The College of Natural Sciences and Mathematics

University of Central Arkansas

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

Abstracts

The 18th Annual Student Research Poster Symposium

April 20, 2012
2:00 - 4:00 pm

McCastlain Hall Ballroom

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

Introduction from the Dean's office

This book contains the abstracts for the 18th 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 74 abstracts with 100 student authors, 41 faculty mentors, and 7 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

Axon Degeneration Is Key Component Of Neuronal Death In Amyloid- β Toxicity

Wilson M. Alobuia
Faculty Mentor: Bhupinder P. S. Vohra

Amyloid -β (Aβ) aggregates constituting senile plaques are one of the hallmarks of Alzheimer's disease. N-terminus cleavage of amyloid precursor protein (APP) generates small fragments of amyloid -β (Aβ) peptides, and accumulation of Aβ leads to neuronal death. Recent studies have revealed that depending upon the stimulus, neuronal cell death can either be triggered from the cell body (soma) or the axon. The sequence of events in Aβ- induced neuronal deaths are however unknown. Therefore, in order to decipher whether neurodegenerative signal in Aβ- induced neuronal cell death emanates from neuronal soma or the axon, we observed the axonal degeneration and neuronal soma death in Aβ-42(the most common isoform of Aβ) treated *in vitro* cultured hippocampal neurons. Our data suggests that Aβ toxicity in hippocampal neurons cause widespread degeneration of axons which precedes neuronal cell death. Overexpression of Bcl-xl is known to block activation of mitochondria-dependent caspase activation pathways. Depending upon the stimulus, axon degeneration can be caspase-dependent or independent; we therefore infected hippocampal neurons with lentiviruses expressing Bcl-xl. We discovered that overexpression of Bcl-xl inhibited both axonal and cell body degeneration in the Aβ-42 treated neurons. These observations suggest the involvement of caspase-dependent pathways in Aβ-42 induced axon degeneration. Nmnat is known to block axon degeneration in a variety of paradigms, but is unable to save neuronal cell body. As a result, if the neuronal death signals in Aβ-42 toxicity originate from degenerating axons, we might be able to block neuronal death by over-expressing Nmnat. We therefore over-expressed Nmnat in hippocampal neurons and discovered that by blocking axon degeneration in Aβ-42 treated neurons, we can also block neuronal cell death. Thus, we conclude that axon degeneration is a key component of Aβ-42 induced neuronal degeneration, and that therapies targeting axonal protection can be key to finding a treatment for Alzheimer's disease.

Evolution Instruction: Does It Elicit an Emotional Response in Students?

Jason Bailey
Faculty Mentor: Mark Bland

Results of brain research in psychology reveal that emotional stimuli can interfere with cognitive processes (Dolcos & McCarthy, 2006). Moreover, Westen et al. (2006) determined that when 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. We hypothesized that if learners respond to evolution on an emotional level, then physiological indices of these learners will reflect varying degrees of emotional responses to images and statements about evolution, with "religious" students responding more strongly than "non-religious" learners. This study was conducted to assess whether students enrolled in a non-majors biology course experience a detectable emotional response upon exposure to evolutionary themes, as well as to see the degree to which participant paper survey responses match their physiological responses.

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

References

Dolcos, F. & McCarthy, G. (2006). Brain Systems Mediating Cognitive Interference by Emotional Distraction. *The Journal of Neuroscience* 26(7), 2072-2079.

Westen, D., Blagov, P. S., Harenski, K., Kilts, C., & Hamann, S. (2006). Neural bases of motivated reasoning: An fMRI study of emotional constraints on partisan political judgement in the 2004 U.S. presidential election. *Journal of Cognitive Neuroscience* 18(11), 1947-1958.

Does the Importance of Crayfish as Shredders Differ with Flow Permanence?

Amanda Bates
Faculty Mentor: Sally A. Entrekin

Detritus is an important energy source in headwater streams. Climate change is expected to alter detrital processing in aquatic ecosystems by modifying hydrologic regimes. Many headwater streams in the north-central Arkansas Ozarks are characterized by upstream ephemeral segments containing residual pools and downstream perennial segments. We examined the contribution of

crayfish to leaf breakdown in stream segments with differing hydrology. We compared leaf breakdown rates in mesh litter bags with either an added crayfish or no crayfish in paired ephemeral and perennial segments of three Ozark streams. We expected faster breakdown in perennial segments because of mechanical breakdown associated with greater water velocity. We also expected non-crayfish invertebrates to contribute more to breakdown in perennial segments and crayfish to contribute more to breakdown in ephemeral segments. On average, breakdown was slightly faster in perennial segments ($k=0.0150\ d^{-1}$ vs. ephemeral segments: $k=0.0144\ d^{-1}$) after 22 days. Breakdown was also faster in bags with an added crayfish in both perennial ($k=0.0169\ d^{-1}$ vs. bags with no crayfish: $k=0.0137\ d^{-1}$) and ephemeral segments ($k=0.0150\ d^{-1}$ vs. bags with no crayfish: $k=0.0141\ d^{-1}$). These results suggest that crayfish contributed more to breakdown in perennial segments because of a greater difference in rates compared to ephemeral segments. Crayfish activity may be reduced in ephemeral segments because of harsh environmental conditions such as lower temperatures and dissolved oxygen concentrations. These data, along with investigation of other shredding invertebrates associated with leaf bags, will clarify the influence of crayfish on leaf breakdown in streams with variable flow permanence.

Is the mediator of cell division, FtsZ, also a mediator of mitochondrial fission?

Dustin Brewton and Aloys Nsereko
Faculty Mentor: Kari Naylor

The powerhouses of the cell, mitochondria, are extremely dynamic. Imaging of these organelles in yeast and mammalian cells demonstrates that the steady state tubular structure undergoes numerous fission and fusion events. The balance of these events ensures that the mitochondria can exchange vital components, as well as remain distributed throughout the cell. These dynamics have been studied in many cell types, and most of the mitochondria studied have this tubular, highly branched structure. Interestingly, *Dictyostelium discoideum* has spherical mitochondria. We have demonstrated that these spherical mitochondria also undergo fission and fusion; our next goal is to identify the mechanism of fission in these cells.

In the organisms studied so far, fission events are mediated by a family of proteins known as Dynamin-related proteins (DRPs). Thus far, the DRPs present in *D. discoideum* do not appear to mediate mitochondrial fission, instead a family of tubulin homologs – FtsZs - appear to be involved. FtsZ mediates cell division of prokaryotic cells, the predecessors of mitochondria.

D. discoideum cells encode two FtsZ proteins, FszA and FszB. To understand the role FszA and FszB play in mitochondrial fission we are creating expression constructs to 1) purify the proteins for structural studies and 2) identify interacting partners. In addition we are creating knock-out constructs so that we may remove the FszA and FszB genes from the *D. discoideum* genome and analyze the rates of fission and fusion in the absence of these proteins. Here we describe our progress. Ultimately, we hope to gain insight into the mitochondrial dynamics of all eukaryotes, as well as increase our understanding of mitochondrial evolution.

Hunger Games:
How isolation can change a fishes diet

Jason Christian
Faculty Mentor: Ginny Adams

Biotic interactions can strongly shape community composition. These interactions are often exaggerated during times of ecological stress, such as isolation in streams from lack of flow. Many streams in the eastern Ozark Highlands are characterized by spring-fed headwaters that have connected pools in the upper reaches and isolated pools in the mid-reaches before becoming perennial. Within isolated pools, macroinvertebrate densities and richness can become lower, limiting food resources for fishes. The objective of this study was to examine the effects of pool isolation on fish diets. My prediction was that if food resources were low, then fishes would have to increase relative gut length. Increased gut length would allow an increase in assimilation efficiencies to account for lower quality or lower availability of food resources. Sampling was conducted during March, May, and July 2011 in a headwater tributary of North Sylamore Creek. We collected total available macroinvertebrates (9 orders; 45 families) and ten individuals of each target fish species (*Chrosomus erythrogaster*, *Semotilus atromaculatus*, and *Etheostoma spectabile*) at each pool for gut analysis in both isolated and connected pools. Non-metric multidimensional scaling (NMS) was used to determine differences in community structure. Densities and richness were significantly lower in isolated pools compared to connected pools (MRPP, P= <0.0001). Community structure had shifted from being rich in mayflies, stoneflies, beetles, and fly's in connected pools, to being driven heavily by daphnia in isolated pools (species indicator analysis, $p<0.05$). We found that in a resource-limited environment, relative gut lengths (covariate, standard length) of all three species increased when compared to high resource environments (ANCOVA, $P<0.05$).

Phylogenetic Analysis of Two Populations of *Fundulus olivaceus* using Cytochrome *b* Gene Sequence

Christi Davis, Trent Hall, and Ben Thesing
Faculty Mentor: Rick Noyes

Fundulus olivaceus, the black-spotted top minnow, is a common species among small streams in central Arkansas. Published work has shown two major lineages in the species, corresponding to major river drainages in the Southeast. We studied the phylogenetic relationships of two urban Conway populations of *F. olivaceus*, one from Stone Dam Creek and the other from Tucker Creek, using cytochrome *b* gene sequence. PCR was performed using the universal primers L14724 and H15915, as well as a third internal primer. PCR products were sent to the University of Missouri for sequencing. MEGA 5.05 was used to analyze the sequences. The data was compared to sequences in GenBank for *F. olivaceus*, *F. notatus*, *F. heteroclitus*, and two outgroup *Fundulus* taxa. The average pairwise distance was calculated to be 0.059. The neighbor-joining and maximum parsimony trees both separate the Arkansas, Tennessee, Kentucky, and Oklahoma populations of *F. olivaceus* from the Louisiana and out-group *F. olivaceus* populations, as well as from *F. notatus* and *F. heteroclitus*. The Stone Dam Creek and Tucker Creek populations are most similar to other *F.*

olivaceus associated with the Mississippi River drainage area, with pairwise distances of 0.002 or less. There is also a slight phylogenetic distance between the two Arkansas populations due to one unique base pair difference in the Stone Dam Creek population, resulting in a pairwise distance of 0.001.

Increased Chironomid Growth with Increasing Phosphorus

Chris Fuller
Faculty Mentor: Sally A. Entrekin

Nutrient enrichment can decrease macroinvertebrate diversity with chironomids often dominating the community in degraded aquatic ecosystems. One reason for chironomid persistence in high-nutrient systems could be their ability to use excess nutrients to increase growth. Previous studies have shown that increased nutrient content in basal food resources can lead to increased growth in detritivorous chironomids. However, it is unclear how representative this broad taxonomic grouping is of different genera. We fed a chironomid genera, *Micropsectra,* leaves incubated in water enriched with combinations of two levels of nitrogen (low and elevated; 11 and 1109ug/L, respectively) and phosphorus (low and elevated; 1 and 109ug/L, respectively). *Micropsectra* fed leaves incubated under elevated nitrogen and phosphorus concentrations grew more (mean±1SE, 1±0.15mm) than those fed leaves from low nitrogen and phosphorus (0.44±0.19mm), elevated nitrogen (0.30±0.15mm), or low nitrogen incubations (0.18±0.15mm) (P=0.0001). Our preliminary data suggests that some genera are able to use excess nutrients for growth. Generic resolution of chironomid response to basal resource enrichment can provide a framework for predicting alterations in community structure in nutrient enriched environments.

Tipulidae Growth Response To Food Nutrient Variation

Jasmine Gilbert and Chris Fuller
Faculty Mentor: Sally A. Entrekin

Macroinvertebrates in small streams play an important role in processing leaf litter for biota downstream. Macroinvertebrate shredders, such as the Tipulidae family, are able to eat whole leaves that other invertebrates cannot process and assimilate. A decline in shredder species can cause subsequent declines in other aquatic species that rely on processed organic matter as a food resource. Detritus is a low quality food resource, with low phosphorus content, which may be nutrient limiting to the tipulids, which have high phosphorus content. Nutrient limitation may be alleviated if the quality of the detritus is improved through nutrient enrichment. We predict that tipulids fed higher quality food will have greater growth and assimilation than tipulids fed lower quality food. We quantified growth of aquatic tipulid larvae fed detritus with different nutrient concentrations. Maple leaves were conditioned with five different variations of nutrients: 0µg/L P + 0µg/L N; 100µg/L P + 0µg/L N; 500µg/L P + 0µg/L N; 100µg/L P + 800µg/L N; and 500µg/L P + 4000µg/L N. Tipulids were fed the same surface area of leaves over a 24 day period and growth was measured as change in length and mass. Tipulid length did not change and individuals lost mass rather than gaining mass. Only one tipulid displayed positive growth (0.094g). Larvae were collected close to emergence, which may explain our results. We are continuing to quantify

ingestion and egestion, with implications for assimilation, predicting that there will be differences across nutrient concentrations. Response of tipulid larvae to altered food quality can lead to more accurate predictions of community change and trophic structure in nutrient enriched systems.

A retrospective epidemiologic analysis of influenza pandemics in Arkansas

Andy Gray and Duy Nguyen
Faculty Mentor: Ben Rowley

The purpose of this study is to compare and contrast influenza mortality in Arkansas during the pandemics of: 1918 (aka Spanish flu), 1957, 1968, and 2009 (H1N1, aka Swine flu). Death certificate and U.S. census data were gathered and analyzed for statistical differences in mortalities based on sex, age, and geographic regions of Arkansas for each pandemic. The geographic regions were defined by the five Public Health Units classified by the Arkansas Department of Health. Regional mortalities were also analyzed across all pandemics to investigate how the different pandemic influenza A viruses affected each individual region. It was hypothesized that males presented higher mortalities than females and the more rural regions exhibited higher proportional mortalities than the urban regions. The young and old populations were believed to present higher mortalities for the pandemics, with the exceptions of the two H1N1 viruses. It was hypothesized that these two pandemics presented higher mortalities in the young adult and middle-age groups. Chi-square analyses for each pandemic showed only the 1918 pandemic had statistical differences between male and female mortalities ($p<0.005$). All pandemics showed statistical differences in mortalities across age groups. Analyses across the regions found statistical differences in mortalities for all pandemics except 1968 ($p>0.5$). Data showed the more urban regions sustained higher proportional mortalities than the rural regions. Over the course of the century, the four pandemics resulted in decreased mortalities throughout the state. Regional mortality rates offer a suggestion as to which areas or regions to focus increased public health efforts during future influenza outbreaks in Arkansas. With this knowledge, health professionals may be able to distribute limited response resources efficiently to reduce mortality rates of future pandemics.

Activation of the ERalpha and ERbeta pathway downregulates voltage-gated Ca^{2+} channels in coronary arteries

Ross Gray
Faculty Mentor: Brent Hill

Our lab has previously demonstrated that a physiological concentration (1 nM) of estrogen (E2) can downregulate voltage-gated, L-type Ca^{2+} (VGCC) channels in coronary arteries. The distal ends of coronary arteries obtained from hearts of female pigs were sectioned into longitudinal strips and incubated for 24 hrs in 1 nM E2, EtOH, an estrogen receptor (ER) alpha/beta antagonist (ICI 182,780), and a G protein-coupled ER antagonist (GPER; G15). The arterial strips were

homogenized for Western blot analysis using an antibody reactive to the VGCC alpha1C subunit. Our preliminary results suggest that the E2 induced VGCC downregulation is mediated through ERalpha/beta, and not GPER. Furthermore, ER activation by E2 in endothelium intact arteries have an increase in protein kinase G expression (known to inhibit VGCCs), decrease in VGCC expression, and less coronary arterial reactivity. Overall, our results suggest that the classical ERs can be therapeutically targeted in postmenopausal women to reduce the density of VGCCs.
Support: NCRR of the NIH, Grant #P20 RR-16460 and the Arkansas SURF program.

Monitoring of Natural Gas Drilling and Fish Assemblages on Gulf Mountain Wildlife Management Area

Jessie Green
Faculty Mentors: Ginny Adams, Reid Adams, and Sally A. Entrekin

The majority of aquatic ecosystems in the United States are imperiled due to anthropogenic effects. New among these is the process of nontraditional natural gas extraction. In the Fayetteville Shale of central Arkansas, nontraditional natural gas extraction has expanded extensively over the last eight years, with over three thousand gas wells currently in existence. Some potential disturbances associated with gas extraction are siltation from pad, road, and pipeline construction, along with improper disposal of production water. Siltation of streams can alter substrates vital for successful reproduction in fishes and macroinvertebrates. To examine impacts of natural gas extraction on headwater streams, we surveyed six headwater streams on Gulf Mountain Wildlife Management Area in north-central Arkansas beginning in 2009. Our study is unique due to the opportunity to obtain an extensive pre-disturbance fish community dataset. To date two well pads have been constructed and further production activities are expected. We sampled fishes quantitatively using backpack electrofishing and multiple pass depletion on multiple riffle-pool units per site. Over the course of the study, overall fish assemblage richness ranged from 2 to 22 species per site. Most sites were dominated by percids and cyprinids. Fish taxa sensitive to disturbances as defined by EPA standards are found on the Gulf Mountain Wildlife Management Area (e.g. Bigeye Shiner *Notropis boops*, Greenside Darter *Etheostoma blenniodes*, and Rainbow Darter *Etheostoma caeruluem*). In addition, two species present in our survey, Ozark Madtom *Noturus albater*, and Autumn Darter *Etheostoma autumnale*, are Ozark Highland endemics. Continued monitoring of these headwater streams will allow us a strong experimental approach to examine what effects the installation and operation of natural gas well pads has on the resident fish assemblages.

Genetic Analysis of Two Central Arkansas Blackspotted Topminnow (*Fundulus olivaceus*) Populations using Amplified Fragment Length Polymorphisms (AFLPs).

Trent Hall, Christi Davis, and Ben Thesing
Faculty Mentor: Rick Noyes

Amplified Fragement Length Polymorphisms (AFLPs) were used to determine the genetic structure and diversity of two isolated, urban populations of the blackspotted topminnow *Fundulus olivaceus*. Twenty-four individuals were sampled from both Stone Dam Creek and Tucker Creek in Conway, Arkansas, for a total of 48 individuals. A total of 203 loci were detected by six primer combinations, 86 of which were polymorphic (42.36%). AMOVA analysis showed a significant amount (30%, $p = 0.01$) of genetic variation among populations, and there was a trend for lower genetic variation within the Stone Dam Creek population ($P = 35.89\%$) when compared with the Tucker Creek population ($P = 38.58\%$). This could be due to a higher concentration of contaminants within the Stone Dam Creek watershed (ADEQ 2002), and further genetic studies should be conducted to monitor the diversity of this population of topminnows—as well as less tolerant fish species.

Analysis of NHE-1Cell Surface Expression in MCF-7 Cells

Daniel Hubbs, Jackson Bagby, and Ashley Long
Facutly Mentors: Leah Horton and Steven Runge

Programmed cell death (apoptosis) is vital to human physiological development and tissue homeostasis. Inhibition of apoptosis, several conditions can result in conditions including degenerative disorders, autoimmune diseases and various types of cancer. Cancer cells divide rapidly and often do not respond to many of the apoptosis triggering signals that keep cell populations of non-cancerous tissues at proper levels. Our cells of interest (MCF-7 breast cancer cells) are somehow surviving the severe hypoxic and acidic conditions created within tumor masses. This implies that cancer cells can regulate internal pH (pH_i) to avoid apoptosis. The NHE family of proteins function as Na^+/H^+ exchangers and are responsible for maintaining a stable pH_i in many cell types.

MCF-7 breast cancer cells will be subjected to an acidic/hypoxic environment that mimics that of a human tumor microenvironment. Using a magnetic bead based affinity purification, the plasma membranes of MCF7 cells will be isolated. The membrane proteins will then be eluted from the beads and analyzed by ELISA. By examining the protein abundance of NHE1 our study will give insight into one way cancer cells may regulate protein expression and thus pH_i, to avoid apoptosis in the acidic/hypoxic tumor environments. Our hypothesis states that NHE1 is being downregulated in response to the (hypoxic/acidic) tumor micro environment and one of the other NHE family proteins is being upregulated. We will examine both the acute and the adaptive response to better understand the exact mechanism by which cancer cells are able to adapt and survive.

Do headless males really make better lovers? Sexual cannibalism in Carolina mantids

Kyle Hurley and Nick Davis
Faculty Mentor: David Dussourd

Sexual cannibalism has been noted in several mantid species including the indigenous Arkansas species, *Stagmomantis carolina.* Females commonly consume the heads of courting males; remarkably, the male is often still capable of attaching to the female. Whether these headless males can actually transfer sperm and fertilize eggs has not been determined for any mantid species. We collected *S. carolina* egg masses from the Railroad Prairie Natural Area located near Hazen, AR. and reared 100 mantids to sexual maturity. We observed sexual encounters between randomly chosen pairs for ~ 24 hour periods. Males were cannibalized in 17 of 45 matings, but the male attached to the female in only one of these. Females starved for longer periods more frequently cannibalized males. In addition, females generally consumed smaller males regardless of female size suggesting female choice based on male size. After mating, females were provided with unlimited food. Egg masses produced by females are currently being hatched in the laboratory; they will allow us to determine if cannibalized males fertilize eggs as effectively as intact males by comparing fertilization ratios.

Macroinvertebrate Community Structure in Intermittent and Perennial Ozark Streams

Julie Kelso
Faculty Mentor: Sally A. Entrekin

Increased urbanization and water withdrawal have altered the natural flow regime in streams, causing increased stream drying, declines in water quality, and local extinctions. The hydrology of perennial streams may become more similar to that of intermittent streams as a result of increased stream drying and flow variability. We predicted that the macroinvertebrate community of intermittent streams would have a greater proportion of taxa with drought resistant traits than the perennial macroinvertebrate community. We quantified the density of macroinvertebrates with traits such as size at maturity, desiccation resistance, generations per year, and rheophily in intermittent and perennial streams in the South Fork Little Red River watershed. We expect drought resistant traits to enable macroinvertebrates to utilize refuge in drying streams such as isolated pools and the hyporheic zone. In the future we plan to quantify the density and community composition of macroinvertebrates using the hyporheic in intermittent versus perennial streams.

"Translating" Studies from Experimental Species to Humans: A Web-based Tool for Researchers and Clinicians

Travis Kersh and Alan Lim
Faculty Mentor: Barbara Clancy

Human brain development is usually studied in non-human species such as rats or monkeys. Yet methods that can be used to convert the timing of brain development in experimental species to that of humans have proved inadequate, and even the rare available data are not easily accessible. We address this problem by employing concepts from neuroscience, evolutionary science, computer science and statistics, creating an online model to "translate time." Our project makes research accomplished in one species directly applicable to another. Our web application, http://www.translatingtime.net/, provides public access to this tool, and includes predicted dates of human brain development, important because most research studies cannot be accomplished in humans. Use of these translations also minimizes the numbers of animals used in studies of developmental disorders and diseases. This project was developed by undergraduate students at the University of Central Arkansas, and currently includes students and researchers from the University of Arkansas at Little Rock and Cornell University. The site has been accessed over 68,000 times, and is in daily use by researchers and clinicians in Arkansas and throughout the world. We estimate the project has already saved many thousands of dollars in research funding, and plan to add new species and developmental ages in the near future.

EST sequencing for *Erigeron annuus* (Asteraceae - sunflower family)

Alan Lim
Faculty Mentor: Richard Noyes

Erigeron annuus is a model for the study of a specialized form of plant reproduction known as apomixis. In order to study the genome of this species, we have begun compiling expressed gene sequences (ESTs) with the goal of using knowledge of the sequence of these genes for genetic mapping. Previously, a plant cDNA library maintained in λ phage had been prepared from flower buds. To obtain gene sequences, an E. coli strain first was infected by λ phages from the library using a technique by which the phage genome circularizes and forms a stable plasmid. These plasmids were then isolated by alkaline lysis and the sizes of the cDNA inserts were determined via PCR and gel electrophoresis. Of 384 samples, we determined 234 to be of acceptable length – between 650 and 2000 bp. These were sequenced at the University of Missouri DNA Core Facility. 'Sequencher' software was used to evaluate sequence quality and to determine the need for performing additional sequence reactions to obtain a complete sequence. Up to this point, we have obtained 178 complete plant gene sequences. Further analyses will include identifying gene identity and classifying gene function (ontology) using diverse web bioinformatic tools.

Does the Jewel Moore Nature Reserve support a bee community typical of native prairies?

Coleman Little
Faculty Mentor: Katherine Larson

The complex pollination webs made up of native plants and their pollinators are responsive to anthropogenic environmental changes such as the introduction of exotic plants, exotic bees, and shifting ranges of native species due to climate change. Although the Jewel Moore Nature Reserve (JMNR) conserves a diverse community of native prairie plants, it also contains many exotic plant species and is embedded in an urban matrix, factors that are known to impact native bee communities. The goal of this project was to determine whether the Jewel Moore Nature Reserve (JMNR) supports a bee community typical of Arkansas River Valley prairies or if it is more typical of disturbed and urban areas. I sampled both JMNR and a high quality native prairie owned and managed by the Arkansas Natural Heritage Commission, Cherokee Prairie. To compare the bee communities of these two prairies I sampled three sites within each prairie during two different time periods. The bee community of each site was sampled using pan trapping and hand netting techniques. In 2011, 650 individual bees were collected and 83 different species were identified. Although expert confirmations are pending, a preliminary nonmetric multideminsional scaling (NMS) with PCOrd software was used to compare the influence of season and site on the bee community composition.

Metabolism and Invertebrate Diversity in Headwater Streams

Mary Mcleod
Graduate Mentor: Amanda Bates
Faculty Mentor: Sally A. Entrekin

The study of metabolism in headwater streams is vital in understanding the process by which oxygen sustains life and how different sources of oxygen affect biological diversity in these streams. Seasonal drying of streams can stress the aquatic macroinvertebrate community with decreased dissolved oxygen levels that result from little or no current. Drying also subjects biota to habitat fragmentation and isolation as streams become a series of pools. Disconnected pools left in intermittent streams after drying are particularly susceptible to dramatic fluctuations in dissolved oxygen concentrations associated with primary production and community respiration because there is no source of oxygenated water from upstream. These pools rely on oxygen produced through photosynthesis, and organisms with high heterotrophic metabolism may be more stressed. I will quantify metabolism in pools of intermittent headwater streams, collect and identify aquatic macroinvertebrates in these same pools, and relate macroinvertebrate diversity to pool metabolism. Measuring changes in dissolved oxygen concentrations over a 24-hour period will allow me to calculate P/R, which is the ratio of primary production (the amount of oxygen produced by autotrophs) to community respiration (the amount of oxygen consumed by heterotrophs and autotrophs). P/R will differ from day to night due to high photosynthetic production during the day and the absence of this production at night. The presence autotrophs and heterotrophs within a pool will cause oxygen depletion due to high amounts of respiration at

night. I predict that pools with P/R <1 will sustain a more diverse macroinvertebrate community. Diversity can be influenced by basal resources, and I expect that a pool with high litter input will have greater diversity due to the introduction of detritus, which serves as a food source for macroinvertebrates but does not consume oxygen. A diverse macroinvertebrate community in headwater streams exports energy to downstream food webs through organic matter processing and invertebrate drift. Because intermittent streams make up more than half of total stream length in the Ozark Highlands, it is important for scientists to understand how habitat isolation can affect macroinvertebrate communities in headwaters.

Land Use Effects On Macroinvertebrates In Arkansas Streams

Adam Musto
Faculty Mentor: Sally A. Entrekin

Land use in north-central Arkansas is primarily forest and pasture, with some urban and natural gas exploration. Natural gas exploration has been increasing in the Fayetteville Shale region since 2005. Streams draining catchments with agriculture, urban area, and gas development can experience increased sediment carrying elevated trace elements, such as aluminum, iron, and copper. Elevated trace elements and associated increases in conductivity can result in a decline in macroinvertebrate density. We sampled macroinvertebrates at ten sites on private land with a mixture of pasture, gas activity, urban, and forest land uses. Ten replicate macroinvertebrate samples were taken at each site, and trace elements were quantified from water samples taken at base flow. We predicted that trace element concentrations would increase with increased urban, pasture, and gas land use, and elevated trace elements would correspond to a decline in macroinvertebrate taxa density. We found that increasing gas well density was positively correlated with concentrations of aluminum ($r=0.70, p=0.02$), chloride ($r=0.72, p=0.02$), lead ($r=0.70, p=0.02$), nickel ($r=0.73, p=0.02$), potassium ($r=0.74, p=0.02$), and sodium ($r=0.68, p=0.03$). There were no significant correlations between other land uses and trace element concentrations. Density of *Caenis sp.* (Ephemeroptera) increased with increasing concentrations of aluminum ($r=0.86, p<0.01$), chloride ($r=0.90, p<0.01$), lead ($r=0.93, p<0.01$), nickel ($r=0.82, p<0.01$), potassium ($r=0.72, p=0.02$), and sodium ($r=0.85, p<0.01$). The mechanism driving the correlation between *Caenis sp.* and these trace element concentrations is unknown at this time. Natural gas drilling is a new land use that is continuing to expand in the shale areas across the United States that is in need of further studying.

Pollination Biology of a Commonly Managed Exotic Invasive Shrub (*Ligustrum sinense)*

Jessie Needham
Faculty Mentor: Katherine Larson

Ligustrum sinense (Chinese privet) is an exotic ornamental shrub that has successfully invaded natural areas throughout the southeast United States. Management of *L. sinense* is widespread and common, but it is not well informed by scientific studies of *L. sinense* life history traits or competition with other plant species. With this in mind, I propose to study several aspects of *L.*

sinense pollination biology. I will examine two *L. sinense* pollination life history traits: self-compatibility and flower phenology. I will determine self-compatibility using pollinator exclusion bags and hand pollination. I predict that *L. sinense* is self-compatible because of its invasive success. I will describe flower phenology by examining flowers daily during the bloom period. I will also examine two aspects of *L. sinense* pollination that could contribute to competition with nearby plant species: the insect pollinator community and pollen loads on *L. sinense* stigmas and insect pollinators. I will identify the insect pollinator community on *L. sinense* by hand netting in various locations. I predict that the insect pollination community will consist of similar generalists at all locations because of its exotic and pervasive nature. Lastly, I will identify the pollen on *L. sinense* stigmas and insect pollinators as either homo- or heterospecific by removing the pollen grains and mounting them on fuchsin gel slides. I predict that *L. sinense* stigmas and insect pollinators will carry both homo- and heterospecific pollen thus indicating competition between *L. sinense* and nearby plant species.

Increasing undergraduate understanding of flow cytometry technology and applications

Duy Nguyen and Alan Nguyen
Faculty Mentor: Ben Rowley

The purpose of this project was to instruct students about the technology of flow cytometry. Undergraduate students lack experience with this useful tool in research and clinical applications, but have an opportunity to gain experience on a unit available in the Biology Department at UCA. Flow cytometry is efficient in the analysis of diverse cell populations. The method has the capability to determine and analyze relatively small cell populations in a mixture of cells, often without the need to grow or separate the cells beforehand. Groups of students in the General Microbiology course (n=43 in Fall 2011, n=42 in Spring 2012) were given an initial general survey on their existing knowledge of flow cytometry. After the course, which included a lecture, small scale experiment performed by the students on the machine itself, and presentation of journal articles that use the technology, the survey was given again. Statistical analyses were performed to determine if an increase in familiarity with flow cytometry by the students had occurred. The students exhibited significant improvement in their survey scores. This project illustrates a worthwhile method for increasing knowledge of and exposure to the concepts of flow cytometry in undergraduate student populations.

Axon Degeneration Share Disttinct Activation And Exicutioner Pathways With Apoptosis

Lynn Nguyen
Faculty Mentor: Bhupinder P. S. Vohra

Axon degeneration is a pathologic hallmark of many neurological conditions but the molecular mechanisms of axon degeneration remain unknown. Axonal destruction shares morphological features with apoptosis but most studies indicate that except in the case of trophic factor withdrawal, axon degeneration is a caspase-independent process. 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 and upregulation of protons are indeed activated in the axon degeneration. Even though caspase inhibition does not block axonal degeneration, we tested whether TLCK (an inhibitor of Trypsin like proteases like proteases that can also block cysteine proteases) can impede axon degeneration. We discovered that TLCK block axon degeneration after trophic factor withdrawal by inhibiting activation of Caspase-6 in the axons. Intriguingly, although caspases are not involved in axon degeneration caused by axotomy or vincristine but TLCK also inhibited axon degeneration in these conditions. Therefore, we believe that some other caspase like proteases which are inhibited by TLCK might be playing a role in axon degeneration caused by axotomy or vincristine. Thus we conclude that axon degeneration not only shares morphological features, but distinct early and late activation pathways with apoptosis as well.

The Role of the Cytoskeleton in MCF-7 Cell pH_i Regulation

Alyssa Papineau
Faculty Mentors: Steven Runge, Kari Naylor, and Leah Horton

Our lab's research goal is to understand the role of changing intracellular pH in apoptosis and to determine whether or not manipulation of the pH regulatory machinery of the cell represents a viable strategy for inducing cell death in cancer cells. The major objectives of this project are 1) to measure the internal pH changes when MCF-7 cells are subjected to acidic environments and 2) to determine if changing the cell's cytoskeleton by adding microtubule stabilizers or depolymerizers affects its ability to regulate pH_i.

A tumor's external pH (pH_e) is approximately 0.5 pH units lower than that seen in normal tissues (Boyer and Tannock, 1992). Even in these acidic environments, the pH_i within solid tumors is usually very close to the physiological pH (Boyer and Tannock, 1992). These findings suggest that tumor cells are able to regulate and maintain their pH_i levels. Therefore, we hypothesize that if cultured MCF-7 cells are subjected to an acidic environment, then they will be able to maintain neutral pH_i levels. In addition, some chemotherapeutics induce apoptosis in cells by altering microtubule dynamics. Based on this information, we hypothesize that if intact microtubule structure is necessary for pH_i regulation, then stabilizing or depolymerizing microtubules will result in the MCF-7 cells' loss of intracellular pH regulation. pH measurements will be done using ratiometric imaging of cells treated with a fluorescent pH indicator. Cells subjected to the same treatments will also be observed with the confocal microscope to visualize microtubule structure.

Functional organization of sensory areas in the nine-banded armadillo (*Dasypus novemcinctus)*

Monica Runge and Johnathan Rylee
Faculty Mentor: Jeffrey Padberg

The nine-banded armadillo is a member of an interesting branch of mammalian phylogeny (superorder Xenarthra) which also includes anteaters and sloths. As a member of this very early branch of Eutherian mammals, armadillos differ profoundly in morphology and physiology from extant members of more modern branches such as the Euarchontoglires. These differences include an ossified carapace overlaying the majority of their dorsal surface and specific polyembryony (they always give birth to identical quadruplets). While the armadillo has become a quite important model in research due to its ability to serve as a reservoir for *M. leprae,* the functional organization of their sensory systems has not been well characterized. We are interested in determining how physical and behavioral differences between armadillos and other Eutherian mammals translate into distinct patterns of neural organization. We have predicted that the osteoderm which overlays the majority of the dorsal surface of the animal restricts the quantity and quality of somatosensory inputs available to the brain. Currently, we are exploring the connectional patterns of armadillos by placing fluorescent tracers into sensory cortex and reconstructing the connections using Neurolucida software (MBF Bioscience). Additionally, we are utilizing standard electrophysiological techniques to determine the overall functional organization of this species. Thus far, we have observed pronounced cortical magnification of the digits, forelimb, and snout. Through this line of experimentation, we will gain insight into the evolution of mammalian brains and how physical and behavioral differences between Xenarthran and Epitherian species translate into distinct neural organization.

Mitochondrial Fission and Fusion: Is it as Ubiquitous as We Thought?

Brixey Schimmel and Greg Berbusse.
Faculty Mentor: Kari Naylor

Mitochondria are the powerhouse of the cell creating energy in the form of ATP. These organelles are very dynamic constantly undergoing fission (splitting) and fusion. These dynamics maintain the tubular, highly branched network of mitochondria found in yeast and mammalian cells.

Mitochondrial dynamics have been studied in many cells types, and thus far all the mitochondria studied have had this tubular, highly branched structure. *Dictyostelium discoideum*, our model system, has spherical mitochondria which also undergo fission and fusion processes. Our goal is to determine the mechanism of mitochondrial fission in these cells in an effort to understand the fission machinery found in all organisms.

As such we have begun to analyze proteins associated with the mitochondria to see if they play a role in fission. We have analyzed MidA, CluA, and have preliminary data on DymA and DymB. We have concluded that both fission and fusion events are significantly decreased in strains not expressing MidA or CluA. We hypothesize, based on other functional data, that the decrease in

these processes in cells lacking MidA is probably an indirect effect. While in cells lacking CluA, the decrease is either because the protein somehow links the fission and fusion or because of a lack of interaction with the cytoskeleton. Additional studies are underway to distinguish between these two options.

By analyzing mitochondrial dynamics in *D. discoideum* cells, we will further our understanding of the mechanism regulating fission in this organism. Ultimately, we hope to gain insight into mitochondrial dynamics of all eukaryotes, as well as increase our understanding of mitochondrial evolution.

Habitat Use of the Redfin Darter, *Etheostoma whipplei*

Loren W. Stearman
Faculty Mentor: Ginny Adams and Reid Adams

The redfin darter, *Etheostoma whipplei*, is a common member of stream fish faunas throughout central Arkansas. Though well studied morphologically and phylogenetically, few studies have addressed any aspects of the ecology of this species. Many researchers have reported the habitat preference of this species anecdotally; however, many of these reports are in conflict with one another. To address this lack of knowledge, we conducted a two-year quantitative analysis of *E. whipplei* across multiple sample streams in north-central Arkansas. Nonmetric multidimensional scaling analysis of sites in habitat space revealed that E. whipplei proportional abundance related significantly positively to habitat variables indicative of small, upland headwater streams both in 2010 (T = 0.54) and in 2011 (T = 0.51), but had no relation to variables indicating small, lowland headwater streams or mainstem rivers in either sample year. Nonetheless, we captured at least one *E. whipplei* at all sites. Our results demonstrate that *E. whipplei* is most common in small, upland headwater streams, but is somewhat flexible in habitat use and may be found in a variety of habitats. Our findings agree with some anecdotal reports, and provide strong empirical evidence of the actual habitat preferences of this species.

Phylogenetic Relationship of the Southern Redback Salamander (*Plethodon serratus*)

Ben Thesing
Faculty Mentor: Richard Noyes

The Southern Redback Salamander (*Plethodon serratus)* is a small terrestrial woodland salamander located in the southeastern United States. The range of the species is currently separated into four widely disjunct regions: (1) the Ouachita Mountains of eastern Oklahoma and western Arkansas; (2) the Ozark Mountains of southeast Missouri; (3) central Louisiana; and (4) the southern Appalachian Mountains of northwestern Georgia, eastern Alabama, eastern Tennessee, and western North Carolina. DNA sequences for a total of 33 samples collected from each of these areas were included in a molecular phylogeny using a concatenated 1444 bp region including the mitochondrial cytochrome-*b* and dehydrogenase subunit 4 genes. Maximum

likelihood and Bayesian trees using MEGA and MrBayes show greater genetic divergence within this species than previously recognized. With additional study some of the more divergent groups may be recognized as new taxa.

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

Page Vick and Sehr Shaikh
Faculty Mentor: Ginny Adams

Natural gas development has increased by 65% since 1998 due to hydraulic fracturing or fracking (Entrekin et al. 2011). Fracking is more damaging than drilling for natural gas because it uses highly pressurized water, sediment, and chemical additives. Fracking began in Arkansas in Johnson County in 2001 with two wells, and fracking has escalated to 481 active wells as of October 2008 (Arthur et al. 2008). Hydraulic fracturing has the potential of polluting streams with sediment and toxins from the flowback water. Fracking may affect the spawning and development of the slender madtom, *Noturus exilis*. Females begin to spawn in early April and are in breeding condition in late July. The mature oocytes of *N. exilis* are "large, yolk-filled, spherical and orange"; small, clear or white oocytes are immature (Mayden and Burr 1981). The greatest threat to madtom conservation is habitat destruction (Banks et al. 2002). The objectives of this study are to observe the life history of *N. exilis* in central Arkansas streams and to observe the impact of hydraulic fracturing on the life history *N. exilis*. The madtoms will be collected from central Arkansas streams in the Fayetteville shale, where gas well drilling is taking place. *Noturus exilis* will be collected using an electroshocking backpack and placed in formalin. The fish will be dissected and their gonads observed for maturity. The slender madtoms collected in 2011 are close to being mature or are mature in June samples. It is important to study the impact of fracking on the environment. Hydraulic fracturing alters habitat, which in turn reduces the population and number of species in the area. This will result in a loss of biodiversity. Studying the impacts of fracking will help to reduce this loss.

Stomate size variation in diploid and tetraploid fleabanes (*Erigeron annuus*; Asteraceae)

Jennifer Wagner
Faculty Mentor: Richard Noyes

Unlike animals, many plant species include both diploid and polyploid individuals. Previous research has shown that cell size is positively correlated with ploidal level. This has been shown to be particularly true for the size of the stomates, i.e., the specialized paired cells on the surfaces of leaves that allow for gas exchange. In this study we examined stomate size in diploid and tetraploid *Erigeron annuus*. All plants studied are progeny from a single asexually producing tetraploid (2n=36) plant that has the ability to produce occasional haplodiploid (2n=18) progeny. Stomate impressions were obtained using a fingernail polish peel technique, viewed at 400X, and measured using computer software. Stomata area and density were measured for ten genotypes for both diploids and tetraploids (24 stomate measures per leaf surface), with measures obtained

from both adaxial (upper) and abaxial (lower) leaf surfaces. Patterns of variability were complex with size and density differences both between the upper and lower leaf surfaces of individual plants as well as between diploid and tetraploid plants.

Understanding The Mechanism Of Mitofusin 2 And Dynamin Related Protein 1 Associated Neuropathies.

Wei Xia
Faculty Mentor: Bhupinder P. S. Vohra

Mitofusin 2 (MFN2) mutations cause a severe neurological disorder called Charcot-Marie-Tooth type 2A (CMT2A), sometimes additional features such as optic atrophy, hearing loss, upper motor neuron signs and cerebral white-matter abnormalities are also associated with this disorder. We have modeled human neuropathy by expressing human disease associated form of MFN2 (R94Q) in cultured dorsal root ganglion neurons. Expression of MFN2 (R94Q) induced mitochondrial structural alterations in neuronal cell bodies and proximal **axons.** Our data suggests that long-term expression of MFN2 mutants and metabolic stress by inhibition of glycolysis in MFN2 (R94Q)-expressing neurons cause widespread degeneration of axons which precedes neuronal cell death. In other set of experiments we found that expression of dominant negative form of Dynamin related protein 1 (DN-DRP1) in DRG neurons results in **extensive axonal degeneration**. DRP1 is involved in mitochondrial fusion, and mutation in the DRP1 cause a syndrome with encephalopathy and optic atrophy. Overexpression of nicotinamide mononucleotide adenylyltransferase (**Nmnat**) is known to protect axons from a variety of insults. Since axon degeneration is the major component of CMT2A associated pathological conditions, we overexpressed Nmnat in MFN2 (R94Q) and DN-DRP 1expressing neurons and discovered that Nmnat can block the neurodegeneration caused by both MFN2 (R94Q) and DN-DRP1. Our data suggests the therapeutic potential of Nmnat in neuropathies associated with mitochondrial dynamics.

The Effect of Dams on the Upstream Movement of American Eels in the Mississippi River Basin

Casey Cox
Faculty Mentors: Reid Adams, Ginny Adams, Lindsey Lewis, and Jeff Quinn

Abstract: Dams are well known to affect river ecosystems. Their effect is arguably most notable to fishes that undergo a migration in order to complete their life cycle. The American Eel *(Anguilla rostrata)* is a species that spends the majority of its life (20-40 years) occupying inland rivers, but relies on a migration to ancestral breeding grounds in the Sargasso Sea (Atlantic Ocean near Bermuda) to reproduce. Once mature eels reach the Sargasso Sea and spawn they will die. Eggs produced from the spawn hatch into leptocephalus larvae, which drift on ocean currents toward estuaries and ultimately back into inland rivers. The American Eel has experienced a drastic decline from its historical populations due to the construction of dams, which block migrations. Free passage into and out of inland river systems is paramount to the success of the species. We

plan to gather longitudinal population data from multiple rivers in the state and observe the upstream movement of young eels at select dams on the lower Arkansas and White Rivers. The goal of this study is to assess the effect of certain dams in the Mississippi River drainage system on the upstream movement of the American Eel.

Nursery habitat function of small, low-order tributaries: An often overlooked feature of river-floodplain ecosystems.

Chris Naus
Faculty Mentors: Reid Adams and Lindsey Lewis

Floodplain habitats have been shown to provide important spawning and nursery habitat (e.g, oxbow lakes, backwater, and seasonally inundated floodplain); however, little attention has been directed specifically to the function of low-order floodplain tributaries that are seemingly undervalued. Despite their visual resemblance to drainage ditches, lowland, floodplain tributaries provide permanent access to seasonally inundated habitat important for spawning. Similar to oxbow lakes, floodplain tributaries may provide low velocity habitat conducive to growth and development of floodplain resident fishes and migratory fishes prior to recruitment to the main channel. From 2007 to 2011 three first to second-order lowland tributaries of the Fourche LaFave River, AR (Caney Creek (CC), Lawson Creek (LC), and West Fork Mill Creek (WFM)) were sampled for richness and abundance of young-of-year (YOY) fish species (CC 2007, LC 2007 and 2008, and WFM 2007, 2008, and 2011). Each sampling event was comprised of 3-4 seine hauls per stream section (upper, middle, and lower) and 1-2 overnight mini-fyke net sets per section. Sampling was undertaken to monitor post spawn species richness and abundance and analyze trends across years of varying hydrologic conditions. Across all years, tributaries, and gear types, approximately 42 YOY species were collected. The young-of-year fish fauna among tributaries was very diverse containing ecologically important fishes (*Dorosoma petenense* and *D. cepedianum*), recreationally important fishes (*Lepomis macrochirus*, *L. gulosus* and *Micropterus salmoides*), and species of conservation concern (*Atractosteus spatula, Etheostoma fusiforme,* and *Erimyzon sucetta*). West Fork Mill Creek was the only tributary sampled in all three years; YOY assemblage composition at this site differed across years with different flooding regimes. Abundant YOY fishes corresponded to coupling of flooding with optimal spawning times of resident and migratory species. Preliminary analysis has shown these low-order tributaries are important fish nurseries containing diverse YOY fish assemblages, necessitating further investigation.

Chemistry

Radiocarbon dating rock art using a multi-sample plasma oxidation system

Lennon Bates, Casey Thurber, Jeremy Mackey, and Josh Loewen
Faculty Mentor: Karen L. Steelman

Our laboratory designed, built, and utilized a multi-sample plasma oxidation system in order to radiocarbon date over 50 rock art samples collected along the Canning Stock Route in Australia. Being able to process multiple samples at once significantly increased productivity. Each sample was pretreated with dilute base to remove humic acids prior to oxidation in a glow discharge. Collected carbon dioxide was analyzed using accelerator mass spectrometry. Results range from modern to 5000 years BP. In addition to supplementing the current archaeological record, these radiocarbon ages have assisted the Martu aboriginal community in implementing sustainable tourism in the Martu Native Title Claim area.

Color Chemistry as a Theme for Chemical Education: Lessons from Natural Dyes and Dyeing

Mishal Benson
Faculty Mentor: Richard M. Tarkka

Over the past two years, we have been implementing new and modified laboratory experiments into the organic chemistry sequence. These experiments better reflect the principles of green chemistry and sustainability. In pursuit of this work, I have been studying the properties of natural dyes extracted from native Arkansas plants, specifically goldenrod, sumac, elderberry, and pokeberry. Those properties include color, solvent interactions, mordant effects, and dye fastness as a function of the structure of both dye and the media to which is it applied. Though none of the dyes were fully characterized, much could be deduced from effects investigated based on chemical principles of intermolecular interactions. Color chemistry as a whole draws from many areas of chemistry and between the sciences for a truly interdisciplinary focus of study.

Optimization of supercritical extraction conditions to remove humic acid contamination from archaeological materials for radiocarbon dating

Jonathan M. Bishop and Ashley A. McKinney
Faculty Mentor: Karen L. Steelman and Robert F. Mauldin

In order to evaluate the potential of supercritical fluid extraction for the removal of humic acid contamination prior to plasma oxidation and radiocarbon dating, we conducted a gravimetric study on pure humic acid standards in order to optimize experimental conditions. Synthetic mixtures of known-age charcoal and humic substances were extracted with neat supercritical carbon dioxide, as well as co-solvent modified supercritical carbon dioxide to determine the extent to which contaminating substances were removed. Experimental variables included the use of a co-solvent (modifier), extraction temperature, and extraction pressure. Utilization of supercritical fluid extraction for sample pretreatment would allow archaeological samples to be radiocarbon dated non-destructively.

Determination of Excited State Ni^+ Production in Sputtering Glow Discharges Using Diagnostic Thermometer Reactions

Casey A. Cameron, Kendall G. Fancher, and Li Chen Chen
Faculty Mentor: William S. Taylor

The gas-phase reactions of ground and excited state Ni^+ with CH_3X and CF_3X (X=Cl, Br, I) were examined in a selected ion drift cell apparatus. Ni^+ was prepared in a sputtering glow discharge utilizing either Ne and Ar as the working gas. State-specific product formation was determined using electron state chromatography. These experiments have revealed that under near-thermal conditions, $Ni^+(^2D)$ (the ground state) produces association products exclusively while certain Ni^+ excited states can abstract X to form NiX^+. While several Ni^+ states may be present during these reactions, overall energetic and spin requirements limit production of NiX^+ to excited doublet states. Ni^+ states with sufficient energy can also participate in charge-transfer with all four neutrals. Thus, observation of either charge-transfer or halogen abstraction is an indication of the presence of specific excited states. Product formation resulting from Ni^+ produced in Ar and Ne discharges suggest that excited state Ni^+ distributions are not the same in the two discharge gases. In addition, kinetic measurements suggest the presence of one or more unreactive excited states.

Identification markers between ACT scores and passing rates in freshman level chemistry courses

Taylor Caston, Yen Le, and Taylor Quattlebaum
Faculty Mentor: Faith Yarberry

To enhance the probability of student success rates for freshman chemistry courses, we identified minimum ACT scores correlating to pass rates for the courses. Five years of data were analyzed and the results suggest that the math ACT score is a better marker of success in freshman chemistry classes than the overall ACT score. The ultimate goal of the project is to provide advisors with fact base data that leads to better advising practices and in the end to fewer students withdrawing and failing freshman chemistry classes. Improved success rates should lead to lower attrition rates due to probation and frustration.

Impact of gold and silver nanostructures on adsorption characteristics of benzamide and its derivatives

TsungYen Chen
Faculty Mentor: Donald Perry

The impact of gold and silver nanostructures on adsorption properties of benzamide and its derivatives in both the monolayer and multilayers are studied with a combination of surface-enhanced Raman spectroscopy (SERS), surface-enhanced infrared absorption (SEIRA) spectroscopy, and density functional theory (DFT) calculation. Solvents used for deposition include acetone, methanol, CCl_4, cyclohexane, and *n*-heptane. Investigation has shown that the adsorption characteristics vary with different deposition solvents and metal nanostructures. Experimentation with brominated and N-methylated benzamide derivatives revealed identical observations. Explanations for these phenomena include solvent incorporation, effects of solvent polarity and degrees of solvation during deposition, and surface-induced catalysis. This work has impacts in many interdisciplinary fields such as biophysical chemistry, environmental chemistry, and biomedical technology where immunoassays, organic and biosensors, and nanometallic carriers are important.

LiTp* in Ligand Synthesis and Complexes

Elisabeth Collins
Faculty Mentors: Richard M. Tarkka and Patrick J. Desrochers

Our previous work showed that in KTp*(a compound that of the scorpionate class), one of three equivalent pyrazole rings - all of which are attached to a central boron atom - can be replaced with a benzotriazole ring. The goal of this study is to determine the generality of this metathesis reaction. The variables being 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. The compounds are characterized by converting them to stable derivatives of nickel. My study confirms that the reaction of LiTp* with 1,2,3-triazole in toluene works well, yielding two stable and easily separable isomers of the form L_2Ni. Reaction in toluene of LiTp* with 1,2,4-triazole, followed by conversion to a nickel complex, gave an intractable solid that proved difficult to characterize. The reaction with 2-mercapto-1-methylimidazole is currently being investigated. Preliminary results are encouraging. The compounds have been characterized with a variety of NMR techniques as well as infrared spectroscopy.

Synthesis of Selenium-Containing Amino Acids

Claire Desrochers, W. Ryan Parker, and Jordan Wilkerson
Faculty Mentor: K. Nolan Carter

Free radicals are important intermediates in the damage of biological molecules such as proteins. There is evidence that protein radicals can transfer damage to DNA, a process which could 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 amino acid derivatives that contain 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. The synthesis for one such amino acid radical precursor is currently being optimized. Furthermore, work is currently underway toward the synthesis of other selenium-containing derivatives of the amino acids phenylalanine and valine. These compounds are being prepared from reductive amination of the corresponding a-oxoesters.

Effect of Troglitazone on Retinoic Acid Metabolism, Cellular Adhesion, and Proliferation in Human K562 Cells

Jessica Gamble and Venusa Phomakay
Faculty Mentor: Melissa Kelley

Retinoids, are essential for many critical life processes including cellular adhesion, proliferation, and immune function. Within immune cells, adhesion and proliferation are impacted by oxidative metabolites of retinol. All-*trans*-retinoic acid (*t*-RA) and 9-*cis*-retinoic acid (9-*cis*-RA) serve as ligands for retinoic acid receptors (RAR) and retinoid X receptors (RXR) that are involved in regulating immune function by impacting cellular adhesion and proliferation. These receptors form heterodimeric partners with other receptors including peroxisome proliferators-activated receptor gamma (PPARγ). In the current study, we examined *t*-RA metabolism in presence or absence of troglitazone in the human pro-red blood cell line K562. Retinoid metabolites were profiled using liquid-liquid extraction and reverse-phase HPLC with photodiode array detection. Additionally, proliferation and cellular adhesion assays were performed with K562 cells treated

with troglitazone, *t*-RA, or troglitazone and *t*-RA. Our data suggests that troglitazone increases retinoid availability within this cell line and modulates cellular proliferation and adhesion.

Cation-induced Phosphate Collapse Is Correlated to DNA Bending In Protein/DNA Complexes

Bryce Grant
Faculty Mentor: Lori Isom

DNA flexibility is crucial in many biological functions including protein/DNA recognition, gene transcription, and DNA packaging inside the cell. This project involves the investigation of the relationship between cation-induced phosphate collapse and DNA bending. Phosphate crowding around high density cationic protein residues in protein/DNA complexes was considered. In this project, crystal structures of protein/DNA complexes with resolution of 2.5Å or higher were selected from the PDB. Structures containing DNA breaks and modified bases were excluded. Each structure matching the criteria was then analyzed and assigned two crowding functions: one that reflected each phosphate's collapse with respect to other phosphates and one reflecting the cation density around each ion. These values were then be analyzed for correlation between cation density and phosphate collapse. The resulting correlation values are then be compared to the type of DNA distortion present in the complex.

Determination of fatty acid composition in ancient paints

Elana Huelle and Derek Watts
Faculty Mentor: Karen L. Steelman

To identify organic binders and/or vehicles added to ancient paint in cave paintings, gas and liquid chromatography were utilized. One theory is that Texas cave paints were made with iron oxides, deer bone marrow, and yucca root. We mixed these materials to make modern paint samples in order to mimic ancient paint. The modern paint samples were subjected to acid-base-acid, base only, and no pretreatment washes to simulate sample preparation for radiocarbon dating. Afterwards, fatty acids were extracted and analyzed using gas and liquid chromatography techniques with mass spectrometric detection. Derivatization of the fatty acids was necessary for gas chromatography. The results of these experiments suggest that pretreatment and derivatization do affect measured values of organic binders and/or vehicles. Identification of organic material in paint samples will increase confidence in radiocarbon results, as well as highlight the use of technology and natural resources by ancient cultures.

Supercritical fluid extraction of archaeological artifacts prior to radiocarbon dating

Vivian Huynh and Amanda B. Wallace
Faculty Mentors: Karen L. Steelman and Robert F. Mauldin

Supercritical fluid extraction employing high-pressure carbon dioxide and methanol was explored to remove humic acid contamination from archaeological artifacts prior to plasma oxidation and accelerator mass spectrometry radiocarbon dating. Archeological sample matrices used in this study included charcoal, fibers, seeds, and macroflora. We varied experimental conditions, including pressure, temperature, and percent methanol modifier – the latter acting as a co-solvent to increase the polarity of the extraction fluid. Radiocarbon dating results after supercritical fluid extraction and traditional pretreatment methods were compared to evaluate the efficacy of supercritical fluid pretreatment. Utilization of supercritical fluid extraction as a pretreatment step could contribute significantly to radiocarbon dating of archaeological samples in a non-destructive manner.

Near-Thermal Reactions of $Au^+(^1S,^3D)$ with CH_3X (X=F,Cl)

Cullen C. Matthews, Ashley J. Hicks, Kendall G. Fancher, and Li Chen Chen
Faculty Mentor: William S. Taylor

Reactions of $Au^+(^1S)$ and $Au^+(^3D)$ with CH_3F and CH_3Cl have been carried out in a drift cell at both room temperature and reduced temperatures at a pressure of 3.5 torr. $Au^+(^1S)$ is observed to yield an association product in addition to $AuCH_2^+$ in parallel steps with both neutrals. Reaction of $Au^+(^3D)$ with CH_3F also results in HF elimination, which in this case is thought to produce $^3AuCH_2^+$. With CH_3Cl, $Au^+(^3D)$ reacts to form $AuCH_3^+$ and CH_3Cl^+ in parallel steps. An additional product channel initiated by $Au^+(^3D)$ is also observed with both methyl halides which yields CH_2X^+ as a higher-order product. Product distributions were determined for association vs. HX elimination to be 79% association/21% HX elimination for X=F and 50% association/50% HX elimination when x=Cl. The observed two body rate constants were below the ADO limit for all reactions except for CH_3Cl with $Au^+(^1S)$.

Polymerization of acetylenes Catalyzed by [Hydridotris(pyrazolyl)borato]rhodium(I) Complexes

German R. Perez
Faculty Mentors: Richard M. Tarkka and Patrick J. Desrochers

Our previous work showed that in KTp*(a compound that of the scorpionate class), one of three equivalent pyrazole rings - all of which are attached to a central boron atom - can be replaced with a benzotriazole ring. The new scorpionate is called Tp'. The goal of this study is to determine what effect, if any, that structural change has on the ability of rhodium-scorpionate complexes to catalyze reactions. It is known that Rh(I) tris(3,5-dimethyl-pyrazolyl)borate - Tp*Rh(cod) - catalyzes the polymerization of phenylacetylene. The effectiveness of Tp'Rh(cod) in polymerizing phenylacetylene was thus evaluated and compared to the effectiveness of Tp*Rh(cod) in catalyzing the same reaction. The reactions were monitored by ^{1}H- NMR spectroscopy and the products were characterized by gel permeation chromatography. Current studies focus on the polymerization of substituted phenylacetylene derivatives to help understand the mechanism of the reaction.

Formation of gold nanoparticles and nanorods for applications in SERS and SEIRA

Katie Primm
Faculty Mentor: Donald Perry

The goal of this research was to develop the best gold nanostructures for applications in surface-enhanced Raman spectroscopy (SERS) and surface-enhanced infrared absorption spectroscopy (SEIRA). Various nanostructures were formed by evaporating gold in vacuum onto CaF_2 substrates at deposition angles ranging from incident to 85°. 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, and a rhodamine-6G monolayer was used to ascertain the SERS enhancement. SEIRA enhancement factors of x20-50 were obtained from metal nanostructures formed by the evaporation of 5-7 nm of gold at incident angle. Gold nanorods aggregated during formation at grazing angles and did not yield larger enhancement factors. This work will influence a range of biological, medical, catalytic, environmental, and nanotechnological applications.

Solute-solvent induced halogen bonding by silver nanostructures

Jenna Shamburger, Reece Borchers, TsungYen Chen, Taylor Razer, and Katie Primm
Faculty Mentor: Donald Perry

We offer evidence for halogen bonding induced by silver nanoparticles (SNPs) in a multilayer containing 4-iodobenzoate ion (4IBI) and CCl_4. SERS experiments show in the monolayer that CCl_4 does not adsorb and 4-iodobenzoic acid (4IBA) adsorbs as 4IBI. SEIRA experiments reveal that 4IBI forms in the multilayer during deposition from CCl_4 on SNPs. Further infrared experiments on clean BaF_2 prove that 4IBI formation caused by underlying SNPs was necessary for CCl_4 inclusion in a 4IBI multilayer. Scenarios involving intermolecular attraction between CCl_4 and 4IBI are proposed to explain the results. Although halogen bonding involving solvents has been theoretically and experimentally demonstrated in solution phase chemistry, in bulk crystals, and at the monolayer level, here it is shown that halogen bonding interactions can be significant in multilayer films. Results from this work will impact a range of applications where halogen bonding in thin films and nucleation chemistry are important.

A Computational Exploration of Mechanisms for σ-Bond Activation in the Reactions of $Au^+(^1S)$ with CF_3X (X=Cl, Br)

Benjamin K. Ward
Faculty Mentor: William S. Taylor

The ability to activate sigma bonds is one of the most interesting characteristics of transition metals. Here, the reactions of $Au^+(^1S)$ with several fluorinated methane analogs have been examined computationally using density functional methods. Optimized molecular geometries were located for intermediates and transition states which occur on reaction pathways resulting in both abstraction and elimination products. This level of theory predicts that with CF_3Br, product channels resulting in both Br^- abstraction and BrF elimination proceed via the expected activation of the C-Br bond; however, a stationary point resulting from C-F bond activation was also located with this neutral. C-F bond activation also leads to Br^- abstraction. Surprisingly, no stable intermediate was found as a result of C-Cl bond activation in CF_3Cl. Rather, all bimolecular product channels with this neutral proceed via activation of the substantially stronger C-F bond.

Increasing visibility on campus: Recruiting and maintaining motivated members

Jordan Wilkerson, Katie Primm, Amanda Wallace, Ashley McKinney, and Venusa Phomakay
Faculty Mentors: Kristin Dooley, Karen L. Steelman, and Faith Yarberry.

Visibility and excitement in the University of Central Arkansas' American Chemical Society student chapter has resulted from expanding our profile on campus and in the community. This has been

accomplished by increasing outreach activities. A key aspect to making our outreach more prominent is increasing recruitment while maintaining a high level of motivation and participation in our current membership. Our student chapter is a registered student organization on campus. We have participated in new on-campus events, community events, and social events. Bi-weekly meetings have been enhanced by chemical demonstrations and door prizes. Our chapter has seen a significant increase in membership activity at chapter meetings and all events.

Computer Science

A CUDA Approach: Revisiting CInDeR Collision and Interference Detection

Aaron Crawford, Cody Hudson, and Doguscan Sozeri
Faculty Mentor: Sinan Kockara

In the realm of simulated environments and graphical rendering, one of the more prominent bottlenecks is collision detection. Recognizing the excessive power of new Graphical Processing Unit (GPU) hardware, many proposed GPU-based solutions to this bottleneck have been produced, such as CULLIDE and CInDeR. Collision and Interference Detection in Real-time, or CInDeR, utilizes pure OpenGL calls on the GPU to implement virtual ray-casting from the edges of objects rendered in a given scene to detect collisions. The number of faces the virtual ray passes through is counted, such that an even number suggests a ray has penetrated an object completely. An odd count suggests that a ray was cast from within another object, which can only be true if a collision has occurred. The colliding objects' IDs are encoded in the color buffer provided by OpenGL and read back to the CPU. Granted this, this research specifically tackles the problems inherent in the original implementation of CInDeR, which include GPU to CPU communication overhead, as well as self-collision noise occluding true collisions. This research aims to solve these, respectively, with a CUDA implementation of CInDeR and self-collision detection and removal before writing the objects' IDs to the color buffer. The results of our implementation of CInDeR will be compared to other proposed solutions to these problems, respectively lossy data compression using texture mipmapping and post-processing filtering of self-collisions. The results will show that both logically and explicitly, our implementation produces more efficient and accurate results than the alternative solutions

Fuzzy Greedy k-Means Decision Forest Model for Protein Local Tertiary Structure Prediction

Aaron Crawford, Cody Hudson, and Minwoo Kim
Faculty Mentor: Bernard Chen

Increasingly, cheap, accurate, and quickly generated protein structure information is becoming a major topic in research, with a wide range of implications for next generation drug design and genomic research. Current wet-lab techniques include x-ray crystallography and NMR spectroscopy, but these are often time consuming and expensive. In response, countless algorithms have been produced to predict protein structure given auxiliary information about the unknown protein, often working on a global scale in regards to the overall protein structure. The algorithm proposed in this work, the Fuzzy Greedy k-Means Decision Forest Model (FGK-DF)

produces *local* tertiary structure based solely on the amino acid sequence of an unknown protein segment. The model utilizes sequential motifs conserved beyond protein homologies to generate clusters of a given training set to begin building the model. Decision trees are then trained on each cluster, incorporating secondary structure information to refine and further extract the sequential motifs present in the clusters. These decision trees then can decide if an unknown protein segment is a member of a cluster. If it is, the structure of the unknown protein is predicted to be the average structure of the cluster. As this model produces predictions at a local scale based on similarity measures that transcend protein family boundaries, the FGK-DF model can be applied to a greater range of unknown proteins than other conventional approaches. This research not only steps through this process and logic, but also shows the results in predicting over a half million protein segments using the FGK-DF model in terms of accuracy and coverage.

Developing A Fetal Disorder Diagnosis System

Aaron Crawford, Karen Gilmer, Travis Jones, and Chase Mitchell
Faculty Mentor: Victor Sheng

The purpose of this research project was to develop a system for predicting neurological and growth disorders among fetuses. The data used is attributed to the University of Arkansas for Medical Sciences (UAMS) and the novel application of their SQUID array for reproductive assessment, or SARA system. For ease of use in various algorithms, incoming data pertaining to gestation week, stimulus application, and heart rates was stored in the attribute-relation file format (ARFF). Converting this data required manipulation of the provided cardiac cycles as well as filtering of erroneous data. Using the Waikato Environment for Knowledge Analysis (WEKA), this data was run through many widely used algorithms to set a benchmark for prediction accuracy. Though the decision table algorithm found using WEKA produced 77% prediction accuracy, an algorithm specifically designed for time series data, Dynamic Time Warping (DTW), was implemented. DTW was used to match similar patterns found in fetal heart rates in a nonlinear way and thus revealed hidden similarities. Early results yielded a prediction accuracy of 55%, which is quite high for non-discretized data. The system developed shows great promise for predicting high-risk pregnancies while being adaptable for many medical purposes.

Obtaining Meaning from Low Quality Multiple Label Data

Aaron Crawford and Minwoo Kim
Faculty Mentor: Victor Sheng

The purpose of this research project was to discern meaning from multiple-label, low quality datum in order to extract expert results. The data used is in the form of movie ratings collected from any willing participant in an online survey. Using this test case represents a perfect opportunity for reaping meaningful information from a set of data containing large ranges of results that could contain significant amounts of noise. To better utilize algorithms, the data was formatted to show submitted results sorted by each film. The multiple labels given as ratings, a value ranging from 1 to 5, were then converted to a binary value for use in classification

algorithms. Using the Waikato Environment for Knowledge Analysis (WEKA), this data was run through classification algorithms including: Naïve Bayesian, Support Vector Machine, Decision Table, and the J48 Decision Tree. The Naïve Bayesian results gave an initial accuracy of 58%. By adding weights to the original binary conversion methods, we were able to achieve accuracies of over 80%. This shows that meaningful results can be obtained from cheap noisy multiple label data sources.

Fractal Methods as a Prognostic Factor To Determine Malignancy in Dermoscopy

Muhyeddin Ercan
Faculty Mentor: Sinan Kockara

One of the leading cancers in the world is melanoma. In the United States, melanoma is the fifth most common malignancy. Dermoscopy is a prevalent method used in diagnosis of melanoma. Melanoma could be cured by a simple excision operation if detected early. Dermatologists draw lesion borders by manually or they use some automated assessment tools for dermoscopic images. Shape features of lesion borders are believed to be important to characterize dermoscopy images. We believe that fractal properties of skin lesions may have prognostic importance. Therefore, primary objective of this study is to investigate importance of fractal dimensions for lesions as a prognostic factor. Fractal dimension is a parameter that measures irregularities. It is a quantity which spatially measures self-similarity in the number of disjoint regions that the dataset can be divided into. Fractal dimension gives statistically sound combined information about the spatial distribution of lesion, volumetric content, and bulk density. In this study, we use seven different fractal dimension calculation methods for 100 dermoscopy image dataset in which lesion borders are determined by a dermatologist and two automated methods. These set of lesions' fractal dimensions are calculated by seven fractal dimension methods. The purpose of this study is two-fold. First is to find which fractal dimension calculation is more accurate for dermoscopy. Second is to realize importance of fractal dimension to determine malignancy of a skin lesion.

Incremental Learning for Multi-label Classification

Cody Hudson
Faculty Mentor: Victor Sheng

Multi-label classification, a relatively new and underdeveloped area of research in data mining and machine learning, is becoming an increasingly important topic as a larger quantity of modern applications (spanning protein analysis to music categorization) require it. Proposed solutions exist but often fail to account for the relationships that can exist between the component labels. This research proposes an ensemble approach that incrementally treats each preceding label as an additional attribute to train for the next label in the multi-label set. This creates a prediction for each label in the multi-label set, for each data member in the testing set. As this per-label learning does account for the relationship that exist between labels, the order in which labels are treated as

attributes has a notable impact on the results. To reduce the inherent randomness of this effect, the proposed solution uses a large number of the possible permutations of the multi-label set, using majority voting on the final predictions to produce the final label values for the testing set. To compare its effectiveness, the results of running this approach on several datasets are compared with a similar ensemble approach, RAKEL, which uses random powersets to train its model. The results show that our proposed solution performs more effectively than the RAKEL algorithm.

Classification with Latent Information from Repeated noisy Labels

W. Ryan Parker, James Lemon, and Aravind Kiran Kumar
Faculty Mentor: Victor Sheng

Advancement in technology has created an increase in storage capacity, which in turn means data can run into hundreds of terabytes. Assigning labels to such immense amount of data is a very tedious process. Crowd sourcing systems provide facilities for obtaining these labels. However crowd sourcing leads to non-expert or imperfect labels that disagree with each other. Thus we need to study how to utilize these noisy labels. Existing classification algorithms are designed to deal with single labels and hence we need to integrate the repeated noisy labels into one single label. Instead of using conventional methods such as Majority Voting, we propose to extend the majority voting strategy with certainty estimations, using Laplace's Correction and M-estimation. In addition, we will also identify latent features from the repeated noisy labels to augment original datasets. We can expect the latent features improve the performance of learning algorithms. We will empirically investigate which performs better among these novel strategies.

GPU-Based Structural Clustering Algorithm for Networks

Thomas Ryan Stovall and Recep Avci
Faculty Mentor: Sinan Kockara

In many fields, complex networks are commonly used to represent relationships among sets of entities in real systems. New community detection or clustering algorithms have brought us significant advances to discover otherwise hidden knowledge. Detecting communities in real systems has great importance in different fields from sociology, biology, to computer science. The Structural Clustering Algorithm for Networks (SCAN) is a fast and efficient clustering technique for finding hidden communities and isolating hub and outlier nodes within a network. However, for very large networks, it still takes considerable amount of time. With the introduction of the Compute Unified Device Architecture (CUDA) by Nvidia, the scientific community has seen an explosion in applications employing graphical processing unit acceleration. In this project, we present a CUDA based parallel implementation of SCAN, GPSCAN, where SCAN's computation steps carefully redesigned. We discuss transforming SCAN into a series of highly regular and independent operations suitable for acceleration via CUDA. Now, a large network or a batch of disjoint networks can be offloaded to the graphics processor for quick and equivalent structural

clustering. The experimental results indicate that GPSCAN generates exactly equivalent results to SCAN. Moreover, GPSCAN is considerably faster than SCAN. Depending on the dataset, this speedup can be up to 254-fold or more.

Mathematics

Emergent Modeling: Sensing to Mathematical Reasoning

Kritika Chhetri
Faculty Mentor: Jason Martin

Learning mathematics can be viewed as a human activity (Freudenthal, 1973) where a learner creates his formal mathematical knowledge himself by employing his intuitive reasoning. In this process of constructing formal knowledge, every learner has to engage in a series of mental challenges. Models are representations of problem situations at hand into various forms; graphical, symbolic, contextual, and visual, that reflect essential mathematical concepts and structures that are relevant for that situation (Heuvel-Panhuizen, 2003). Emergent modeling comprises a series of co-evolving sub-models which emerge as students reorganize their models that emerged from their informal or intuitive reasoning. While several studies on emergent modeling have been done with younger students, little research has been done with calculus students. This research aims at placing calculus students in real life problem situations and understanding the mental challenges they face and resolve while reasoning about these situations. Understanding the challenges they face and the thought processes they undergo from applying their intuition to constructing and applying more formal mathematical reasoning is important as it helps to design lessons that make sense to students, and that allow them to create their own mathematical knowledge.

Improving Gauss-Legendre Quadrature

Ezechiel Degny
Faculty Mentor: Clarence Burg

Gauss-Legendre quadrature is used in numerical approximations of integrals scaled to the interval [-1, 1], where the integrand is evaluated at one or more locations within the interval and the results are weighted together appropriately. The order of accuracy of this approximation is based on the number of locations in the interval at which the integrand is evaluated. When using one location, there are two unknown values, which are the value of the weight and the location at which the function is evaluated, resulting in second order of accuracy. In our study, we are comparing with Gauss-Legendre quadrature using two locations, which gives us four unknowns and thus, fourth order of accuracy when approximating the integral. Our goal is to improve the existing fourth order of accuracy by replacing the function value at the second location by its derivative and then approximating the value of the derivative using the existing function values. As a result, we can obtain fourth order accuracy by only using one function evaluation per interval, making this method much more computationally efficient than Guass-Legendre quadrature. Now that we have fourth order accuracy with only one function evaluation, we want to understand the

numerical process better, with the goal of developing even higher order accurate schemes using only one function evaluation.

Designing a Mathematical State-Feedback Control for the Regulation of Blood Glucose

Alex Gramling
Faculty Mentor: Weijiu Liu

In this project we propose a mathematical feedback control mechanism for the regulation of blood glucose. A system of non-linear ordinary differential equations is used to simulate the oscillating concentrations of glucose in the liver, glycogen in the liver, and glucose in the blood plasma. The controllability and observability of this system is then demonstrated before designing the feedback controller. After introducing the respective controllers, linearization techniques are employed to assess conditions for local stability of the modified system's equilibrium. By constructing the controllers appropriately the stability of the system allows for the regulation of blood glucose to a predefined level. Ultimately, these feedback controllers can be implemented in a closed-loop insulin delivery system where the current state of blood glucose is known.

Optimization Analysis Of Patient Waiting Time And Resource Utilization In An OB/GYN Clinic - A Simulation Approach

Xiaowei Hu
Faculty Mentors: R.B.Lenin

Health Care providers have faced ever-increasing pressures to deliver quality and efficient service while facing rising cost. One major measure for the quality of service is the waiting time of patients. It is necessary to make the optimal utilization of resources such as doctors, nurses and staff while minimizing patients' waiting time. We developed a computer simulation model to achieve this goal. A discrete-event simulation software package, called MedModel, is used in this study to develop the computer simulation model. The main advantage of this model is to identify optimal resource allocation and other changes to the virtual system before committing such changes to the real system.

In this work, we developed a computer simulation model for the Freeway Obstetrics/Gynecology (OB/GYN) Clinic of University of Arkansas for Medical Sciences (UAMS) to analyze different scenarios for number of resources such as nurses and staff, their working schedules, and appointment schedules of patients. The effectiveness of the simulation model is illustrated through various graphs.

Modeling Patient Flow in an Outpatient Clinic

Aaron McMoran
Faculty Mentor: R.B Lenin

The University of Arkansas for Medical Sciences (UAMS) opened a new facility on the west side of town to cater to a rising demand for appointments from obstetrics /gynecology (OB/GYN) patients. One of the goals of the clinic was to provide an efficient service while minimizing the waiting times for the patients. In order to decrease the waiting time, it is essential that the clinic optimizes patient flow and resource utilization. One approach to this problem involves creating a computer simulated model of the clinic. This approach would allow for certain changes to be made in the computer model to see if the changes would produce a more efficient system. The initial goal for this project was to successfully model the clinic, using a discrete-event simulation software called Medmodel, before the clinic was in full operation. This process involves a series of steps (problem definition, data collection, model building, verification, validation, experimentation, results, and analysis) that would allow us to successfully model the clinic. The next goal was to accurately estimate registered nurse (RN) and licensed practical nurse (LPN) hiring requirements while optimizing physician utilization and resource availability. After validating the model with data from a similar OB/GYN clinic, we were able to produce an optimal system that contained the appropriate amount of LPN's and RN's for the new clinic.

Mathematical Modeling and Numerical Simulation of Aerial and Submarine Granular Flow With Erosion

Jonathan Taylor
Faculty Mentor: Long Le

In this thesis, a Savage-Hutter type model is presented for a granular flow down an incline. It first considers conservation of mass and momentum equations, which are then scaled to generalize the problem for flows of varying sizes. Through integration, the equations are depth averaged to remove a spatial dimension for integration and calculation. The model allows for simulation of aerial flows and submarine flows. For the submarine flows, a frictional term is introduced for the interface between the flow and the water. Both settings also allow for the inclusion of erosional terms. For erosion, allowance is made for the transfer of mass from the basal domain to the flow through velocity and pressure relationships. For erosion to occur, we assume threshold values that velocity and pressure must both pass in order for erosion to occur. In numerical simulations, we explore the effects that many different parameter values have on the flow. Overall, we find that submarine flows travel with less momentum, are taller, more compacted horizontally, and experience greater shear stresses at the base. With erosional terms, more mass is introduced into the flow, and it thusly grows in height, as well as experiences greater shear stresses at the base.

Physics and Astronomy

In vivo Loss of 17β-estradiol Increase Voltage Gated Calcium Ion Channel function in Vascular Smooth Muscles

Charmain Fernando
Faculty Mentors: Brent Hill and Azida Walker

The occurrence of cardiovascular disease is dramatically higher in postmenopausal women compared with premenopausal women which suggest that the decline in plasma estrogen (17β-estradiol) after menopause is associated with the development of cardiovascular disease, the leading cause of death for women in the United States. 17β-estradiol protects against abnormal vascular tone and high blood pressure and the reduction or loss of 17β-estradiol (E2) during menopausal years is a risk factor for the development of hypertension. Studies conducted by Pratt et al. (2002), states that the development of hypertension could be mediated by an overexpression of voltage-gated Ca^{2+} (Ca_L) channels in smooth muscle cells resulting in increased Ca^{2+} influx, which in turn leads to vasoconstriction of blood vessels. Thus, the objective of our study is to determine if the *in vivo* loss of E2 will increase Ca^{2+} currents in vascular smooth muscle cells. C57BL/6 inbred female mice will be ovariectomized at 8 weeks and euthanized 4 weeks post surgery. Blood samples will be collected for E2 serum analysis. Body weights and uteri weights will be measured to compare uterus to body weight ratios. The mesenteric arteries and aorta of each mouse will be dissected and smooth muscle cells will be isolated using a collagenase solution. Whole cell Ca^{2+} currents will be measured in isolated aortic and mesenteric smooth muscle cells. We expect that the *in vivo* loss of E2 (via the ovariectomy) will increase the influx of Ca^{2+} into these cells. This study will look at how the decline in estrogen after menopause will affect Ca^{2+} influx into smooth muscle cells.
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Energy Transfer of Alpha Particles to a Copper Target with Analysis of Beta Energy Calibration*

Matthew Hankins and Niravkumar D. Patel
Faculty Mentor: Rahul Mehta

In this experiment, the transfer of energy from alpha particles to a target was studied in order to determine a relationship between target thickness and energy deposited. An ^{241}Am source was used as the alpha emitter, and a copper foil was used as the target. Various thicknesses of foil were placed between the source and the detector and the energy of the alpha particle emerging from the foil was measured. The rate of decrease in the energy of the emerging alpha particle with thickness of the copper foil (dE/dx) was calculated. From this, a relationship for the energy

transfer between the incident alpha particle and the foil could be determined. The relationship between energy deposited and foil thickness was most similar to a power law; though, when the foil is 'thin' (6 mg/cm^2 or less) the relationship behaves in a linear fashion. Additionally, the accuracy of beta energy calibration was tested in order to determine the reliability of energy calibration results. Beta emissions from a ^{137}Cs source were used to calibrate the detected energy values. Using this calibration, the energy values for the beta emissions given by a ^{207}Bi source was then measured and compared with accepted values. The average percent difference between the experimental results and the accepted values was 4.2%.

*Acknowledgements: Dr. Jerome Duggan, Dr. Duncan Weathers from University of North Texas (UNT)

A Trigger for a Helmholtz Resonator

John Lahmann
Faculty Mentors: Stephen R. Addison, William V. Slaton, and Carl K. Frederickson

With the use of a Helmholtz Resonator, our objective is to investigate wave coupling mechanisms at low frequencies. The resonator will work as an impulsive sound source which will be used to calibrate low frequency detectors. Acting as the resonator is a 2 ½' stainless steel pipe 4" in diameter closed at both ends. Using a different assortment of flanges, we have securely closed off one end of the pipe. To close off the other end we use different thicknesses of sheet aluminum which acts as a diaphragm held on by one of the flanges. To create the pulse, we pull a vacuum in the pipe to the desired pressure and trigger the resonator by puncturing the diaphragm causing it to rupture. For the pulse to be used as a calibration source, the diaphragm must be punctured so that we receive a consistent pulse each time. We have recently developed an automated triggering mechanism that gives this reliable puncture. Work to date is concentrated on testing the resonator in large rooms and analyzing the reverberation times of the pulse to discover acoustic properties of the rooms.

Electrical and Physical Properties of Micropipettes Pulled from Borosilicate Glass

Nick Martinez
Faculty Mentor: Azida Walker

The plasma membrane is one of the most important structures of the cell. Not only is the membrane the boundary between the inside and outside of the cell, it also acts as a gatekeeper regulating ion flow. Ion transport occurs at specific proteins that are embedded in the plasma membrane called ion channels. Understanding the structure and function of these channels have many applications in cellular physiology along with pharmaceutical research. The most popular method for studying ion channels is the patch clamping method. The principle of this method is to

isolate a patch of membrane electrically from an external solution and to record ionic current. This is done by pressing a glass micro pipette that is filled with an electrolyte solution against a cell and applying suction. These pipettes are usually created on site by using a micropipette puller. The geometry of the pipette along with the type of glass being used are the determining factors for what type of resistance is produced. For this study a vertical micropipette puller was used to produce borosilicate glass micropipettes by using two methods; the one-step pull (commonly used for microinjections) and the two-step pull (commonly used for patch clamping). Scanning electron microscopy technique (SEM) was used to show how the resistance varies with the tip dimensions. The data presented will compare the resistances of pipettes drawn from each method and confirm experimentally that the resistance is inversely proportional to the tip radius of the micropipette.

The Impact of Scattering in the UV on the Abundance Determination of Yttrium in Galactic Halo Stars

Tristan Odekirk
Faculty Mentor: Debra L. Burris

The goal of this research is to compare Y N-capture element abundances as calculated by different versions of the MOOG software. Originally usingMOOG as developed by Sneden (1973), Y abundances of old metal-poor galactic halo stars were calculated. Because of Yttrium's spectrum, shorter wavelengths are more prone to the effects of scattering. The same lines are therefore to be used with MOOG adapted to accommodate for scattering by Sobeck and Friel(2011). This ideally should yield better results to contribute to the search for a light N-capture process.

Moseley's Law and Gamma Ray Angular Correlation*

Jacob Teffs and Jon White
Faculty Mentor: Rahul Mehta

Moseley's Law is an empirical law determined by comparing the transition energies of electron in an element to its atomic number. This relation empirically determined the correct order of elements in the periodic table. In the experiment an x-ray source was used to fluoresce x-rays from 10 different elemental samples. In fluorescence, the incident x-ray energy excites one or more of the electrons in the sample to a higher energy orbital. In a very short time, the atom de-excites when the excited electrons transition back to a lower energy orbital and in the process they release an x-ray with energy representing the transition. These x-ray energy were measured using AMPTEK XR100SDD Superdrift detector. The energies compared well to the established values and were used to see their relationship to the atomic number. In the case of Gamma Ray Angular Correlation, a Na-22 source was placed in between two gamma ray detectors. As the Na-22 source decays, it produces an electron and a positron. The positron meets another electron and annihilates it. The conservation of angular momentum requires that 2 gamma rays must be emitted simultaneously in directions opposite from each other. This angular correlation among the 2 gamma rays was tested by using a set of two BGO detectors. One of the two detectors was

allowed to move on a semi-circle while the other one is kept fixed. The gamma rays were counted only when both detectors detected a gamma ray at the same time. The results of our measurements clearly show this angular correlation.

*Acknowledgement: for assistance from the following from University of North Texas: Mangal Dhoubadel, Venkata Kummari, Duncan Weathers, Ph.D, and Jerome Duggan, Ph.D

A Survey of Silver Abundances in Metal-Poor Galactic Halo Stars

Jacob Teffs
Faculty Mentor: Debra L. Burris

Using high resolution spectra obtained from the Keck Observatory, we calculate the abundance of Silver in a survey of 13 metal-poor halo stars. In particular, we look at two of the stronger absorption lines of silver, 3280 and 3382 angstroms. These lines reside in the UV part of the spectrum and are susceptible to several sources of scattering. We are using a new version of MOOG developed recently by Jennifer Sobeck to account for scattering that occurs in these regions. Since silver is a light n-capture element, calculating the abundance values will eventually allow a comparison of silver to other elements to find trends.

Acoustic Radiation of a Plane Circular Piston

Skipper L. Thurman
Faculty Mentor: William V. Slaton

A plane circular piston is a theoretical acoustic model used to study many practical systems including loudspeakers and organ pipes. The piston itself is modeled as a large number of individual sound sources, arranged in a plane, all oscillating and emitting sound. These many individual sound sources oscillate together as the whole plane oscillates. Phase differences between the individual sources create interference in the loudness of the sound created by the whole piston. This is because the sound from different sources on the piston must travel different distances to a given point in front of the piston. Due to this interference, sound in the area in front of the piston will be loud at some angles and quiet at other angles relative to it. These patterns of loudness and softness are called beam patterns and change depending on the frequency of the sound and the size of the speaker. In our research we are theoretically calculating the beam pattern for specific frequencies and then making experimental measurements of an actual speaker for comparison.

Roars, Moans, and Tail Flicks – Deciphering the mysteries behind tiger communication

Courtney Dunn
Faculty Mentor: William V. Slaton and the National Tiger Sanctuary

Researchers estimate tigers will become extinct within the next 20 years – leaving behind many unknowns about this keystone species. Because of this, it is important now more than ever to try to understand the complexities behind their communication. Further insight into this topic could lead to a conservation catalyst similar to what occurred for whale conservation as well as provide a means for tracking wild tigers. The purpose of this project was to identify behavioral patterns behind vocalizations as well as seek to understand the diversity of their acoustic language.

Over the span of four months, vocalizations and behaviors of one Bengal, seven Siberian-Bengal, and two Sumatran Tigers were observed at the National Tiger Sanctuary in Branson, MO. 18 unique frequency patterns were recorded amongst the individuals. These vocalizations ranged from 150Hz to over 20.29KHz with the majority of behavioral contexts relating to individuals greeting one another. Due to lower frequencies being more common, a more sensitive microphone should be used in future projects. Overall, the data reflected a complex communication system with a variety of vocalizations related to different daily behaviors.

Elemental Analysis of Hard Tissue Using EDS Spectroscopy and Measurement of the Shear Modulus†

Niravkumar D. Patel
Faculty Mentor: Rahul Mehta, Parimal Chowdhury, Michael Soulsby, and Nawab Ali

The aim of this study was to determine composition of the leg bone tissue of rats that were exposed to Hind-Limb Suspension (HLS) by tail for two weeks employing Scanning Electron Microscopy (SEM). The leg bones were cleaned of soft tissues and then were cross-sectioned, dried and sputter coated. These were placed horizontally on the stage SEM where 10- to 20 keV electron beam was incident in the vertical direction. The SEM images were obtained using a backscattered detector and a secondary electron detector. X-rays emitted from the sample during electron bombardment were measured with an Energy Dispersive Spectroscopy (EDS) feature using a Si(Li) detector with a resolution of 144 eV at 5.9 keV ($_{25}$Mn K_α x-ray). K_α- x-rays from carbon (0.283 keV), oxygen (0.523 keV), phosphorus (2.01 keV) and calcium (3.69 keV) formed the major peaks in the spectrum. Relative percentages of these elements were determined using a software that could also correct for ZAF factors namely Z(atomic number), A(X-ray absorption) and F(characteristic fluorescence). The control groups and experimental groups were analyzed on well-defined parts of the leg bones. The dead time of the detector was kept below 10%. Also measured was the mechanical stress by mean of applying a known force and measuring the bending displacement. A stress vs. strain graph was plotted, allowing us to estimate the breaking points of a leg bone for control and HLS samples. The elemental composition of bones above and below the knee was analyzed and results indicated a strong relationship between the

compositional ratios of calcium, carbon, phosphorus and oxygen with the location on the leg. The analysis of bone shows that there must be some change in the hydroxyl or phosphate group of the main compound of the bone, hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$], due to hind limb suspension.

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Interdisciplinary

High temperatures in young cotton leaves may pre-adapt plants to late season growing conditions.

Daryl Chastain, Trent Hall, and Daniel Brinker
Faculty Mentors: John Choinski, William V. Slaton, Derrick Oosterhuis, and Reid Adams

High growth temperatures have been shown to affect agricultural crops negatively through decreased photosynthesis, fruit formation and retention and increased respiration. For example, heat stress from projected increases in global temperature is expected to decrease cotton lint yield by as much as 9%. Previous research has documented increased thermotolerance and quick recovery from heat damage in young leaves, when compared to mature leaves. In our field study, young cotton leaves were less affected by high leaf temperatures than older leaves in early, open-canopy measurements. This effect disappeared after canopy closure and may be due to homogenizing microclimates formed by transpiration from nearby vegetative material and an overall decreased vapor pressure. We hypothesize that high leaf temperatures in young leaves may induce changes in leaf chemistry that can pre-adapt leaves to warmer, late-season air temperatures. This increased thermotolerance in young cotton leaves may be due to higher thylakoid membrane lipid saturation levels, which can be correlated to lower amounts of trienoic fatty acids.

(1) University of Central Arkansas, Department of Biology,(2) University of Central Arkansas, Department of Physics and Astronomy, (3) University of Arkansas, Department of Crop, Soil and Environmental Sciences

Algebra Tiles on iPad

Hai Le
Faculty Mentors: Long Le and Mark Smith

Manipulatives are objects used in teaching mathematics, mainly for hands-on activities that connect with abstract concepts. With manipulatives, students can visualize, touch, and arrange objects to form a concrete idea, or example, of a concept. Manipulatives exist in both physical (real objects) and virtual (on-line) forms. Physical manipulatives are cumbersome to carry and store, because most of them are made from small pieces. Virtual versions are convenient and allow easier access to many types of manipulatives from a computer with internet connection. However, in the situation where a computer, or internet, is not available, virtual manipulatives can be hard to access. Furthermore, virtual manipulatives do not have the hands-on, physical-interaction characteristics that the real objects do. In contrast, the tablets or slate-like digital devices can

provide both tactile characteristics and convenient access. The most widely used tablet at this time is the iPad, made by Apple. We will present an app to use one type of manipulative, called algebra tiles, for the iPad.

Drag Forces on a Cylinder due to Fluid Flow

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Drag forces impact today's mobile world. For example, the drag forces on a moving car affect the car's fuel efficiency. In this particular example, the air produces a resistance to the car which generates drag forces onto the car. In general, fluids produce drag forces on objects of varying shapes and sizes. With this in mind, the goal of this research is to create both a physical and a computational model of the drag forces on an aluminum cylinder due to airflow. An electric leaf blower was attached to one end of a 4 inch diameter PVC pipe with a soda straw flow straightener inside that creates a controlled airflow over the cylinder placed at the other end of the pipe. The cylinder was attached to a counter-balanced lever system that produces a measurable opposing torque. Analysis of the torque on the lever system gives the drag forces on the cylinder. In order to generate a range of flow velocities, a variable transformer was used to vary the voltage supplied to the leaf blower. Additionally, the leaf blower was replaced with a small cooling fan to expand the range of velocities that can be measured. The flow velocities at the location of the cylinder relative to the pipe were measured with an anemometer. Thus, the relationship between the drag forces and the flow velocities can be graphed. The collected data can, then, be compared to computer simulations of the physical model based on the incompressible Navier-Stokes flow equation.

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