will be performed.

## Environmental Factors Affecting Amphibian Relative Abundance and Species Richness in Wildlife Ponds in the Sylamore Ranger District, Arkansas

***Derek Filipek, Elliot Thompson, Micah Kendrick, and David Holt***
*Faculty Mentor: Ginny Adams*

Amphibian sampling was performed in nine ponds in the Sylamore Ranger District in Arkansas. Sampling was performed using dip net sweeps in each pond, visual counts of amphibian egg masses, and by placing recorders at all ponds to record frog calls. Habitat and water quality were also taken at each pond in order to determine how these factors affect amphibian relative abundance and species richness. The list of factors tested include water quality, canopy density, distance of a pond to a main road, percent aquatic vegetation, large woody debris, pond area, maximum pond depth, and fish presence. The recordings yielded multiple frog species calling at the majority of the ponds and the dip net sampling also yielded multiple amphibian larval species. Egg mass counts varied greatly for each pond.

# Histochemical Organization of the Dorsal Thalamus in the Nine-Banded Armadillo (Dasypus novemcinctus)

***J. Fletcher*, B. Moffitt, C. Sherwood , and N. Scroggins***
*Faculty Mentor: Jeffrey Padberg*

Most comparative neurobiological studies of mammals have focused on species within five of the six mammalian superorders, or superclades. However, there remain gaps in our understanding of the organization of mammalian somatosensory and auditory systems, which will only be filled by considering examples from all six superorders. Notably, the neural organization of members of the relatively early superclade Xenarthra remains largely unexamined. The nine-banded armadillo, a member of Xenarthra already recognized as holding promise for studies of neural development due to its polyembryony, constitutes an excellent model for studies of evolutionary neurobiology. In a related study, we are examining the neuroanatomical organization of the armadillo thalamus. While others have previously described the diencephalic organization of armadillos (e.g. Papez, 1932; Howe et al., 1933), we are extending these findings through the use of modern Histochemical staining techniques as well as classical methods (e.g. cytochrome oxidase and Nissl). In cytochrome oxidase series, the ventroposterior nucleus (ventrolateral of Papez) is segregated into a medial portion, which is moderate to dense in staining intensity and relatively homogenous, and a lateral portion, which is densely stained and somewhat interrupted by small fiber bundles. The ventrolateral nucleus, located just dorsal to the ventroposterior lateral nucleus, is lighter and is very homogenous. The lateral geniculate is densely stained and occupies a large dorsolateral extent of the posterior thalamus. While generally in support of the earlier parcellation, the divisions of the ventroposterior nucleus are very clear in CO stained tissue. Neuroanatomical tracer experiments are expected to clarify further parcellation of these nuclei based upon thalamocortical connections.

# Response of Chironomid Growth and Elemental Composition to Changes in Resource Stoichiometry

***Chris Fuller***
*Faculty Mentor: Sally Entrekin*

Aquatic macroinvertebrate diversity in freshwater systems often declines with nutrient enrichment, resulting in dominance by tolerant taxa like Chironomidae larvae. Chironomid dominance in enriched systems could be due to a physiological ability to allocate increased nutrients in food resources, like nitrogen and phosphorus taken up by detrital heterotrophic microbial biofilms, towards growth. Some detritivorous chironomids can increase growth rates when resource phosphorus content is elevated; however, it is unclear if all chironomid genera are able to use increased nutrients for growth. Leaves were incubated in nutrient enriched water to produce three food quality levels defined by carbon:phosphorus ratio (C:P). Incubated leaves were then fed to different chironomid genera (*Micropsectra, Chironomus*). *Micropsectra* fed high quality (824C:P) food grew significantly more (mean±1SE, 10.77±0.50%/day) than those fed medium (1127C:P; 5.77±1.31%/day) or low quality food (1504C:P; 6.57±0.84%/day) ($p=0.02$).

*Chironomus* growth did not differ significantly across food levels (p=0.63). Our preliminary data suggests that chironomid responses to nutrient enrichment may differ across genera, possibly based on differential carbon and phosphorus allocation to body tissue, causing differences in organism C:P. Generic resolution of chironomid response to basal resource enrichment can provide a framework for predicting alterations in community structure in nutrient enriched environments.

## Implications of Long Distance Migrations in Relation to Life History Strategies of Striped Mullet, *Mugil cephalus*, in the Lower Arkansas River

**Garrett Grimes**
Faculty Mentors: Reid Adams and Ginny Adams

The striped mullet, *Mugil cephalus*, is a cosmopolitan species of fish that can be found off the coastal waters of the United States, and has sometimes been labeled a catadromous species due to their migrations into brackish and freshwater. In Arkansas, striped mullet have been labeled a curiosity due to their perceived low abundance; however, a large aggregation of striped mullet has been observed occurring in the lower Arkansas River. Sampling using boat electrofishing occurred at monthly intervals from September 2012 through February 2013. Striped mullet in the area were found to be present (N=306, CPUE=0.9 fish/min) during all sampling events. This observed abundance suggests a permanent population; however, catch rates varied drastically in monthly samples with highest catches occurring at the start of our sampling in the fall ( September n=185, CPUE=3.08 fish/min) and the lowest catch occurring during winter sampling (December n=21, CPUE=0.23 fish/min). It is unknown why the striped mullet found in the lower Arkansas River have migrated such a large distance from saltwater, and what role the freshwater habitat has in their life history. Investigations into this population are planned to continue throughout 2013, and will be compared to non-migratory populations found in Louisiana in order to determine potential differences in life history strategies.

## Effects on Environmental Quality in North and South Sylamore Headwater Streams Located in the Sylamore Ranger District, Arkansas

***Nick Gaulden, James Holder, and Landon McClain***
*Faculty Mentor: Ginny Adams*

Environmental assessments are vital for evaluating habitat quality and determining factors that potentially threaten environmental health. In order to complete the senior capstone course Environmental Practicum, a group research project was completed. The goal of our research was intended to test our hypothesis that overall environmental quality will be higher for tributary sites on North Sylamore Creek than tributary sites of equivalent size on South Sylamore Creek, which have historically been more impacted. We assessed several factors that influence stream habitat

quality which included analysis of water quality parameters, collection of macroinvertebrate indicator species, riparian vegetation and land use/land cover analysis. Methods we used to asses these factors included; Pfankuch stream stability scale, GIS mapping of the individual sites, data comparison of water quality parameters which include temperature, pH, dissolved oxygen, turbidity, flow rate, nitrogen and phosphorus levels, and conductivity.

## Examining Correlations Between Natural Gas Development and Life History Characteristics of Redfin Darters (*Etheostoma whipplei)* in the Fayetteville Shale, AR

***Jessie Green***
*Faculty Mentor: Ginny Adams*

Rapid development of unconventional natural gas extraction can impact surface waters through reduced streamflow from water extraction, contamination from chemicals or wastewater from fracking processes, and increased sediment runoff from deforestation, construction of roads/pipelines, and heavy use of unpaved roads. Environmental perturbations are well known to cause phenotypic plasticity in life history characteristics of fishes, including: alterations in size at maturity, sex ratio, reproductive investment, and reproductive success (trade-offs between number and size of offspring). Redfin darters (*Etheostoma whipplei*) were collected from 12 sites during the peak spawning season (March-May) 2012. Life history characteristics were examined to determine mechanisms of negative correlations between year class one *E. whipplei* and increasing gas well density. March 2012 samples showed increased reproductive efforts (gonadosomatic index) in both males and females from sites with high gas well density ($F_{2,99}$=22.67, $P$ <0.0001; $F_{3,82}$=4.49, $P$=0.0141; respectively) compared to control sites. Redfin darter populations impacted by gas well activity were skewed towards mature (>30.40mm) individuals and had the smallest mature individuals. Preliminary results suggest life history tradeoffs may exist for populations with gas well activity. These data may provide insight into the established reduction in year class one Redfin Darters.

## Enhanced Photosynthetic Thermotolerance of Young *Gossypium Hirsutum* (Cotton) Leaves is Associated with High Levels of Total Lipid and Thylakoid Membrane Lipid Fatty Acid Saturation

***Trent Hall and Harold Owiti***
*Faculty Mentor: John Choinski*

Young cotton leaves respond differently to the environment than more mature leaves. We have shown that young leaves (1-5 days old) when measured early in the growing season (but not in the late season) were as much as 15°C warmer (during periods of peak irradiance mid day) than more mature leaves (~13 days old) as a consequence of lower stomatal conductance and less

developed stomata. Warmer, young leaves also had higher photosynthetic thermal optima than the cooler, more mature leaves as determined by gas exchange and chlorophyll *a* fluorescence. We hypothesized that changes in thermal optima during leaf expansion were caused by alterations in fatty acid saturation levels in total lipids plus in the key thylakoid glycerolipids, monogalactosyldiacylglycerol (MGDG) and digalactosyldiacylglycerol (DGDG) along with the phospholipids, phosphatidylglycerol (PG) and phosphatidylcholine (PC). The results generally supported the hypothesis: total leaf lipids showed decreases in saturated 16:0 and increases in trienoic 18:3 fatty acids as the leaves expanded. DGDG, but not the other thylakoid lipids, also showed a similar pattern of decreasing saturation as the leaves expanded and cooled. We plan to further investigate the impact of fatty acid saturation levels on thylakoid membranes by directly measuring fluidity using a spin label and EPR spectrometry. We also intend to study the expression of fatty acid desaturase (FAD) genes during leaf expansion to determine whether alterations in membrane lipid composition are regulated at the transcriptional level. Our results may be important in understanding how young cotton seedlings survive the crucial weeks after planting, and also relevant to how plants will respond to expected rising global temperatures and increased desertification.

## Loopy Loopers Lacerate Leaves Lacking Laticifers

***Kyle Hurley***
*Faculty Mentor: David Dussourd*

Herbivorous insects on plants that emit latex or other exudates commonly sever leaf veins before feeding, thereby reducing the outflow of poisonous, sticky exudate at their distal feeding site. Surprisingly, soybean loopers (Chrysodeixis includens) not only sever veins of plants with exudates, but also cut veins of geranium, Pelargonium hortorum, which lacks canal-borne exudates. In laboratory assays, final instar soybean loopers did not exhibit vein cutting when tested with three defensive chemicals found in geranium: quisqualic acid, a neurotoxin that mimics L-glutamic acid and causes paralysis in Japanese beetles; geraniol, an essential oil associated with insect deterrence; and anacardic acid, a long chain phenol found in the glandular trichomes. The trichomes were extremely toxic to soybean looper eggs. Significantly fewer eggs hatched when treated with fluid from a single glandular trichome. First instar caterpillars mostly died within 24 hours when enclosed on intact or excised geranium leaves. However, survivorship increased substantially when the excised leaves were rinsed with ethanol, thereby removing the orange exudate from trichomes. These results document the effectiveness of geranium chemical defenses against a generalist folivore. It remains to be determined if vein cutting actually benefits soybean loopers on geranium or if it is simply an inappropriate response to a nonnative plant.

## Environmental Summary of Conway, Arkansas Parks

***Andrew Jones, Sehr Shaikh, and Bailey Williams***
*Faculty Mentors: Ginny Adams and Steve O'Connell*

The parks system in the city of Conway, Arkansas offers a variety of amenities and facilities for the residents of Faulkner County. In an effort to improve upon the existing parks and establish an all-inclusive GIS database for a Master Plan of Conway Parks, we created a summary of environmental attributes and biological data for 15 city-owned parks and the Jewel Moore Nature Reserve at the University of Central Arkansas (UCA). Conway parks with highest tree diversity were Laurel Park, with 9 genera and Cadron Settlement park, which had 6 genera located within the park. The parks with the highest bird diversity included Beaverfork Lake and Tucker Creek parks, these were also parks proximal to bodies of water. GIS data of park amenities and facilities were used to create maps of the parks. The results of the survey to date showed 97.8% of the participants felt that presence of a park in their neighborhood had a positive effect over all; 93.3% felt park presence improved mood and 87.8% agreed parks had positive effects on physical health. When asked to rank importance of park services, participants ranked recreational utility, security, and natural feel the highest. These data will be available to the public for information on existing park amenities and locations. Data has also been retained for use in further research or planning activities and locations.

## Calpain Inhibition Blocks Tributyltin Induced Neurodegeneration

**Miki Lindsey**
*Faculty Mentor: Bhupinder P. S. Vohra*

Tributyltin (TBT), an endocrine-disrupting chemical, has been used as a heat stabilizer, an agricultural pesticide, and a component of antifouling paints. When TBT degrades it produces dibutylin and monobutylin which are toxic to diverse organisms, including humans. TBT dissolves easily in lipids and fats, so it can be absorbed by body very easily through inhalation, contact with skin, or ingestion. Upon cellular contact TBT causes an increase in intracellular calcium in various cell types but the mechanism of TBT neurotoxicity remains unknown. In the present study we found that TBT exposure lead to extensive axonal and neuronal cell body degeneration in the *in vitro* cultured dorsal root ganglion neuron. We discovered that TBT upregualtes neuronal calcium levels which is followed by the activation of calpains. Inhibition of apoptotic pathways by overexpression of Bcl-xl did not block neuronal demise in TBT treated neurons and overexpression of Nmnat1 also failed to provide axonal protection in these conditions. However, overexpression of calpastatin in these neurons inhibited the TBT induced calpain activation and neuronal death. Thus we conclude that mitochondrial apoptotic pathways or Nmnat mediated pathways do not play a significant role in TBT neurotoxicity and the calpain inhibitors can be utilized as a potential protective agent in TBT induced neurodegeneration.

## The Bee Communities of the Arkansas River Valley

***Coleman Little***
*Faculty Mentor: Katherine Larson*

Pollination is arguably the most ecologically important plant-animal interaction in nature and despite urbanization, pollinator communities can remain diverse and abundant wherever floral resources remain. This project is focused on bees because of their diversity, abundance, importance to pollination webs, and the lack of information on bees in Arkansas. The goal of this project was to quantify and document the bee communities in Arkansas River Valley prairies, specifically contrasting a large native prairie complex with a small native prairie contained within an urban setting. I am interested in whether the Jewel Moore Nature Reserve (JMNR), an urban reserve on the UCA campus housing a small remnant native prairie, supports specialized bee species or if the community is more typical of disturbed and urban areas. I sampled JMNR, Laurel Park, and a high quality native prairie owned and managed by the Arkansas Natural Heritage Commission, Cherokee Prairie. To compare the bee communities of these sites I sampled three sites within each prairie during the spring of 2012. The bee community of each site was sampled using pan trapping and hand netting techniques. These collections yielded 2,713 individuals, 28 genera and 116 species. Although expert confirmations are pending, statistical analysis using nonmetric multideminsional scaling (NMS), rarefactions, ANOVAs, and similarity indexes show JMNR has bee community similarities with the other sites while maintaining its own, unique community.

## The Effects of Hypoxia and Acidification on MCF-7 Cell Microtubule Arrangement

***Ashley Long and Carson York***
*Faculty Mentors: Steven Runge and Leah Horton*

This experimentation is designed to exploit the effect of hypoxic and acidic conditions on microtubule arrangements in MCF-7 breast cancer cells. It is predicted that the acidification will contribute to destabilization of the microtubule cytoskeleton, when exposed to low pH (6.75 or lower) at each time point; therefore, confocal microscopy is used to image MCF-7 cells exposed to highly acidic conditions and compare them to a control group of normal acidity. There are three experiments that take place: acidification alone, hypoxia alone, and both acidification and hypoxia. First, cultured MCF-7 breast cancer cells will be exposed to acidification alone for pH 7.25 (control), 6.75, and 6.25 at time points 0, 2, 4, 6, 8, and 10 minutes. Second, the cells are exposed to hypoxia alone at the same time points. Finally, the cells will be exposed to both hypoxic and acidic conditions at the same time, and then the cells will be imaged with confocal microscopy, quantified, and compared to that of normal MCF-7 cells to determine the overall effect of both hypoxia and acidification. Preliminary data shows destabilization of the microtubules at pH 6.25 time zero, whereas pH 6.75 has no overall effect on the microtubule organization when compared to the control.

## Algae and Snails Influence the Rate of Leaf Decomposition

***Mary McLeod***
*Faculty Mentor: Sally Entrekin*

Detritus-based food webs of headwater streams with dense canopy cover rely on large amounts of leaf litter input as the main energy source for heterotrophs. The leaf litter fuels the production of bacteria and fungi, which are the first colonizers of leaves. Decomposition of leaves by bacteria and fungi provides nutrients for algal colonizers and also a more nutritive biofilm for shredding macroinvertebrates to consume. Macroinvertebrates play a key role in breaking down this organic matter; by consuming coarse particulate leaves and releasing fine particulate matter as frass. Macroinvertebrate grazers, especially snails, release high concentrations of phosphorus and can directly and indirectly increase leaf decomposition rates My study will examine how snails directly affect leaf breakdown rates through consumption in the presence and absence of algae. I predict the breakdown rates will be the higher in treatments with snails due to their radula scraping the leaves. I will also quantify how algae present and absent on leaves will affect decomposition rates. I predict that the labile carbon released by algae will stimulate heterotrophic microbial activity, increasing leaf breakdown rates. This study will use multiple treatments in environmentally controlled conditions where leaf decomposition rates will be manipulated by presence of snails and algae.

## Changes in Aquatic Macroinvertebrate Community Structure Along a Longitudinal Gradient in a Mixed Land Use Catchment

***Chelsea Miller, Carolyn Pollard, and Joseph Larson***
*Faculty Mentor: Sally Entrekin*

Natural waterways are a source of fresh water for human populations and are integral to ecosystem health. Headwater streams are a major component of river networks, and are composed of small swales, creeks, and streams, which form the building blocks for large rivers and lakes. Headwater streams deliver nutrients downstream and provide habitat for a wide range of aquatic species, which are used as metrics for water quality and stream health. Invertebrate assemblages are of particular importance to stream health because they directly affect primary production, decomposition, and resource acquisition rates, which alter food web structure. In Arkansas, headwater streams account for 90% of stream length. Many headwater streams are within state wildlife management areas (WMAs). Gulf Mountain, a 14,000 acre WMA, was pastureland until it was reforested in the mid-1900s. Today, Gulf Mountain WMA is managed for hunting, forestry, and, recently, natural gas recovery from shale. We predict that this combined alteration in land use could affect the invertebrate assemblages within the headwater streams such that they deviate from the framework presented in the River Continuum Concept (RCC). According to the RCC, the invertebrate assemblages in headwater streams will be composed of shredders and collectors, which feed on the coarse particulate organic matter. We predict that the cumulative land disturbance from pasture, timbering, and natural gas recovery from shale could cause the stream communities to be more generalist feeders such as filter and collector-gathering taxa, which was tested by the collection of invertebrates and coarse and fine particulate organic

matter. Invertebrate and material samples were collected from four sites that represented a gradient from forested headwater streams to mid-order river. Using summary statistics, we compared the community structure of Gulf Mountain to the RCC to evaluate community changes from land use past and present.

## Evolution: Verification of Emotional Response in Students

***Elizabeth Morrison***
*Faculty Mentor: Mark Bland*

Research in psychology has revealed that emotional stimuli can interfere with cognitive processes. For example, when study participants viewed positive and negative statements about their choice of 2004 presidential candidates, their emotional centers increased in activity, while their reasoning centers did not. It was hypothesized that if learners react emotionally to evolutionary themes, then physiological data collected from these learners will reflect these emotional responses. This study was conducted to determine whether students enrolled in a non-majors biology course experience a detectable emotional response upon exposure to evolutionary themes, and to determine whether correlations exist between participant paper survey responses and their physiological responses.

Physiological data including respiratory rate, heart rate, and galvanic skin response was collected from students while they were asked questions on evolutionary themes, neutral themes, and religious-based themes. Additionally, a survey was administered to students enrolled in the same section of the non-majors biology class 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 the degree of correlation between participants' physiological responses and their survey responses.

## The Relationship Between Land Disturbance and Trace Elements in Streams of North-Central Arkansas

***Adam Musto***
*Faculty Mentor: Sally Entrekin*

Unconventional oil and gas extraction (UOG) is an important energy source in the US and its importance is expected to increase through 2035. UOG could deliver trace elements to streams by sediment disturbance during pad formation, spilled or leaked hydraulic fluids and produced water, and increased road traffic. Altering trace element concentration in streams has the potential to alter macroinvertebrate communities. Base-flow trace elements and macroinvertebrates were collected across a gradient of UOG extraction in streams of the Fayetteville Shale in spring 2011 and 2012. We predicted trace element concentrations in stream water would increase in catchments with more gas activity. Principle components analysis indicated positive correlations between Al, Cl, Pb, Ni, Na, $SO_4$, K, and gas well density (r=0.79), paved road density (r=0.61) and %

pasture (r=0.60). Further, we predicted increased concentrations of heavy metals would result in a decline in Ephmeroptera, Plecoptera, and Trichoptera density. Our prediction was supported by a decrease in Plecoptera (r=-0.77) and Trichoptera density (r=-0.71), and percent Ephemeroptera, Plecoptera, and Trichoptera (r=-0.63) with increasing trace element concentrations. We will continue to examine relationships between water column and sediment trace elements and macroinvertebrate community structure.

## The Physiological Effects of Nickel on Aquatic Microbial Biofilm

***Adam Musto and Desiree' Shaw***
*Faculty Mentor: Sally Entrekin*

Nickel is found in the earth's crust and is released into the environment as dust in windstorms and by the eruption of volcanoes. Nickel also enters the aquatic system from anthropogenic sources as a by-product of the combustion of fossil fuels and resource extraction. The nickel in the contaminated atmosphere enters the ground and surface waters during rain events. Heterotrophic aquatic microbes are at the bottom of the aquatic food web, and are an important food for other organisms higher in the aquatic ecosystem. Metals are an essential trace element but can be toxic at elevated levels. A reduction in biofilm could adversely affect the food web whole within an entire ecosystem. We conducted an experiment to quantify the effect of nickel on microbial respiration by exposing the microbes to varying concentrations of nickel in the form of nickel chloride (Exp 1: 0.00mg/L-3.00mg/L, Exp 2: 0.00mg/L-4.70mg/L). The change in biochemical oxygen demand data for each sample was calculated. Analysis of variance indicated differences in respiration rates from experiment 1 $F_{(6,14)}=9.16$, $p<0.01$ where rates were greatest at 0.20 mg/L nickel chloride compared to the control and the other treatments . The same experiment conducted another time resulted in different results. $F_{(7,33)}=0.67$, $p=0.70$ . Because the microbial biofilm was not destroyed by the high levels of nickel, the nickel has the opportunity to travel up the food web.

## Fish Communities in Multiple Floodplain Habitats of an Intact River-Floodplain System

***Chris Naus***
*Faculty Mentor: Reid Adams*

Floodplain habitats provide important spawning and nursery habitats for fishes (e.g., oxbow lakes, seasonally inundated floodplain, and low-order tributaries). Relative to oxbow lakes; low-order tributaries are an understudied feature of the river-floodplain. Understanding tributary usage by fishes is important because oxbow lakes are no longer being naturally created in regulated systems. Previous sampling in tributaries along the Fourche LaFave River, AR, using seine and mini-fyke nets has yielded 36 adult and 42 young-of year species. Species include ecologically important fishes (*Dorosoma cepedianum* and *D. petenense*), recreationally important fishes (*Lepomis macrochirus* and *Micropterus salmoides*), and species of conservation concern

(*Atractosteus spatula* and *Erimyzon succeta*). In May, June, and July 2012, mini-fyke nets were used to sample 4 upper tributaries, 4 lower tributaries, and 3 oxbow lakes, to describe and compare fish communities found within each habitat along the Fourche LaFave River. Preliminary analyses of July mini-fyke net data showed a significant difference in species richness between habitats (P=0.03), but no difference in total abundance (P=0.48). On average, both richness and total abundance was highest in lower tributaries followed by oxbow lakes and upper tributaries. Our research suggests an apparent undervaluing of tributaries relative to oxbow lakes and necessitates further investigation.

## Reproductive Biology of Two Exotic, Invasive Flowering Plant Species: Chinese Privet and Japanese Honeysuckle

***Jessie Needham***
*Faculty Mentors: Katherine Larson, Rick Noyes, and Ginny Adams*

Chinese privet (*Ligustrum sinense*) and Japanese honeysuckle (*Lonicera japonica*) are two of the most frequently encountered exotic, invasive flowering plant species in the SE United States. Much is known about their invasion biology, but there are gaps in the published literature concerning their reproductive biology. Therefore, I conducted pollination experiments and pollinator observations for Chinese privet and Japanese honeysuckle. Chinese privet has significantly higher fruit set when insect pollinated than when insects are excluded, and fruit set is highest when xenogamously pollinated. It also appears that Chinese privet is visited by a diverse community of pollinating insects including exotic European honeybees. Japanese honeysuckle has higher ambient fruit set during secondary flowering than primary flowering and fruit set is highest when xenogamously pollinated. Japanese honeysuckle stigmas are receptive on both the first and second days the flowers are open. The Japanese honeysuckle population sampled was not pollen limited. It appears that Japanese honeysuckle is visited by a small species pool of pollinators. Pollinator abundance and species richness were greatest in the morning, followed by dusk, and smallest after dark. With this better understanding of Chinese privet and Japanese honeysuckle reproductive biology, it is possible to ask more applied questions such as how changing pollinator communities affect fruit and seed set.

## The Effect of Arterial Endothelium on Voltage-Gated Ca2+ Channels

**Edouard Niyonsaba**
*Faculty Mentor: Brent Hill*

The contraction of coronary arteries is mediated by the influx of $Ca^{2+}$ through voltage-gated $Ca^{2+}$ channels (VGCCs). Our laboratory has previously found that estrogen downregulates the expression of these channels, but it is not known if it is dependent on the endothelium. Therefore, the aim of this study is to determine the effect of the endothelium on the selective activation of these VGCCs to mediate an arterial contraction. The right coronary artery was dissected from hearts of female pigs, sectioned into rings, and incubated for 24 hrs in E2 (1 nM) or EtOH. The

endothelium was removed on half the rings using a toothpick. After 24 hrs, the rings were suspended in organ baths to measure isometric tension in response to selective agonists. In experiment #1, tension was measured in response to acetylcholine (10 mM) followed by the VGCC agonist, FPL64176 (3 mM). In experiment #2, tension was measured to acetylcholine and thapsigargin (10 mM; inhibitor of the sarcoplasmic reticulum calcium pump) followed by FPL64176. In both experiments, after the peak contraction was achieved to FPL64176, relaxation was induced using the VGCC antagonist, nifedipine (20 mM). Our results are inconclusive regarding the difference in contraction between coronary arteries with and without endothelium.
Support: NCRR (5P20RR016460-11) and NIGMS (8P20GM103429-11) from the NIH.

## Are the FtsZ Proteins Responsible for Mitochondrial Fission Events? Creation of FtsZ Knockout Cassettes

***Aloys Nsereko***
*Faculty Mentor: Kari Naylor*

Mitochondria fusion and fission are two processes that are required to maintain an even distribution of mitochondria in the cells. The balance of fusion and fission also maintain the structure and thereby the function of this cellular organelle. We believe that FtsZ the protein responsible for bacterial cell division and may also be responsible for mitochondria fission. To determine if the FtsZ homologs (FszA and FszB) in our model system, *Dictyostelium discoideum,* are essential for mitochondria fission, we are creating strains lacking these proteins. To do this we will generate knockout cassettes for each FtsZ gene and transform these cassettes into *D. discoideum* to replace the FtsZ genes with a selectable marker. Once we have our new strains we will use immunofluorescence microscopy to quantify the fusion and fission events and compare these rates to the fission and fusion rates in wild-type cells. We have generated our cassettes and we are currently in the process of transforming *D. discoideum* cells and selecting for knockout strains. The goal of this work is to determine whether or not the function of FtsZ in bacterial cell division events has been retained in eukaryotes by directing mitochondrial fission.

## Identification of Novel Regulators of Nuclear Cation Channels Controlling the Establishment of Plant-microbe Symbioses

***Jonathan Pennington***
*Faculty Mentor: Arijit Mukherjee*

Acquisition of nitrogen from the soil is a major issue for sustainable agriculture. This has led to an increasing dependence on nitrogen-based fertilizers. In order to minimize the economical, ecological and health hazards associated with such treatments, we need to take advantage of beneficial plant-microbe interactions like root nodule symbiosis. Legumes form symbiotic associations with nitrogen-fixing bacteria called rhizobia. The legume-rhizobia symbiosis provides the plant with nitrogen essential for its growth and the bacteria receives carbohydrates in return. Establishment of this symbiosis requires a signaling cascade in which several plant genes are

involved. The *Medicago truncatula DMI1* gene encoding a nuclear cation channel is an integral piece of this signaling pathway and leads to the establishment of this symbiosis. The *dmi1* mutants are characterized by their inability to form nodules and express the *ENOD11* gene in the presence of rhizobia. This project aims at identifying suppressors of the mutant allele B129 (*dmi1-2*). The screening strategy employed aims to identify suppressors by their ability to restore nodulation and *MtENOD11* expression using a non-destructive GUS assay that will report *ENOD11* expression. Identification of new genetic components in the nodulation pathway will help us in efficient fertilizer management and reducing the deleterious effects associated with nitrogen based fertilizers.

## Indirect Effects of a Shredding Invertebrate on Leaf Breakdown

***Steven J. Polaskey***
*Faculty Mentor: Sally Entrekin*

Shredder-detritus interactions may differ with stream nutrient concentrations. Aquatic invertebrate shredders often break down lignocellulose, making refractory carbon more labile. We predicted increases in labile organic matter (LOM) from shredder processing of detritus would stimulate degradation of refractory organic matter by increasing labile carbon available to microbial decomposers, thus increasing their activity and indirectly increasing litter decomposition. We quantified decomposition rates of maple leaves with two levels of C:P, and with or without shredding *Tipula* larvae. We predicted greater mass loss of low C:P leaves than high C:P leaves, and in chambers with *Tipula*. *Tipula* were fed *ad libidum* for one week in chambers with mesh bottoms. Leaf disks were placed at the bottom of chambers under mesh, excluding *Tipula* consumption and allowing heterotrophic microbes. Mass loss was not different between leaf C:P levels ($p=0.55$) or *Tipula* treatments ($p=0.48$); yet mass loss trended to be greatest on high C:P leaves with Tipula, and least on high C:P leaves without *Tipula* ($p=0.07$). Shredder influence on decomposition is predicted to be both indirect and direct with strength of indirect effects determined by stream nutrient concentrations.

## Improving Nitrogen Fixation in Cereals

***Hannah Posey***
*Faculty Mentor: Arijit Mukherjee*

Availability of nutrients, and especially nitrogen, is a major constraint for crop productivity and sustainable agriculture. Over the last decades, there has been an excessive dependence on chemical nitrogen fertilizers with dire economic and ecological consequences. Taking better advantage of beneficial plant-microbe interactions is a promising alternative to improve crop yields while maintaining the sustainability of our agricultural systems. The two most efficient plant-microbe interactions are the ones with nitrogen-fixing bacteria, rhizobia, and with arbuscular mycorrhizal fungi. In both these symbiotic associations the plant benefits by improved nutrient uptake. While associations with nitrogen-fixing bacteria are just limited to legumes, more

than 85% of land plants (including cereals) can form symbiotic relationships with mycorrhizal fungi. Over the last decades genetics in model legumes identified several key plant genes that are required for the establishment of these associations. Studies have shown that plant hormones also play significant roles in establishment of these associations. For instance, auxin transport inhibitors and cytokinins have been shown to induce the formation of nodule-like structures known as pseudonodules in roots of *Medicago sativa* and *Medicago truncatula* in the absence of bacteria. Interestingly, in many cereals such as wheat and corn, addition of such hormones stimulates the formation of similar nodule-like structures called paranodules and this stimulates nitrogen fixation. Currently we are performing experiments to optimize the conditions to study paranodule formation under *in vitro* conditions in the model plants, *Medicago truncatula* and *Oryza sativa*. In the long term, we plan to investigate the genetic pathways controlling paranodule formation in cereals.

## Identification of Novel Regulators of a Calcium Calmodulin Dependent Protein Kinase (DMI3) Controlling Plant-microbe Symbioses

***Aakash Rana***
*Faculty Mentor: Arijit Mukherjee*

Acquisition of nitrogen from the soil is a major issue for sustainable agriculture. This has led to an increasing dependence on nitrogen-based fertilizers. In order to minimize the economical, ecological and health hazards associated with such treatments, we need to take advantage of beneficial plant-microbe interactions like root nodule symbiosis. Legumes form symbiotic associations with nitrogen-fixing bacteria called rhizobia. The legume-rhizobia symbiosis provides the plant with nitrogen essential for its growth and the bacteria receives carbohydrates in return. Establishment of this symbiosis requires a signaling cascade in which several plant genes are involved. The *Medicago truncatula DMI3* gene is an integral piece of this signaling pathway and leads to the establishment of this symbiosis. The *dmi3* mutants are characterized by their inability to form nodules and express the *ENOD11* gene in the presence of rhizobia. This project aims at identifying suppressors of the mutant allele TRV25 (*dmi3-1*). The screening strategy employed aims to identify suppressors by their ability to restore nodulation and *MtENOD11* expression using a non-destructive GUS assay that will report *ENOD11* expression. Identification of new genetic components in the nodulation pathway will help us in efficient fertilizer management and reducing the deleterious effects associated with nitrogen based fertilizers.

## Functional Organization and Cortical Architecture of Somatosensory Cortex in the Nine-Banded Armadillo (*Dasypus Novemcinctus*)

***Johnathan Rylee and Brooke Skinner***
*Faculty Mentor: Jeff Padberg*

We are interested in determining neural features common to all mammals and are therefore exploring the organization of the brain of a representative species of a very early branch in mammalian phylogeny, superorder Xenarthra. The nine-banded armadillo is the only extant xenarthran species that resides in North America and possesses several physical and physiological features that are uncommon or absent in other mammals. These include an ossified dermal layer which overlays the majority of the dorsal surface of the animal, and invariably giving birth to litters of identical quadruplets. We have predicted that the bony exterior of the animal would necessarily restrict somatosensory input to the brain. In order to determine the functional organization and architectural features of somatosensory cortex, we have utilized intracortical microrecording techniques in conjunction with histochemical staining to generate a cortical map and identify salient structures within the cortex. Under gas anesthesia, the cephalic shield was removed followed by a craniotomy and excision of the dura mater to expose presumed sensory cortex. Multiunit recordings were made while providing tactile stimuli and the recording sites and corresponding receptive fields were documented. After mapping all exposed cortex, the animals were euthanized, perfused, and the brains were removed. Serial sections of each brain were made in either the coronal plane or tangential to the cortical surface. These sections were then histochemically processed for nissl substance, cytochrome oxidase, and myelin fibers. The somatosensory map is dominated by a large, sensitive snout representation occupying the rostrolateral region and a slightly smaller forelimb representation approaching the midline. Unexpectedly, the majority of the observed responses were to cutaneous rather than deep stimuli. We have also observed large dark staining clusters of cells in nissl sections and corresponding voids in the myelin lattice in adjacent myelin stained sections. These clusters average 350μm and are approximately circular in shape. While their function has not yet been determined, they bear resemblance to modular features observed in dolphin auditory cortex, and may indicate functional modules within xenarthran somatosensory and auditory cortices. Through continued experimentation along this line, we will gain insight into the evolution of mammalian brains, and how physical and behavioral differences between xenarthran and epitherian species translates into distinct patterns of neural organization.

## Mitochondrial Membrane Dynamics and Motility in the Lower Eukaryote *Dictyostelium discoideum*

***Brixey Schimmel, Greg Berbusse, and Laken Woods***
*Faculty Mentor: Kari Naylor*

Mitochondrial morphology is maintained by two dynamic, intricate membrane events—fission and fusion. Altering these evolutionarily conserved processes has been shown to disrupt mitochondrial morphology, distribution and function. To identify fission and fusion events in the

lower eukaryote *Dictyostelium discoideum,* our lab developed an assay utilizing laser scanning confocal microscopy to observe in real time fission and fusion events in addition to assessing the involvement of the mitochondria-associated proteins MidA, CluA, and two DRPS—DymA and DymB. From the assay, we have shown that fission and fusion events are balanced in Wildtype *D. discoideum* cells and the DRPs are not necessary for maintenance of both processes. Additionally, MidA was found to exert an indirect influence in the regulation of both fission and fusion of mitochondria; CluA demonstrated an impact on both processes indicating its involvement in mitochondrial membrane dynamics. Finally, to assess mitochondrial motility in Wildtype and protein knockout strains of *D. discoideum*, our lab used kymograph analysis with preliminary data suggesting no significant difference across strains.

## Infestation Patterns of the Fish Ectoparasite *Argulus ingens* on Arkansas Alligator and Longnose Gar

***Hayley Seay and Chris Naus***
*Faculty Mentor: Reid Adams and Don Gettinger*

The genus *Argulus* has a widespread distribution and unlike most parasites, is thought to demonstrate wide host preferences rather than strong host specificity, being able to parasitize multiple species of fishes. *Argulus* are crustacean ectoparasites, and generally thought to parasitize locations that will provide them with the most productive route to nutrient intake. Because of this, they are typically found on the gill operculum and fins of fishes. On gar, *Argulus* are normally found on the ventral side of the body, along the fins, and on the operculum flap. During routine sampling of a population of alligator and longnose gar in the Fourche LaFave River, *Argulus* have been observed parasitizing the oral cavity at a higher rate than on the external body. During a December 2012 sampling trip to a known gar overwintering location 30 longnose gar were caught and examined for *Argulus*. 26 of the 30 individuals caught were infested (prevalence of 0.87); the average number of *Argulus* sampled from the oral cavity was 2.9 per fish. The average number of *Argulus* sampled from the external surface of the gar was 0.03 per fish. The oral cavity of gar has both hard and soft areas. The average number of *Argulus* on the hard surface area was 1.23 per fish versus the average number on the soft surface area of 0.9. By quantifying the number of *Argulus* per specific location in the oral cavity of the gar we hope to begin to understand the adaptive nature of this interesting host-parasite association. Many questions remain: Are these ectoparasites actively feeding or have they moved to the oral cavity seasonally, as an overwintering mechanism?

# Incubation during the Laying Period in Two Cavity-nesting Passerines

***Alexis Shipley***
*Faculty Mentors: Jennifer M. Wang and Mary Victoria McDonald*

Nest-box videos of the Western Bluebird (*Sialia mexicana, n* = 4 nests) and the Oak Titmouse (*Baeolophus inornatus, n* = 4 nests) were observed to investigate nest attentiveness and avian breeding behavior. The frequency and duration of incubation bouts on the developing embryo may play a significant role in the overall fitness of the resulting nestling. To obtain data on avian nest attentiveness, continuous in-box videos were analyzed using a free, open-source computer program, CowLog. Although both species increased the proportion of the day incubated during the laying period, neither increased the proportion of night incubated in the last two nights of laying. Daytime bout duration gradually increased in Oak Titmouse nests but not in Western Bluebird nests. Nighttime bout duration for Oak Titmouse nests appeared to decrease in the last two nights of the laying period, while no change was apparent in Western Bluebird nests. Incubation at Western Bluebird nests was characterized by shorter and more frequent incubation bouts, compared to Oak Titmouse nests.

# Presence of *Argulidae* Ectoparasites in Larval-Fish Light Trap Samples

***Geoffry Spooner and Chris Naus***
*Faculty Mentor: Reid Adams*

The family *Argulidae*, an ectoparasite that parasitizes fish and known to cause secondary infections at the attachment site, has been found in larval fish samples collected with light traps in the Fourche LaFave River floodplain. To our knowledge, this has never been observed, but may provide the opportunity to study the free-living (unattached) phase of the parasite's life cycle. Argulids in the samples could be falling off fish that were collected by the traps. The size of the larval fish is quite small and offers a different reason why argulid attachment was not observed. An alternative is the argulids were free-living and attracted to the light source (chemical light stick). Ectoparasites have a finite amount of time (approx. 4 days) from hatching to find a host. Argulids have been found in approximately 80% of traps examined. Specimens are being counted and identified and related to the number of adult and larval fish in the light trap samples. This research sheds light on a previously unknown method of collecting argulids and may provide the opportunity to study the free-living life stage of this fish ectoparasite.

## Histology of Girdles Cut by *Theroa zethus* Caterpillars

***Madalyn Van Valkenburg***
*Faculty Mentor: David Dussourd*

Caterpillars in the family Notodontidae typically feed on hardwood trees and sometimes cause extensive deforestation. Some species perform an intriguing behavior known as girdling. They chew a circular groove around a stem or petiole, the function of which is currently unknown. An unusual notodontid, *Theroa zethus,* feeds not on hardwoods, but instead attacks herbaceous euphorbs that release latex exudates. *Theroa* employs a technique similar to girdling; however, they do not chew the girdle, but instead compress the stem, petiole, or midrib in a ring with their mandibles. Surprisingly, the plant withers at the girdle. Withering could be due to constriction with mandibles, application of saliva, or secretion of acid from the ventral eversible gland (VEG) between the head and first pair of legs. The VEG ordinarily serves to spray acid at predators. The goal of this project is to employ plant histological methods to determine what causes withering and identify how petiole constriction, saliva, and acid secretions affect plant tissues at the cellular level. Initial cross sections of poinsettia leaf midribs will be presented.

## The Effect of Hydraulic Fracturing on the Life History of the Slender Madtom (*Noturus Exilis*) in Central Arkansas Streams

***Page Vick, Chelsey Sherwood, and Jessie Green***
*Faculty Mentor: Ginny Adams*

Natural gas development has increased by 65% since 1998 due to hydraulic fracturing, and over 4,000 gas wells currently exist in the Fayetteville Shale region of central Arkansas. Activities associated with natural gas development, including pad and road construction, may result in increased sedimentation with resultant impacts to benthic fishes. Previous research on *Etheostoma whipplei* showed a decline in Year 1 age class in relation to gas well density. Slender madtoms (*Noturus exilis*) represent a native benthic species that requires clean interstitial spaces for habitat and reproduction. *Noturus exilis* were collected from 6 sites within the Fayetteville Shale across a gradient of gas well densities to examine age class structure and compare life history characteristics. Gas well density ranged from 0 to 3.26 well/km$^2$. Collections occurred in 2012 (March through May) and encompassed the spawning period (late April to early June). Individuals were collected using a backpack electrofisher with multiple pass depletion. Gonads were examined for reproductive stage and gonadosomatic index to compare reproductive development among sites. Male:female ratio, female size at first reproduction, and percent of Age 1 individuals were also examined. Proportional abundance of males decreased as gas well density increased and may be partly attributed to males having a higher postreproduction mortality. Understanding population level metrics in relation to gas well disturbance may provide a more detailed understanding of mechanisms driving change compared to coarse community data.

# GSK3b Mediated Apoptotic Pathways are Activated in Axon Degeneration

***Yao Xu and Lynn Nguyen***
*Faculty Mentor: Bhupinder P. S. Vohra*

Axon degeneration is a pathologic hallmark of many neurological conditions, but the molecular mechanisms are still unknown. Since degenerating axons exhibit morphological features of apoptosis, we tested whether early or late apoptotic events are activated during the process of axon degeneration. We discovered that early apoptotic processes in the form of phosphatidylserine translocation are activated in the axon degeneration. Even though the axonal degeneration is not blocked by caspase inhibition, we tested whether TLCK (an inhibitor of Trypsin like proteases which can also block cysteine proteases) can prevent axon degeneration. We found that TLCK blocked axon degeneration after trophic factor withdrawal by inhibiting activation of Caspase-6 in the axons. NGF deprivation activates glycogen synthase kinase 3 (GSK3) at the axon tip, which initiates an apoptotic signal that travels back to the soma to induce Jun-mediated neuronal apoptosis. We discovered that GSK3 inhibition protected the axons by blocking caspase 6 activation in the NGF deprived axons. Intriguingly, although caspases are not involved in axon degeneration, which is caused by axotomy or vincristine, TLCK and GSK3 inhibition also inhibited axon degeneration in these conditions. Therefore, we believe that there are other caspase like proteases which are inhibited by TLCK and GSK3 might be playing a role in axon degeneration caused by axotomy or vincristine. Thus, we concluded that axon degeneration shares not only morphological features, but also distinct early and late activation pathways with apoptosis as well.

# Induced Differentiation of Pluripotent P19 Teratocarcinoma Stem Cells in to Neurons and Cardiac Cells

***Yao Xu, Laken Woods, Tara Parish, Casey Pulliam, Miki Lindsey, Marcus Loudermilk, Ashley Long, Derek Karr, Megan Hammond, Lauren Hyde, Christian Haney, and Faviola Aguilar***
*Faculty Mentor: Bhupinder P. S. Vohra*

Understanding the mechanisms and chemicals responsible for the differentiation of pluripotent stem cells is essential for future breakthroughs not only in understanding development biology, but also in potential treatments and better understanding of genetic disorders in humans. Neuronal degeneration is especially important to understand and study because once these cells degenerate they cannot be reproduced from existing neuron cells. While stem cells may not be able to repair the damages either, they will give some insight on how we can treat individuals with neurological disorders better. In this investigation, pluripotent teratocarcinoma P-19 stem cells were differentiated using Retinoic Acid (RA) to activate NeuroD and Dimethyl Sulfate ($DMSO_4$) to induce myogenesis by activating MyoD. These factors were responsible for turning our stem cells into neurons and cardiac muscle cells. Cardiac muscle cells were observed under a phase contrast microscope but were not further investigated. The differentiated neuron cells were observed under phase contrast and then introduced to neuron specific TUJ-1 rabbit antibodies as well as CY3 and Alexa-488 conjugated secondary anti-rabbit antibodies. Under specific wavelengths CY3 and Alexa-488 allowed us to see that our differentiated cells were indeed neurons and not neuron like cells. Floxuridine (FUDR) was also introduced to some cultures to destroy dividing cells leaving only differentiated neurons. Human Embryonic Kidney 293T unipotent stem cells were

also used as a control in this experiment and did not differentiate when introduced to RA or $DMSO_4$.

# Chemistry

## Construction of Low-Coordinate Iron-Sulfur Clusters Supported by Bidentate Guanidine Ligands

***Jamie D. Beck***,
*Faculty Mentor: Lei Yang*

The iron-molybdenum cofactor (FeMoco) is the catalytic site of nitrogenase to fix atmospheric nitrogen gas ($N_2$). The high-resolution crystal structure of nitrogenase showed that the belt iron atoms are four-coordinate at rest state. Recent studies indicated the threecoordinate iron might be one of the transition states during catalysis. Our project focuses on the construction of new low-coordinate iron-sulfur clusters supported by bidentate guanidine ligands, which are super-bases with strong coordination donors to metal centers. Two bidentate guanidine ligands were synthesized and characterized by NMR, IR, mass spectrum and elemental analysis. Iron compounds with the ligands have been prepared to react with sulfur source such as $S_8$, NaSH and $Na_2S$. Further characterizations of these compounds are currently underway.

## Surface-Enhanced Infrared Spectroscopy from Elongated Ni Nanostructures

***Reece Borchers***
*Faculty Mentor: Donald Perry*

The goal of this research was to develop optimal Nickel nanoparticles for applications in surface-enhanced infrared absorption spectroscopy (SEIRA). Various elongated nanoparticles were formed by oblique angle deposition (OAD) through evaporating Nickel in vacuum onto $CaF_2$ substrates at angles ranging from $75^0$ to $80^0$. These nanostructures were characterized with AFM, SEM, and UV/Vis-NIR spectroscopy. A monolayer of *p*-nitrobenzoic acid was deposited onto the Nickel nanostructures to determine the degree of vibrational enhancement in SEIRA. No SEIRA enhancement was observed for non-OAD depositions. However, OAD work on elongated Nickel nanoparticles (NNPs) showed SEIRA enhancement factors up to x25. This work will influence a range of biological, medical, catalytic, environmental, and nanotechnological applications.

## Synthesis of Boron-Centered Heteroscorpionates by Metathesis Reactions of LiTp* with Heterocycles

***Elisabeth Collins***
*Faculty Mentor: Richard Tarkka*

One of three equivalent pyrazole rings of the scorpionate KTp* can be replaced with a benzotriazole ring. The goal is to determine the generality of the metathesis method for the synthesis of boron-centered heteroscorpionate ligands. The variables investigated include the counterion ($K^+$ vs. $Li^+$), solvent (DMF vs. toluene), and incoming aromatic ring (benzotriazole vs. 1,2,3-triazole. 1,2,4-triazole and 2-mercapto-1-methylimidazole). When the incoming ring is 1,2,3-triazole, the resultant LiTp" ligand forms cis and trans isomers of the form $L_2Ni$ where L = Tp". Analogous studies, which use different incoming heterocycles, and in which the $L_2Cu$ complexes were synthesized, will also be reported.

## Synthesis of Phenylalanine and Valine Radical Precursors

***Claire Desrochers and Jordan Wilkerson***
*Faculty Mentor: K. Nolan Carter*

Free radicals are key intermediates in the damage of biological molecules such as proteins. These altered proteins can then damage DNA molecules, which can cause mutations and possibly cancer. Mutated DNA can also lead to cell death, which can ironically be beneficial to a cancer patient by targeting his or her tumor cells. In our research, we are synthesizing a-amino acid derivatives that include a carbon-selenium bond. This bond can be homolytically cleaved by ultra violet (UV) light to produce specific amino acid radicals. Because proteins are merely a combination of many amino acids, a single amino acid radical can serve as a model for the larger, damaged biomolecule. Work is currently underway toward the synthesis of selenium-containing derivatives of the amino acids phenylalanine and valine. These compounds are being prepared from reductive amination of the corresponding selenium-containing a-oxoesters.

## Growth of Elongated Silver, Gold, and Copper Nanoparticles for Applications in SEIRA

**John Whitt Golden *and Will Henry***
*Faculty Mentor: Donald Perry*

The goal of this research was to develop optimal silver, gold, and copper nanoparticles for applications in surface-enhanced infrared absorption spectroscopy (SEIRA). Various elongated nanoparticles were formed by oblique angle deposition (OAD) through evaporating silver, gold, or copper in vacuum onto $CaF_2$ substrates at angles ranging from $75^0$ to $80^0$. These nanostructures were characterized with AFM, SEM, and UV/Vis-NIR spectroscopy. A monolayer of *p*-nitrobenzoic

acid was deposited onto the gold nanostructures to determine the degree of vibrational enhancement in SEIRA. This OAD work on silver, gold, and copper metal nanoparticles (MNPs) showed SEIRA enhancement factors up to x5 better than MNP grown at incident. We have observed that SEIRA enhancement factors of close to x200 for elongated silver MNPs and enhancement factors of around x100 and x50 for elongated gold and copper MNPs, respectively. This work will influence a range of biological, medical, catalytic, environmental, and nanotechnological applications.

## Activation of $CO_2$ by Zinc-beta-diketininate Complexes

***Joshua A. Goodner and Brandon Powers***
*Faculty Mentor: Lei Yang*

$CO_2$ is one of the most important greenhouse gases and a potential low cost carbon source for both commodity chemicals and complex organic molecules. Therefore, activation of $CO_2$ is not only a significant environmental issue, but also has a great impact in industry level. In recent years, the significant interests in conversion of $CO_2$ by transition metal complexes to value-added products have been continuously increasing. In this project, we focus on the activation of $CO_2$ by zinc-alkyl complexes supported by b-diketiminate ligand platform. Zinc complexes have been synthesized and characterized by NMR, X-ray crystallography, IR and mass spectrum. Interesting reactivities of these complexes with $CO_2$ have been observed in NMR studies.

## DNA Phosphate Crowding Correlates with Protein Cationic Side Chain Density and Helical Curvature in Protein/DNA Crystal Structures

***Bryce Grant, Elizabeth Dourlain, Jayme Araneda, and Madison Throneberry***
*Faculty Mentor: Lori Isom*

Sequence-specific binding of proteins to their DNA targets involves a complex spectrum of processes whose endpoints are generally categorized as depending on DNA sequence either directly through protein contacts with the DNA groove (direct or base readout) or indirectly through the conformational helical characteristics imparted by the sequence (indirect or shape readout). To investigate the relationship between protein cationic residue density (Cpc) and DNA phosphate crowding (Cpp), these values were quantified for a subset of 58 high resolution protein-DNA crystal structures. The correlation between Cpc/Cpp was calculated for each structure. Those structures containing strong Cpc/Cpp correlation ($>\pm0.25$) were likely to contain DNA helical curvature. Further, the correlation factor sign predicted the direction of helical curvature with positive (16 structures) and negative (7 structures) correlation containing concave (DNA curved toward protein) and convex (DNA curved away from protein) curvature respectively. Protein-DNA complexes without significant Cpc/Cpp (36 structures) correlation ($-0.25<0<0.25$) tended to contain DNA without significant curvature. Interestingly, concave and convex complexes

also include more lysine and arginine phosphate contacts respectively while linear complexes included essentially equivalent numbers of Lys/Arg phosphate contacts. Together these findings suggest a potentially important role for indirect readout backbone contacts in protein-DNA complexes involving helical curvature.

## Retinoids Modulate Cellular Adhesion and Proliferation in the Human K562 Cell Line

***Amanda Hanson* and *Jenni Goodwin***
*Faculty Mentor: Melissa Kelley*

Retinoids are essential for such critical life processes as cellular adhesion and proliferation. All-*trans*-retinoic acid (*t*-RA) and 9-*cis*-retinoic acid (9-*cis*-RA) serve as ligands for retinoic acid and retinoid X receptors and can form heterodimeric partners with peroxisome proliferators-activated receptor gamma (PPARgamma). Proliferation and cellular adhesion assays were performed with K562 cells treated with troglitazone, *t*-RA, 9-*cis*-RA or troglitazone and *t*-RA or 9-*cis*-RA. Cellular adhesion assays were conducted on three substrates: fibronectin, FN-120, or FN-40. Our data suggest that, in the presence of troglitazone, cells treated with *t*-RA or 9-cis-RA increase cellular adhesion to both fibronectin and FN-120. Additionally, K562 cells treated with *t*-RA or 9-*cis*-RA and troglitazone decrease cellular proliferation compared to cells treated with *t*-RA or 9-*cis*-RA alone. We examined *t*-RA and 9-*cis*-RA metabolism in the presence or absence of troglitazone using liquid-liquid extraction and reverse-phase HPLC. Troglitazone appears to increase retinoid availability and modulates cellular proliferation and adhesion.

## Deposition of Antibiotics on Silver and Gold Nanostructures

***Elyahb Kwizera and Adam Price***
*Faculty Mentor: Donald Perry*

The goal of this research was to determine the interaction of certain antibiotics with gold nanostructures (GNS) and silver nanostructures (SNS) though utilization of surface-enhanced infrared absorption spectroscopy (SEIRA). Metal nanostructures were formed on $CaF_2$ plates by vacuum evaporating gold or silver. After the NS were deposited onto the $CaF_2$ plates, the films were characterized by UV/Vis-NIR spectroscopy. Antibiotics investigated are Levofloxacin, Pyrazinecarboxamide, Ciprofloxacin, Isoniazid, D-cycloserine, (+)-6-Aminopenicillanic acid, Metronidazole, and Nalidixic acid. Each antibiotic was deposited onto the nanostructures to determine the degree of vibrational enhancement in SEIRA. Density Functional Theory (DFT) calculations were simulated to analyze the interaction of the antibiotics to the GNS and SNS, which were then compared to the experiments. The impacts of this research will influence biological and medical related applications.

## Polymerization of Phenylacetylenes by Rhodium(I) Scorpionate Catalysts

***Laney Mason***
*Faculty Mentor: Richard Tarkka*

Tp'Rh(cod) and Tp*Rh(cod) are catalysts containing a rhodium ion and a boron centered scorpionate ligand. The distinction between these two catalysts is a slight structural difference on one of the heterocyclic rings: one of the dimethylpyrazole rings of the tris(pyrazolyl)borate ligand, Tp*Rh(cod), is replaced by a benzotriazole ring to make Tp'Rh(cod). The goal of this study is to investigate how effective these two rhodium(I) scorpionate catalysts are in the polymerization of phenylacetylene and similar monomers. Kinetic experiments were run using 1H NMR spectroscopy. Results show that the initial rate of polymerization depends on the structure of the catalyst and the substitution pattern of the phenylacetylene monomer.

## Synthesis and Characterization of Dynamic Porous Coordination Polymers (DPCPs) Supported by Amide Ligands

***Ethan P. McMoran and Pyi Thein Kyaw***
*Faculty Mentor: Lei Yang*

Guest-host chemistry of small gas molecules, such as $H_2$, $N_2$ and $CO_2$, with dynamic porous coordination polymers (DPCPs) has attracted considerable attention due to the high selectivity and efficiency of these materials. In pursuit of new generation of DPCPs, we synthesized a serials of organic ligands functionalized with amide groups, which are expected to significantly improve the flexibility of the framework and improve the interaction between guest molecules and the host surface. Transition metal compounds with various nuclearity have been prepared and characterized by X-ray crystallography, IR, UV-vis, Mass spectrum and elemental analysis. The interesting structural and spectroscopic features of these complexes will further enhance the understanding of ligand design and polymer construction, which are major contributors for adsorption properties of DPCP materials.

## DFT Simulations of Glycine and Alanine Clusters

***Aaron Owen***
*Faculty Mentor: Donald Perry*

The goal of this research was to determine the optimum geometry for clusters of simple amino acids - glycine and alanine - in order to produce simulated infrared and Raman spectra. Simulated spectra were compared to experimental data obtained from the molecules. Experimental data was obtained by means of Surface-enhanced vibrational spectroscopy studies including experiments of surface-enhanced infrared absorption (SIERA) and Surface-enhanced Raman spectroscopy (SERS)

of amino acids thin films on silver and gold substrates. Enhancement from these substrates arises due to the nanostructures at the surface of the substrate. Absorption Transmission Reflectance (ATR) spectra of the amino acids were also accumulated and compared to the theoretical spectra.

## An Improved Synthesis of a Valine Radical Precursor

***W. Ryan Parker***
*Faculty Mentor: K. Nolan Carter*

Proteins are subject to damage by reactive oxygen species such as hydroxyl radical. Since hydroxyl radical is nonselective, it can react at with any amino acid and at multiple sites within the same amino acid. Due to this non-specificity, evaluating the role played in protein damage by specific radical intermediates is difficult. To facilitate the study of this process, we have designed a photolabile amino acid radical precursor to generate a specific valine radical upon photolysis. The current synthesis of this compound is made difficult by problematic protecting group chemistry. Results of efforts toward improving the synthesis of this compound and characterizing the radical it produces will be discussed.

## Pigment Analysis of Australian Rock Paintings

***Andrew J. Poppe and Amanda B. Wallace***
*Faculty Mentor: Karen L. Steelman*

Pigment analysis was performed on red, yellow, white, and black aboriginal paintings in the Western Desert of Australia. While in the field, we collected over 200 data sets using a portable XRF (pXRF) spectrometer for elemental analysis. Then, back in the laboratory, we utilized SEM-EDS, FT-IR, and XRD. Complementary elemental and molecular analyses are useful for understanding pigment composition. Problems with pXRF studies on rock paintings include analysis spot size, thickness of paint, as well as the elemental composition of the rock substrate. We found pXRF to be particularly important in distinguishing between black manganese pigment and charcoal paintings.

## University of Central Arkansas Student Chapter: Collaborating with other Science Clubs on Campus

***Johnathon Schmidt, Ethan McMoran, Jordan Wilkerson, Amanda B. Wallace, and Amanda Hanson***

*Faculty Mentors: Kristin S. Dooley, Faith Yarberry, and Karen L. Steelman*

A major goal this year has been to build stronger relationships with other science clubs on campus. Our student chapter accomplished this by maintaining close contact with the biology and physics clubs. Large-scale joint events include: starting a local Science Café, organizing a pumpkin carving event for Halloween, helping with highway cleanup around the Little Red River, and hosting a demonstration-based competition between the three clubs for underclassmen. By practicing active collaboration, all three clubs benefit by being able to host larger events. The social networking between the clubs also boosted membership turnout at the joint activities, as well as chemistry club events.

## First Radiocarbon Dates for Chilean Rock Paintings

***Amanda B. Wallace***

*Faculty Mentor: Karen L. Steelman*

We obtained the first radiocarbon dates for rock paintings in northern Chile using plasma oxidation and accelerator mass spectrometry. In contrast to combustion, plasma oxidation is below the decomposition temperature of carbon-containing minerals such as carbonates and oxalates. Therefore, their inclusion in the dated extract is avoided for samples with a high mineral content. Each paint sample was pretreated with one molar sodium hydroxide solution to remove potential humic acid contamination prior to oxidation in a glow discharge. Organic material in the paint samples was converted to water and carbon dioxide, which is collected for $^{14}C$ measurement. Bayesian statistical calibration, using SHCal04, was conducted. Archaeologists are able to use these results to study the relationship between art styles found in varied regions of the country including the coast, valleys, cordillera, and altiplano.

# Computer Science

## Active Learning De-Duplication Process for Very Large Dataset Using Hadoop

***Shabbir Ahmed***
*Faculty Mentor: Victor S. Sheng*

De-duplication is the process of detecting and eliminating exactly same or almost similar copies repeating data. It is a key operation when large organization, such as Acxiom Corporation, receives data from multiple sources like USPS, survey, etc., and because those data are prone to be duplicates entities. If we use hard-coded functions to eliminate duplicate data can cause too much of resource time and can cause error because of data inconstancy. Interactive de-duplication using active learning has proven to be an efficient process to eliminate duplicate data. The main advantage of using active learning is that it reduces number of instances needed to train classifier which can be applied to very large amount of data to eliminate duplicate. If the data is very large we face problems since, in worst case, we have to compare each and every record with each other record in the in order to find the duplicate record. In other world, worst case, a Cartesian product results in too much processing time or sometime it is needed to slipt the data and process over and over to resolve duplicate data. In order to overcome this process I am using Hadoop framework to process very larger number of data in a very efficient way. I will be using interactive de-duplication by active learning algorithm suggested by Sunita Sarawagi and Anuradha Bhamidipaty to prove that by using Hadoop framework we can process very large number dataset without facing any issue.

## Melanoma Lesion Detection using Mobile Infrared Thermography

***Aaron Crawford, Alex Loney, and Cody Hudson***
*Faculty Mentors: Sinan Kockara and Tansel Halic*

Cancerous skin lesions, specifically melanoma, are strongly thought to be hyperthermic in relation to surrounding skin. Through a process called thermography, cancerous skin lesions can be detected with manual analysis of infrared imaging. This research proposes and implements an application that utilizes mobile hardware (Windows Phone 8), cloud computing (Windows Azure), and thermal infrared cameras with connected microcontrollers to create a scanning system that can accurately, quickly, and automatically predict the presence of cancerous tissue on a user by capturing thermal images of the suspect lesion and performing border detection on said scanned images. The designed system is inexpensive and intuitive, allowing any user familiar with basic smart phone interfaces to utilize the scanning hardware and application.

## Virtual Reality Based Electrosurgical Skin Lesion Excision Simulation

***Aaron Crawford, Cody Hudson, and Alex Loney***
*Faculty Mentor: Tansel Halic and Sinan Kockara*

Electrosurgery is surgical procedure that relies on high-frequency electrical current to provide both visceral and coagulating actions upon a given area, resulting in clean incisions and minimum blood loss. As such, electrosurgery has been successfully used for cancerous skin lesion removal, becoming increasingly popular and therefore a necessary procedure for training physicians to learn. In light of the costs and relative unevenness of traditional training, this research strives to utilize haptic force feedback devices, physical emulation, and visualizations to provide a realistic simulation of the electrosurgical technique in order to serve as a viable training mechanism for physicians.

## Does One-Against-All or One-Against-One Improve the Performance of Multiclass Classifications?

***R. Kyle Eichelberger***
*Faculty Mentor: Victor S. Sheng*

One-against-all and one-against-one are two popular methodologies for reducing multiclass classification problems into a set of binary classifications. In this paper, we are interested in the performance of both one-against-all and one-against-one for classification algorithms, such as decision tree, naïve bayes, support vector machine, and logistic regression. Since both one-against-all and one-against-one work like creating a classification committee, they are expected to improve the performance of classification algorithms. However, our experimental results surprisingly show that one-against-all worsens the performance of the algorithms on most datasets. One-against-one helps, but performs worse than the same iterations of bagging these algorithms. Thus, we conclude that both one-against-all and one-against-one should not be used for the algorithms that can perform multiclass classifications directly. Bagging is better approach for improving their performance.

## Validating an Object-Based Method for Interoperablility:

***Kaitlin Howle (Christian Brothers University), Erica Sheff, and Cody Hudson***
*Faculty Mentor: Paul E. Young*

In the field of Health IT, it is pertinent that we are able to exchange patient information across healthcare systems that utilize distinct standards for collecting patient data. Such differences in standards result in inconsistencies among systems; for instance, one system may include a patient's date of birth and social security number, whereas another may not. In addition, one

system may measure a patient's weight in pounds while another system uses kilograms. The Object-Oriented Method for Interoperability (OOMI) utilizes an Integrated Development Environment (IDE) to model information exchanged between systems and resolve differences in modeled information to enable systems to interoperate. The focus of this research was to create sample patient healthcare messages as test cases in order to validate the algorithms used by the OOMI for resolving differences among systems and thereby ensure their interoperability.

## Empirical Comparison of Multi-Label Classification Algorithms

***Clifford A. Tawiah***
*Faculty Mentor: Victor S. Sheng*

Multi-label classifications exist in many real world applications. This paper empirically studies the performance of a variety of multi-label classification algorithms. Some of them are developed based on problem transformation. Some of them are developed based on adaption. Our experimental results show that the adaptive Multi-Label K-Nearest Neighbor performs the best, followed by Random k-Label Set, followed by Classifier Chain and Binary Relevance. Adaboost.MH performs the worst, followed by Pruned Problem Transformation. Our experimental results also provide us the confidence of the correlations among multi-labels. These insights shed light for future research directions on multi-label classifications.

## The BearClaw: Mobile Mixed Reality System for Physical & Occupational Therapies

***John White, R. Kyle Eichelberger, Michelle Enfinger, and Ben Tackett***
*Faculty Mentors: Tansel Halic and Sinan Kockara*

We propose an affordable, easily portable, accessible, mobile mixed reality system that will assist physical therapy patients with hand/wrist/forearm related ailments, to be used in conjunction with current rehabilitation treatments. With modern advances in medical and computer sciences, far too many rehabilitation patients still do not obtain optimal results for their hand/wrist/forearm related ailments. Boredom or lack of motivation to attend their frequent rehab or therapy appointments is one factor in this problem – not to mention the expected at-home exercises the patient is generally required to do by their specialist. Add in the costs of time and money to make each of these sometimes tri-weekly appointments, especially in rural areas, and one will find even less motivation to continue receiving proper care for their condition. Our proposed BearClaw system allows for exercising to be done virtually anywhere, any time. This is done using a full range of motion glove infused with pressure, flex, stretch and motion sensors rigged to a Windows smart phone, accompanied with a family-friendly game app. This creates an easy to use mixed reality system that will allow the creation and control of dynamic, three-dimensional, ecologically valid, stimulus environments that offer new options in the rehabilitation process. All the while, the specialist is receiving instant progress reports of the patients' rehab sessions away from the clinic via the patients' mobile device and our interactive game app. The

user will be able to practice exercises without the direct attention and care of medical professionals. As the user progresses in their ability to perform their exercises, they advance in the game. This provides direct motivation to improve strength, mobility, and flexibility in their hands and fingers in order to make progress. The BearClaw system offers a way to improve on the individualization of the rehabilitation process and an increase in field standards.

## A Robot Librarian

***Maoyuan Yan (Ryan)***
*Faculty Mentor: Vamsi Paruchuri*

As technology advances forward, the lives of humans have become more and more convenient. Today, one of the most intensely studied areas of technology is robotics - the future revolutionary appliance of mankind. Robots are able to carry out assigned tasks and learn through experiences like human beings. Many robotic applications have already been employed in our lives, such as robotic vacuum cleaners, toys, and machines that explore space. As the popularity of the use of robots increases, more and more research and studies have been conducted to the development of robotic applications.

The research goal of this project is to introduce a new type of programmed robot: Robo Librarian. Robo Librarian is a robot that can potentially be implemented in libraries to assist librarians in their management of vast collection of books. The ultimate goal is to program a robot that is able to autonomously locate misplaced books in libraries. The robot needs to be able to navigate through bookshelves and scan each book as it passes by. After collecting books' information, the robot needs to be able to distinguish out-of-ordered books in an accurate and speedy manner.

In order to achieve this goal, there are three main physical components that are implemented: an Arduino Uno Board, the Radio Frequency Identification (RFID) technology and a Voice Recognition Module. The Arduino Uno serves as the brain for information storage, calculation and sending commands. The RFID technology serves as the information collector. The Voice Recognition Module is the interface which enables users to communicate with the robot.

# Mathematics

## Hopf-Cole Transformations for a Viscous Burgers' Equation

***Brandon Ashley and Thomas Deatherage***
*Faculty Mentor: Danny Arrigo*

It is well known that solutions of the linear heat equation can used to generate solutions of Burgers equation through the Hopf-Cole transformation. Recently it has been shown that a Hopf-Cole type transformation exists such that solutions of the fast diffusion equation can be used to generate solutions of a viscous Burgers equation. In this poster we show that this result generalizes. We present results showing that there exists large classes of Hopf-Cole type transformations where solution of nonlinear diffusion equations gives rise to solutions of viscous Burgers equations.

## Emergent Modeling and Riemann Sum

***Kritika Chhetri***
*Faculty Mentor: Jason Martin*

This study focuses on the mental challenges that students face and how they resolve those challenges in constructing a formal mathematical structure of Riemann sum while modeling "real life" contexts. A pair of Calculus I students who had just received instruction on definite integral defined using Riemann sums and illustrated as area participated in 10 interview sessions. They were given contextual problems related to Riemann sums but were not informed of this relationship. The intent was to observe students' transitioning from informal to more formal mathematical reasoning while modeling these problem situations. Results indicate how their ways of acting and reasoning about their first two tasks supported them in reasoning about a third task. In particular, the process of how they constructed and reasoned about a multiplicative structure for their first task repeatedly through evolving pictures, numerical representations, algebraic expressions and graphs supported them in constructing subsequent relationships for different situations related to Riemann sums.

## Derivative-Based Gauss-Lengendre and Midpoint Quadrature Rules

***Ezechiel Degny***
*Faculty Mentor: Clarence Burg*

New numerical integration formulas based on Gauss-Legendre quadrature and midpoint rule are developed. These formulas use a weighted average of function evaluations at a certain locations in [a, b]. These new formulaÂ use derivatives to increase the order of accuracy. The concept of precision is used to set up a system of nonlinear or linear equations for the weights and/or the locations. It is also used to determine the error associated with these methods.Â  For Gauss-Legendre quadrature, two points are used where function evaluation is at one location and derivative function evaluation is at the other location, followed by a numerical approximation of the derivative to reduce computational cost. This new method is fourth order of accuracy but computationally half as expensive as the other fourth order Gauss-Legendre methods.Â  To improve the midpoint rule, derivatives were used at the endpoints. Since the coe_fficients of the odd derivatives sum to zero, only the derivatives at the endpoints of the overall interval of integration must be evaluated. The basic formula using the midpoint function evaluation and the first derivatives gives fourth order of accuracy from N/2 function evaluations and two derivatives in the composite form, whereas the midpoint rule is second order of accuracy, and uses N/2 function evaluations. By adding two derivative evaluations, we improve the accuracy to fourth order. This process was used for first and third, then first, third, and fifth derivatives, showing similar improvement. Compared to the existing same order of accuracy of Open Newton-Cotes quadrature rules, these new integration formulasÂ use less function evaluations, thus making them more computationally effi_cient than the existing ones. In both types of numerical quadratures, the introduction of derivatives is beneficial in regards to accuracy and computational cost.

## "What-if" Scenarios for Outpatient OB/GYN Clinic

***Xiaowei Hu***
*Faculty Mentor: R.B. Lenin*

Health Care providers have faced ever-increasing pressure to deliver quality and efficient service while facing rising cost. One major measure for the quality of service is patients' waiting time. Long waiting time for treatment has been a common complaint by patients and remains to occur even though appointment systems are implemented in most of the clinics. West Little Rock (WLR) Obstetrics/Gynecology (OB/GYN) clinic, affiliated to the University of Arkansas for Medical Sciences (UAMS), is interested in finding ways to reduce patients' waiting time. Therefore, the purposes of this study are to develop a simulation model for the existing clinic; to validate model by using actual data; and to conduct ``what-if'' scenario analysis to propose an optimal utilization of human resources while reducing patients' waiting time. We collected two months of patients' data from 6/1/12 to 7/31/12 that represents the operations of WLR OB/GYN clinic. Using the validated simulation model, 16 ``what-if'' scenarios were carried out to identify suitable parameter values to reduce patients' waiting time. We proposed three better scenarios for each MD on each working day.

# An Entropy Solution to the Behrens-Fisher k-sample Contrast Problem

***Rebecca Smith***
*Faculty Mentor: Patrick Carmack*

Testing linear combinations of normal group means with unequal variances and possibly unequal samples sizes using a t-statistic is a well known problem for which the effective degrees of freedom are unknown. Satterthwaite (1946) and Welch (1947) set forth their approximations based on the ratio of combinations of fourth moments, and their methodology remains the de facto standard. We propose a new approach that extends their results by defining what we call Measure of Equivalent Exchange (MEE), which is a function of a tuning parameter, $\tau$, and the eigenvalues of a positive semidefinite matrix. We establish a number of important properties that MEE possesses, and provide a link to Shannon's entropy, which uniquely defines $\tau$. We then demonstrate the entropy defined $\tau$'s efficacy with simulations involving two and three group contrasts. We conclude with some commentary about the potential applications of MEE in other areas such as spatially correlated data and general covariance cross-validation.

# Physics and Astronomy

## Expert-like Physics Problem-Solving Framework: Utility for the Classroom and Teacher Training

***Mishal Benson***
*Faculty Mentor: Andrew Mason*

Abstract: STEM education reform is currently underway in Arkansas. Physics education research (PER) has recently begun at the University of Central Arkansas that could address this reform. Computer modules in development for introductory calculus-based physics courses, as part of collaboration with the University of Minnesota, are a toolset for possible use to this end. The modules are intended to explicitly introduce and "coach" an expert-like problem-solving framework to novice students. Several coaching modules have already been adapted to algebra-based physics. These coaches could be used in high school physics classrooms and training for pre- and in-service teachers in teaching the framework. The first step is collaborating with Arkansas high school physics teacher volunteers in evaluating these coaches for use in the classroom. Then we would adapt as necessary for trial among volunteers in high school physics courses. Eventually, these coaches will be available online. Other avenues of interest include creating modules with life-science oriented physics problems and developing applications for mobile devices and tablets.

## Comparison of Radar and Ground-level Precipitation Data for a Precipitation Event over Central Oklahoma

***Mishal Benson and Nick Heller***
*Faculty Mentor: Debra Burris*

Radar and particle precipitation data were collected for a precipitation event at Purcell, Oklahoma on March 29, 2013. We will compare radar data to the precipitation data collected at ground level.

## Alternative Visualization Methods of Wine Glass Resonance

***Shelby Burns***
*Faculty Mentor: William Slaton*

Breaking a wine glass with sound is a visually striking achievement and a great way to get potential students interested in Physics. The goal of this project is to not only break the wine glass but to build an apparatus that is portable and easily setup for lecture room demonstrations as well as outreach. The apparatus should also provide enough visibility for a room full of observers to easily see the resonance. Thus we constructed an enclosure using clear plexiglass, attached to two compression driver, hooked up to an amplifier and then hooked up to a signal generator. Until now our experiment has only been approached from one angle which is the utilization of a strobe light apparatus as the way to view the different modes of the wine glass. Moving forward with the experiment we began to explore different ways of viewing the modes of the wine glass. After receiving a generous loan from University of Mississippi in the form of a high speed camera, it is now possible to capture the modes without the use of a high speed strobe light. The apparatus should also provide even better visibility than previously achieved for a room full of observers to easily see the resonance. In a larger setting a camera could be used to relay the relatively small image of the wine glass to a projector for better visibility, only now there is a possibility to enhance the quality of those pictures and videos. From a more technical stand point, the project will provide an opportunity to experiment with resonance on a variety of different capture methods. In order to prepare for the ?nal demonstration, many different wineglasses will be tested in the test chamber as well as different capture methods.

## Rain Drop Distribution Experimental Set-up & Analysis

***Shelby Burns and Aaron Johnson***
*Faculty Mentor: Debra Burris*

Junior Laboratory at the University of Central Arkansas has allowed students to go out and take data at laborites other than UCA's such as the National Storms Lab in Norman Oklahoma. At the National Storms Lab, rain drops were collected to study the drop size distribution and its correlation to storms. However our poster is over the actual method and experimental set-up of the apparatus. Analyzing the material, costs, and as well the durability of the apparatus.

## Determinations of Neutron Capture Elements in Galactic Halo Stars Using the Hubble Space Telescope

***Scott Harrison***
*Faculty Mentor: Debra Burris*

The formation of heavy elements ($Z > 26$) is achieved by two main neutron capture processes: the 'rapid' or r-process and the 'slow' or s-process. R-process nucleosynthesis is thought to occur in

extreme environments with very high neutron fluxes like core collapse supernova or binary white dwarf mergers. The galactic halo is home to populations of asymptotic giant branch (AGB) stars which are advantageous for studying abundances of r-process elements which are not normally visible in stellar spectra. Among these elements, there are many which only have strong transitions in the ultra violet. These elements are not well studied because UV radiation does not penetrate Earth's atmosphere well. To overcome this difficulty, observations using the STIS instrument on the Hubble Space Telescope (HST) were utilized. Data sets were retrieved from the StarCAT Data Portal. Analysis was preformed with the spectral synthesis program MOOG. Patterns in abundances in these stars will assist in expanding our understanding of the r-process for some of the heaviest known elements.

## Designing and Building a Tabletop Molecular Acoustics Experiment

***Ashley J. Hicks***
*Faculty Mentor: William Slaton*

This work describes the design, construction, and testing a project investigating the molecular absorption of sound in certain gases, including the development of a capacitance transducer. The transducer is based on designs presented in the literature, modified to work optimally in our system which consists of 4-inch diameter steel pipe. The experiments will be conducted at atmospheric pressure, eliminating design constraints involved when using high pressure gas. However, work done by Bass & Shields shows that to work in these experiments at atmospheric pressure, the transducer must have a frequency range of 1 kHz – 100 kHz. [J. Acoust. Soc. Am. Vol 62, p. 346-353, 1977] The basic concept of our transducer depends upon creating a parallel plate capacitor from metal that is flexible enough to move when a sound wave hits it. Our design utilizes 0.051 mm thickness aluminized Mylar film tensioned with a brass retaining ring over a brass backing plate with both secured to a Delrin plastic base for its electrically insulating properties. We will report on the transducer's performance and initial testing in a sound absorption experiment with carbon dioxide.

## Determining the FWHM of the Hβ Emission Line of Active Galactic Nuclei

***Jeremy Jacobs, Matt Hankins, and Steven Clark***
*Faculty Mentor: Debra Burris*

The Narrow Line Emission from an Active Galactic Nuclei contains the Balmer Hβ emission line. These lines are believed to come from material further from the central black hole. The Hβ line can be used to determine the velocity of the gas which in turn allows the mass of the central black hole to be determined. We have recently began a project using IRAF to measure the FWHM of the Hβ line for a group of AGN selected by the research group of Dr. Julia Kennefick at the University of Arkansas. This will provide an independent mass determination for use as they seek a correlation with spiral galaxy pitch angle and black hole mass.

## Importance of Venus to the Dwellers of the Point Remove Mound Complex

***Jordan Krebs***
*Faculty Mentor: Debra Burris*

Observing the path of Venus to determine its possible relevance to the alignment of the Native American mounds at Point Remove in Conway County.

## Acoustic Properties of Various Flight-Approved Materials

***Justin Mann and Matthew Sission***
*Faculty Mentor: William Slaton*

How do sound waves interact and move through different materials? This is a question that concerns NASA's Johnson Space Center when trying to minimize the excess noise in manned spacecrafts. Numerous potentially flight-approved materials and some of the necessary laboratory equipment were sent to UCA in order to help answer this question. A technique requiring a cylindrical tube and two microphones was implemented to essentially determine how much sound gets absorbed into a certain material at various frequencies. This can be used to decide which material is optimal to diminish noise at a certain frequency. In addition, density considerations were taken into account to possibly minimize the cost of sending these into space. Further, this research would be very useful in determining the choice of materials used in auditoriums, concert halls, classrooms, etc. For example, an instructor would not want a classroom in which it is difficult to hear because of reverberations of their voice. Though the original motivation for this research applies to spacecrafts, it can be easily directed to situations and environments that are closer to home.

## Overview of Airborne Videosonde and Laser Disdrometer Apparatus

***Ethan McMoran and Benjamin Thines***
*Faculty Mentor: Debra Burris*

Analyzing disdrometer and radar data recorded on 03/29/2013 from the National Severe Storms Laboratory in Norman Oklahoma.

## Doppler Measurement of the motion of a Physical Pendulum

***JeanPaul Ngabonziza***
*Faculty Mentor: Carl Frederickson*

The Doppler shift of a reflected acoustic signal has been used to characterize the motion of a physical pendulum. The pendulum is covered with a rough surface to provide specular reflection at any angle. Comparison between theoretical and measured spectrograms will be presented. The measurement dependence on the frequency of the source signal will be explored. Source frequencies will be in the audible range. The system is being evaluated for use with a double physical pendulum modeling the motion of a human leg.

## Demonstration of the Negative Refraction of Microwaves

***Tristan Odekirk***
*Faculty Mentor: William Slaton*

Light, upon reaching the boundary between two media of differing index of refraction, will bend. All materials have a positive index of refraction, meaning the angle at which the light bends will be greater than zero. Specific arrangements of materials called metamaterials can result in an effective negative index of refraction causing light to bend at an angle less than zero. A paper by Velasquez-Ahumada et. al. has demonstrated the use of metamaterials designed to have a negative index of refraction for microwaves. It is the goal of this project to reproduce these results using geometry similar to that used in the paper.

## Measuring the effect of Hind-Limb Suspension(HLS) on the Elasticity of Bones†

***Greg Sheffer and Ashley Cotnam***
*Faculty Mentors: Rahul Mehta, Nawab Ali, Michael Soulsby, and Parimal Chowdhury*

The purpose of this study was to find the elastic modulus of the leg bone of rats that were exposed to Hind-Limb Suspension (HLS) by tail for two weeks. The hind limb suspended rats and the control rats were maintained and fed the same diet for the duration of the experiment. The animals were then sacrificed and leg bones were collected. After removing soft tissues, the bones were sectioned to produce the leg sections that can be approximated as cylinders with the medullary cavity being hollow. One end of the bone was held and a force was applied near the opposite end in a normal direction. Measurements were made of strain produced by a known force by measuring the bending displacement. The applied force was kept below a certain value to ensure that the bone would stay in its elastic limit and would continue to behave linearly. The Euler-Bernoulli beam theory was modified to account for the shape of the bone being measured. This modification mainly came from determination of the moment inertia of the bone starting with one for a solid cylinder and approximating for the soft tissue part in the bone to give it a shape of a

cylindrical shell. The modified theory along with the measured data provided the Young's modulus. The control bones were found to have a modulus 2-3 times larger than that of the HLS bones, implicating the role of experimental microgravity in bone elasticity.

†Supported by Arkansas Space Grant Consortium

## Design and Testing of a Custom Air Horn

***Jerrod Ward***
*Faculty Mentor: William Slaton*

Construction and testing of an air horn can provide insight into how certain design decisions can influence resulting acoustic properties. The unique sound of the air horn is produced when compressed air enters the main chamber through an inlet and builds up pressure against the diaphragm. As pressure builds, this diaphragm flexes to allow the air to leave the chamber through the outlet which is flush against it. This relieves the pressure in the chamber and the diaphragm returns to its original position, slamming against the outlet, creating the signature sound. We have designed and manufactured an air horn where it is possible to vary many different experimental parameters such as nozzle length, outlet diameter, diaphragm material, diaphragm thickness, diaphragm tension, etc. In this study, we have focused on the properties of the diaphragm and their relationship with the air pressure. By trying different permutations of diaphragms and seals with a range of pressures, it is possible to produce a desired tone over a very large range of frequencies. The system is very delicate and things like a good gasket seal for the diaphragm and solid, flush connections between the outlet and the diaphragm are absolutely necessary to ensure that pressure builds and relieves itself appropriately.

## Phase Transitions within Ferrofluid

***Bryan M. Wofford***
*Faculty Mentor: Stephen R. Addison*

Ferrofluids undergo phase transitions under the action of magnetic and electric fields, respectively. These materials are simple metamaterials. We are in the process of probing the properties of ferrofluids ultrasonically and through thermal testing. Preliminary results and experimental designs will be presented.

# Interdisciplinary

## Understanding Vocal Patterns in Tigers, *Panthera tigris*, and Application to the Census and Conservation of Endangered and Threatened Species

***Courtney Elizabeth Dunn***
*Faculty Mentors: Mary Victoria McDonald, Reid Adams, Ben Cash, and William Slaton*

Majestic, powerful, awe-inspiring, and critically endangered – all of these characteristics describe the remaining subspecies of *Panthera tigris* left in the wild. In recent decades tiger populations have plummeted by over 50% throughout their shrunken-down ranges which currently only occupy 7% of their historic lands (IUCN) (Seidensticker et al. 1999). Not only is the rapid disappearance of this keystone species creating an immeasurable impact on the ecosystems they support but it is also leaving behind many unanswered questions about their biology. One such area is their communication systems. The aim of the study is to determine if a unique acoustical pattern exists between *P. tigris* individuals in their vocalizations as well as if males can be discriminated from females and females in estrus from females not in estrus. Recordings for this analysis will be collected at the National Tiger Sanctuary (Saddlebrooke, MO) and Big Cat Rescue (Tampa, FL) over a span of nine months from 28 tigers. Vocal properties such as minimum and maximum fundamental frequencies, duration of vocal period, duration of inter-call intervals, duration of each call, and number of calls within a period will be compared amongst categories. The hypothesized complexity of vocalizations will enable a vocal "fingerprint" to be developed for individuals, which, in turn will allow for vocal monitoring as well as censusing when using microphone arrays placed strategically over tiger home ranges. Determination of sex as well as estrus levels also has the potential for representation of breeding populations. Other *Panthera* species could benefit from this project as well as amphibian, avian, and bat species which communicate largely by vocalization.

## *In Vivo* Loss of Estrogen Increases Voltage-Gated Calcium Channel Function in Mesenteric Arterial Smooth Muscle Cells

***Charmain A. Fernando and William R. Gray***
*Faculty Mentors: Brent Hill and Azida Walker*

The presence of estrogen in premenopausal women protects against the development of vascular dysfunctions, such as hypertension. Previous studies from our lab demonstrated a slight ($p=0.12$) increase in voltage-gated, L-type $Ca^{2+}$ channel (CaL) expression in mesenteric arteries from ovariectomized (OVX) mice. Therefore, in this study we hypothesized that the *in vivo* loss of estrogen will increase $Ca^{2+}$ influx in mesenteric arterial smooth muscle cells. Mice (C57BL/6)

underwent an ovariectomy or sham surgery at 8 weeks of age. At 12 weeks, the mice were sacrificed, mesenteric arteries dissected, and smooth muscle cells isolated. Lack of gonadal estrogen production was verified by a reduction ($p=0.004$) in uterine weights. No significant difference ($p=0.496$) in weight gain between mice groups was observed. Ratiometric fluorescent imagining was conducted on isolated cells loaded with the $Ca^{2+}$ fluorescent dye, fura-2AM. Cells isolated from the mesenteric arteries of OVX mice ($n=23$) demonstrated an increased ($p<0.001$) intracellular $Ca^{2+}$ response to the CaL agonist, FPL64176 ($1x10^{-6}$), compared to the sham mice ($n=15$). These results suggest that the loss of *in vivo* estrogen leads to the enhanced influx of $Ca^{2+}$ into arterial cells which may lead to a chronic elevation of vascular tone in postmenopausal women.

## *Tipula* Growth Response to Variation in Leaf C:P

***Jasmine Gilbert* and Chris Fuller***
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Aquatic cranefly larvae (Order Diptera, Family Tipulidae) are important consumers of detritus. Based on ecological stoichiometry theory, we predicted the low-body C:P Tipula would have faster growth rates when fed leaves with low compared to high C:P. Tipula were fed maple and oak leaves incubated at 3 nutrient levels resulting in a range of leaf C:P from 754-5340. Tipula were fed conditioned leaves ad libitum for 28-days having instantaneous growth measured. Tipula grew more (mean±1se; 2.5±0.2%d-1) on low C:P (2850±279 and 1665±279) oak leaves compared to growth (2.0±0.2% d-1) on higher C:P oak leaves (5340±279, p=0.0002). Tipula also grew more (2.2±0.3% d-1) on low C:P (754±327) maple leaves compared to growth (1.2±0.2% d-1) on higher C:P leaves (3679±327 and 1184±327, p=0.0002). Tipula grew ~1% d-1 slower when fed maple with a C:P of 2105±175 compar
ed to individuals fed oak leaves with a C:P of 3285±175, which might indicate an interaction between carbon quality and the organisms' threshold elemental ratio. The positive growth response of Tipula to eutrophication will provide more accurate predictions of shredder responses to nutrient enrichment.

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