The College of
Natural Sciences and Mathematics

University of Central Arkansas

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

Abstracts

The 17th Annual Student Research Poster Symposium

April 22, 2011
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 17th 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 81 abstracts with 115 student authors, 37 faculty mentors, and 9 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.

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Biology

Do crayfish-insect interactions alter leaf breakdown rates in intermittent streams?

Amanda Bates and Kasey Nix
Faculty Mentor: Sally Entrekin

Orconectes ozarkae is the dominant invertebrate in an intermittent forested stream in the Arkansas Ozarks. Crayfish are often important to leaf breakdown in forested headwaters; however, when crayfish-accessible and crayfish-exclusion leaf bags were deployed in pools and riffles, rates were faster in pools ($k=0.0051\ d^{-1}$) than riffles ($k=0.0028\ d^{-1}$) but did not differ with crayfish accessibility ($k=0.00273\ d^{-1}$ vs. exclusion: $k=0.0029\ d^{-1}$). The best predictor of breakdown rates was total number of insects ($p=0.007$, $r^2=0.73$). We predict higher crayfish density may result in lower insect density resulting in slower breakdown. We sampled invertebrates seasonally in an upstream 500m reach that flows most of the year and a 500m reach with permanent pools. We predict higher overall macroinvertebrate density in the perennial reach with fewer crayfish and lower overall macroinvertebrate density in the intermittent reach with more crayfish. We found that crayfish densities did not differ between the perennial (5.35 ± 2.05 ind./m^2) and intermittent (2.05 ± 0.47 ind./m^2) reach, but seasonal variation was substantial (range=0.12-17.42 ind./m^2). We will examine how stream permanence mediates crayfish-insect interactions and thus could alter organic matter processing.

Immunological Effects of a Nickel-Based Compound in Mice

Autumn Bewley
Faculty Mentor: Benjamin Rowley

Heavy metals have been shown to induce autoimmune responses in mice. Several drugs utilize heavy metals in their composition, including anti-cancer drugs such as cisplatin. This study examines the possibility of induction of autoimmune responses from treatment of mice with a novel nickel-based anti-cancer compound. This

compound was developed in the Chemistry Department of the University of Central Arkansas. Previous studies have shown this compound will induce cytotoxicity in MCF-7 cells, a breast cancer cell line, *in vitro*. Determining potential toxicity *in vivo* is the next logical research step for this compound. To this end, two strains of mice were treated for eight weeks by subcutaneous injection with low doses of the compound. Sera obtained at two week intervals were assayed for autoimmune response markers, including IgG1/IgE levels by ELISA and anti-nuclear/nucleolar autoantibody production by HEp-2 immunofluorescence. Heavy-metal susceptible SJL/J mice exhibited a modest autoimmune response earlier than heavy-metal resistant BALB/c mice. However, both mouse lines exhibited a time-dependent induction of autoimmunity. This could imply that long-term use of this compound in human beings may induce mild autoimmune responses dependent upon genetic background.

Analysis of Mitochondrial Fission and Fusion in D. discoideum

Jordan Bird, LaRhonda Apata, Kelly Dunning and Sarah Stark
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. Interestingly, as we describe here, our model system *Dictyostelium discoideum* has spherical mitochondria. Our goal is to determine if these spherical mitochondria also undergo fission and fusion events. Through our analysis of time-lapse confocal images we found that *D. discoideum* mitochondria do indeed undergo both fission and fusion events which occur approximately 1 event every minute.

In the future we plan to identify the proteins involved in the fission process. Review of the literature has identified a minimum of 6 proteins that play a role in mitochondrial structure. To determine if these proteins are involved in fission we will obtain knockout strains quantify fission activity.

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.

Life History Characteristics of *Mugil cephalus* in the lower Arkansas River.

Jacob Bird and Derek Finley
Faculty Mentors: Ginny Adams and Reid Adams

The Striped Mullet, *Mugil cephalus*, is a euryhaline fish that resides in oceans, estuaries, and freshwater. Once larvae reach about 35 mm in size they become juvenile and reach their osmoregulatory capabilities (Anderson 1958). Once a juvenile, the fish can move into freshwater. Spawning occurs near the continental shelf off the coast of the U.S. (Jacot 1920; Anderson 1958). *Mugil cephalus* migrate from shallow coastal areas, estuaries, and rivers to spawn in offshore marine habitats. During the spawning months (October-April), mullets have been found in the lower Arkansas River. Many of these female mullets are gravid. To try to understand why these mullets are staying in freshwater and not migrating to the ocean to spawn, we are conducting an aging and life history study. To age the mullets, we mounted and filed otoliths and examined ring deposits. Egg sizes were measured and gonadosomatic indexes were determined to get insight on their reproductive traits. Researching the age-growth characteristics along with a gonadosomatic index will allow us to determine if the mullets are migrating to the ocean, spawning in freshwater, or resorbing their gonads. An overview of our project and data collected to date will be discussed.

The effects of the protein kinases, CaMKII, PKA, and PKG, on the regulation of SERCA expression by the estrogen-receptor complex

Cristian Bratu-Ene, Stuart Sherwood, Andreya E. Reed, and Tramaine Shepard
Faculty Mentor: Brent Hill

Arterial constriction in coronary smooth muscle cells is induced by a high cytoplasmic Ca^{2+} concentration. This may limit blood flow to the heart and induce a heart attack especially if the arteries have already demonstrated atherosclerotic plaque formation. The sarcoplasmic/endoplasmic reticulum Ca^{2+} (SERCA) is known to reduce intracellular Ca^{2+} levels and relax arteries. SERCA activity was found to be increased by the protein kinases, Ca^{2+}/calmodulin-dependent kinase II (CaMKII), protein kinase G (PKG), and protein kinase A (PKA). However, it is not know if these kinases also increase the protein expression of SERCA. Our lab has previously determined that estrogen (E2) independently increases SERCA2b, PKA, PKG, and CaMKII expression. The purpose if this study is to determine if E2 increases SERCA via the protein kinases, and if this increase of SERCA expression is dependent on the formation of the E2-receptor complex. The distal portion of right coronary arteries obtained from female porcine hearts were cut into longitudinal strips and incubated for 24 hour in 1×10^{-9} M E2, 1×10^{-5} M ICI, 1×10^{-9}M E2 + 1×10^{-5} M ICI, 1×10^{-5} M

KN-93 and the vehicle solvents for E2, ICI, and KN-93. Western blot analyses suggest that the binding of E2 to its receptor is responsible for the increase in SERCA expression, and that PKG is responsible for the increase in SERCA expression, while PKA and CaMKII seem to have no effect. Identifying the E2-mediated pathway for the increase in SERCA expression is important for understanding the cardioprotective effects of E2 in women.

Life Histories of *Siren intermedia* and *Amphiuma tridactylum* in Brinkley, Arkansas

Trevin Byrd
Faculty Mentors: Ginny Adams and Reid Adams

Two of the least known aquatic salamanders found in Arkansas are the three-toed amphiuma (*Amphiuma tridactylum*) and the western-lesser siren (*Siren intermedia*). Little is known about these elusive species in relation to life history, diet and habitat use. These data gaps are important because many larger species of salamanders have experienced range declines due to habitat alteration. My research focused on determining sex ratios, total and snout-to-vent length comparisons, total masses, weight vs. length relationships, digestive somatic indexes and gonad somatic indexes of both species. Specimens were collected from streams and ditches within the Big Piney watershed in Brinkley, Arkansas during the northern snakehead *Channa argus* eradication which took place March 2009. Under Arkansas Game and Fish procedures, the salamanders were collected by hand or net after rotenone had been released into the waterways. Deceased or dying specimens were preserved in formalin and classified based on location distribution. Animals were weighed prior to and after dissection with the digestive and reproductive systems weighed separately to the nearest milligram using an analytical balance. Salamanders and contents were labeled individually for future observations with specimens categorized as being male, female or juvenile. Many adult *Amphiuma tridactylum* specimens presented hermaphroditic characteristics while those of *Siren intermedia* were strictly either male or female. Research from neighboring states has shown that *Amphiuma tridactylum* is a sexually dimorphic species. Life history data will be discussed.

Exploring the Role of Cyclin Dependent Kinase in enteric Nervous System Development

Esther Campos
Faculty Mentor: Bhupinder P. S. Vohra

The enteric nervous system (ENS) manages intestinal functions such as intestinal motility, epithelial secretion and blood flow. To carry out these functions there are diverse types of enteric neurons that express specific neurotransmitters, and have different patterns of neurite branching, electrophysiology and function. All of these neurons arise from a set of neural crest-derived precursors that migrate through the bowel, proliferate, and then differentiate into both enteric neurons and glia. When this development fails, serious problems relating to intestinal function occur such as distal intestinal aganglionosis (Hirschsprung disease, HSCR) and intestinal pseudo-obstruction syndrome. Hirschsprung disease is a common multigenic disorder with variable penetrance. Lately, it has been demonstrated that glycogen synthase kinase 3 (GSK-3) play a crucial role in many aspects of ENS precursor development in culture. For instance, blocking GSK-3 considerably slows the migration of ENS precursors through cultured gut explants. In addition, GSK-3 is decisive for both neurite growth and for neuron polarization (specifically determining axon number). These new data are fascinating since axon number typically associates with neuronal subtype and function in the ENS and has been employed to catalog enteric neurons for more than a century. Whereas the outcomes of these studies are thrilling, we must to discover more concerning the molecular mechanisms that manage polarized and directed cell migration in the developing ENS. Furthermore, it also well known that, collapsin response mediator protein 2 (CRMP2), a protein target of GSK-3β also play a vital function in ENS precursor development. Fascinatingly, GSK-3β can control the action of CRMP2 only in the circumstances when CRMP2 is phosphorylated by cyclin dependent kinase 5 (CDK5). The motive of our interest in CDK5 is that GSK-3β phosphorylation of CRMP2 necessitates "priming" phosphorylation by Cdk5 and because both GSK-3β and CRMP2 have important roles in ENS development. As a result, we hypothesize that CDK5 is necessary for ENS development and we will investigate whether altered CDK5 signaling predispose to Hirschsprung disease.

Competition and Niche Breadth Among Fishes in an Intermittent Headwater Stream

Jason Christian
Faculty Mentors: Ginny Adams and Reid Adams

Streams characterized by highly variable hydrology have fewer species of fish and these fish tend to have adaptations that enable them to temporarily move in response to changing conditions or to tolerate extremes in abiotic conditions. The headwaters of the eastern Ozark highlands contain intermittent streams that have isolated pools in the mid-reach sections and spring fed connected pools in the upper reach sections. Headwater streams in this region are classified by a fish assemblage composed mostly of cyprinids and percids. Sylamore Creek, a stream representative of many Ozark headwaters, has a community dominated by four species: *Etheostoma spectabile, Semotilus atromaculatus, Chorosomus erythrogaster,* and *Campostoma anomalum.* The objective of this study is to examine the effects of pool isolation on niche breadth and overlap within and among the species in the stream. To assess this question I will be collecting total available macro-invertebrate prey and fish for gut analysis in isolated and connected pools on a tributary of Sylamore creek. Data will be presented to show a comparison between isolated and connected pools.

Sexual Cannibalism: Can Males Cannibalized During Courtship Still Fertilize Eggs

Nick Davis and Kyle Hurley
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 still capable of attaching and apparently copulating with the female. Whether these headless males can actually transfer sperm and fertilize eggs has not been determined for any mantid species. We propose to rear ~200 mantids to sexual maturity and to videotape encounters between males and females. We have collected ten *S. carolina* egg masses from the Railroad Prairie Natural Area located near Hazen, AR. and reared the emerging mantids to the fourth instar. To grow, mantids require daily access to live prey. We have developed techniques for mass rearing fruit flies, house flies, and crickets. The mantids currently consume ~500 house flies each day. We anticipate that the mantids will reach sexual maturity in approximately one month. Males and females will then be paired together in arenas and videotaped while mating for ~24 hours. We anticipate that the heads of some males will be consumed during courtship whereas other males will survive the encounter intact. Mated females will be

provided with unlimited food. The number of eggs they produce and the number that hatch will then be recorded to determine if cannibalized males fertilize eggs as effectively as intact males.

An In-depth Look at Lignification Patterns in Blackberry and Raspberry Prickles

Jessica Fite, Kayla Hill and Ryan Finley
Faculty Mentor: J.D. Swanson

Blackberry and raspberry are in the genus *Rubus* and develop prickles, protective epidermal structures. By looking at prickle development in blackberry and raspberry plants we expect to gain insight into cell to cell communication as it relates to growth and development. We hypothesized that the way lignin was deposited in the growing prickle will differ for blackberry versus raspberry, and that PAL1 will play a greater role in the lignification process compared to PAL2. By looking specifically at lignifying stage four (mature) prickles, it is possible to discern the way in which genes are involved in the lignification process of these organs. Phenylalanine Ammonia-lyase (PAL) was of particular interest because of its involvement in the Phenylpropanoid pathway and the lignification process. Expression of PAL1 and PAL2 genes in developing *Rubus* prickles were analyzed using *in-situ* hybridization and quantitative PCR, data were linked to lignifications using a stain specific to lignin. After comparing lignin-stained tissue sections, two different expression patterns, both between genes and species, of the PAL genes were seen. PAL1 is expressed in the area of active prickle lignification and involved in the active growing process, while PAL2 is expressed more evenly throughout the prickle, suggesting involvement in maintenance after the growing process. Lignin-stained tissue sections showed that the two species of *Rubus* have different lignification patterns as well. Lignification in raspberry occurs from the outside of the prickle in, while in blackberry it occurs in a wave from the tip of the prickle to the base. Since both the expression and lignification patterns differ between raspberry and blackberry there is a possibility that there is a species difference.

Differences in Leaf Decomposition Rates and Driving Mechanisms Based on Wetland Type and Surrounding Land Use

Allyn K. Fuell
Faculty Mentor: Sally Entrekin

Leaf decomposition and associated drivers may be used to assess changes in wetland carbon cycles within altered landscapes. We quantified mass loss of green ash leaves in five flat and five riverine backwater wetlands in a forested (54%), urban (30%), and pasture (7%) dominated catchment in the Arkansas River Valley. Riverine backwater wetlands occur within the floodplain of an associated channel. Backwaters were inundated longer than isolated flats due to backwater flow from the channel. We hypothesized that backwaters would have increased microbial activity and faster decomposition rates due to longer inundation. We also predicted that wetlands surrounded by more urban land would exhibit increased decomposition rates and heterotrophic activity from runoff and more frequent wetting within a wetland type. The amount of leaf material lost was measured from zero to 84 days. After 84 days, there was no difference in leaf mass loss (20%-22%) between wetland types ($p=0.34$). After 21 days, mass loss in flats was related to heterotrophic respiration ($p<0.001$, $R^2=0.97$) while there was a weaker relationship between respiration and mass loss in backwaters ($p<0.01$, $R^2=0.12$). We will expand our analysis between microbial respiration and mass loss in flats and land use effects on the drivers of decomposition in both wetland types.

Feeding and Growth Experiments on Chironomids

Chris Fuller
Faculty Mentor: Sally Entrekin

Nutrient increases in streams and rivers, due to fertilizers and other run-off, may give a competitive advantage to some species, like chironomid insects (Order Diptera). Chironomids may be able to assimilate excess nutrients, like phosphorous, and use them for increased protein production. This increase in growth rate will allow them to competitively exclude other species and lead to low diversity. We are conducting feeding and growth experiments on chironomids related to nutrient enrichment. Pre-determined concentrations of phosphorous and excess nitrogen will be added to the water column of incubating leaf discs, which will be assimilated on the leaf bio-film. The leaf disks will then be added to feeding dishes with pre-measured chironomids. Chironomids will then be measured after feeding on the enriched food source for 10 days to determine growth rate. We predict that chironomids will be able to assimilate the excess nutrients gained from their food to increase protein production, and thus growth rate.

The Use of Ultrasonic Imaging in the Sex Determination of Alligator Gar (*Atractosteus spatula*)

Brittany A. Gates
Faculty Mentors: Ginny Adams, Reid Adams and Lindsey Lewis (FWS)

Biotic and abiotic factors continually threaten certain populations of important organisms in our ecosystems. Without adequate data on these potentially threatened and endangered species, conservation efforts are difficult. Alligator gar (*Atractosteus spatula)* is an important apex predator in American freshwater river and floodplain ecosystems, and they are a species of concern due to their rapidly declining populations. Because of the nature of gar anatomy, it is impossible to sex alligator gar in the field without harming the organism. This means that there is little data on the numbers of different sexes in any given population, making it extremely difficult to determine which populations are viable or endangered. I am determining an accurate and non-invasive method for sexing alligator gar in the field using ultrasonic imaging. This will provide the methodology needed to determine which populations are in need of protection.

Retrospective Epidemiologic Analysis of Influenza Pandemics in Arkansas

Andy Gray
Faculty Mentor: Benjamin Rowley

The purpose of this study is to compare and contrast influenza mortality in Arkansas during epidemics including: 1918 Spanish Flu, 1957, 1968, and 2009 (H1N1, aka 'swine flu'). Data from death certificates will be analyzed for possible differences in death rates by age group, gender, race, date of death, and geographic region of Arkansas. It is hypothesized that the group showing the largest number of deaths will be young adults and middle-aged individuals during the Spanish Flu and 2009 H1N1 epidemics with more deaths from the younger and elderly individuals within the other two recognized epidemics. This prediction is based on anecdotal depictions of the populations hardest hit by each epidemic-which will make it interesting to ascertain if such depictions are accurate. A secondary hypothesis predicts significantly higher mortality rates in the rural regions of Arkansas compared to the urban areas due to less access to quality healthcare. The information gathered from this study will help us better understand outbreaks of influenza and their impact on the populations of our state. This information will help health professionals tailor possible future responses to new epidemic outbreaks to where they will be most beneficial and needed to save the most lives.

Estrogen prevents voltage-gated calcium channel expression through the β3 subunit in the mouse mesentery

Ross Gray
Faculty Mentor: Brent Hill

The long-term goal of this project is to provide a new route of intervention for controlling hypertension in post-menopausal women (PMW). Hypertension incidence sharply increases after menopause, while estradiol levels decline. Hypertension is a major contributor to cardiovascular disease, which is the leading cause of death in PMW. Women, as they age, are less likely to have controlled hypertension than men despite current medical treatments. It is estimated that only 20% to 30% of treated hypertensive PMW have fully normalized blood pressure. Increased vascular tone through the upregulation of voltage-gated L-type calcium (Ca^{2+}) channels (Ca_L) is a hallmark finding in hypertensive subjects. 17β-estradiol is known to cause vasodilation by decreasing Ca^{2+} influx through Ca_L channels. Calcium channel blockers (CCBs) act on Ca_L channels to decrease resistance, while ACE inhibitors and beta blockers are also known to decrease vascular tone in hypertensive patients. Despite current treatments, hypertension is still prevalent in many treated PMW. Further research into the genomic and non-genomic mechanisms of 17β-estradiol could provide long-term hypertensive therapy to the many women with poorly controlled hypertension. We predict that 17β-estradiol acts non-genomically on the β3 subunit of the Ca_L channel. Thus preventing the shuttling and insertion of the entire Ca_L channel into the plasma membrane.

Action of trypsin-like proteases and chymotrypsin-like proteases in the axonal degeneration

Laura Gutiérrez Miranda
Faculty Mentor: Bhupinder P. S. Vohra

Axonal degeneration is a hallmark of many debilitating neurological disorders and is thought to be regulated by mechanisms distinct from those governing cell body death. Why is axonal degeneration a common element of a diverse set of neurological disorders? A favorite hypothesis is that a wide range of neuronal insults triggers a general axonal self-destruction program. In support of this hypothesis, overexpression of Wlds, or its component Nmnat, blocks degeneration in response to many distinct stimuli. The intrinsic pathways that drive degeneration are poorly understood; however calcium influx, regulated protein degradation, and JNK activation by DLK have all been implicated. A general molecular pathway

leading from the initial insult to the effectors of axonal breakdown has remained elusive. Although axonal destruction shares morphological features with apoptosis, most studies indicate that it is a caspase-independent process as manipulation of the mitochondrial apoptotic machinery or caspase inhibitors fail to block axonal degeneration. In the proposed investigation we will focus and try to understand the other possible pathways that might cause axonal degeneration. We start with the premise that axon degeneration is based in membrane fragmentation and taking into account that the membrane of the axons are made of proteins and lipids, it is logical to think that proteases and lipases could be the enzymes involved with this phenomenon. We will put our efforts in understanding the role of trypsin-like proteases and chymotrypsin-like proteases in axon degeneration.

Trafficking of Sodium Hydrogen Exchanger (NHE) in Breast Cancer Cells

Tara Havens and Zac Byars
Faculty Mentor: Steven W. Runge

Cancerous cells proliferate in a harsh tumor environment, which includes low pH (acidosis) and low oxygen concentration (hypoxia), that would be detrimental to normal cellular function. The Sodium/Hydrogen Exchanger (NHE) family of proteins plays an essential function in normal cell pH homeostasis and may be used in cancerous cells for survival in the tumor environment. Plasma membrane and whole cell protein abundance for NHE were investigated. MCF-7 cells were treated for 48 hours under either hypoxic (1% O_2) or normoxic conditions in combination with media of varying pH levels, mimicking the tumor microenvironment. Protein abundance will be analyzed using immunoblotting techniques. We hypothesized that under hypoxic and acidic conditions, whole cell and plasma membrane NHE1and NHE 3 will decrease and NHE2 will be upregulated in response to acidic and hypoxic environmental stress. Previous studies have not addressed what function NHE isoforms play in a combined acidic and hypoxic environment such as found in the tumor microenvironment. Determination of NHE protein abundance on the plasma membrane and in the whole cell will provide insight into how different NHE isoforms are being utilized by cancer cells in response to acidic or hypoxic stress. Data obtained through these studies will allow us to begin to formulate a picture of how NHE1, NHE2, and NHE3 isoforms may be involved in pH regulation in solid tumors, potentially giving insight into how they play a role in cancer cell survival.

Macroinvertebrate diversity and density along a gradient of gas well densities in North-Central Arkansas

Nicki Jensen
Faculty Mentor: Sally Entrekin

Access to natural gas has increased in the Fayetteville shale play in Arkansas, resulting in a 50-fold increase in gas well density in the last five years. Few studies have addressed the effects of drilling associated with shale development on aquatic macroinvertebrates. Potential effects to stream water quality include increased turbidity and sediment runoff that could alter macroinvertebrate community structure. Macroinvertebrates were collected from pool, bedrock, and riffle habitats in 200m reaches from 11 streams within the Fayetteville shale across a gradient of well densities. Preliminary analysis of macroinvertebrates in riffle habitats indicated no correlation between taxa richness ($p=0.14$, $r=0.75$) or total macroinvertebrate density ($p=0.95$, $r=0.04$) and well density. Taxa richness ranged from 11-13 and was correlated with silt ($p=0.08$, $r=-0.83$) and sand ($p=0.09$, $r=-0.82$) percent cover. Macroinvertebrate density ranged from 1494-2800 individuals/m^2 and was not correlated with any measured habitat variables. Further analysis will assess the relationship between macroinvertebrate species traits and indicators of gas well disturbance, such as road and pipeline density, rate of well pad installation, and well distance from stream channels.

Description of a Lowland Agricultural Fish Fauna

Clint Johnson
Faculty Mentors: Ginny Adams and Reid Adams

Agricultural landscapes represent a significant contribution to biotic habitat for a variety of terrestrial and aquatic taxa worldwide, though species inhabiting these communities, factors which influence community structure, and best management practices are understudied. The northern snakehead eradication in Spring 2009 allowed an unprecedented sampling opportunity of fishes inhabiting a variety of habitats associated with row crop agriculture in eastern Arkansas. Sampling of 42 sites yielded 7,102 fishes representing a surprisingly robust fish community of 40 species, two of which (*Notropis maculatus* and *Erimyzon sucetta*) are conservation listed by Arkansas Natural Heritage Commission. Multivariate analyses of community composition separated sites into two groups: 1. small, heavily disturbed ditches with a fish fauna indicative of altered systems, and 2. ditches of varying size and wetland habitat with a fish fauna indicative of undisturbed river floodplain habitat. Separation of group 2 was significantly correlated with presence of aquatic vegetation and small wood cover. Inclusion of samples collected at a pristine wetland (Dagmar WMA) into multivariate analysis indicated similarities between

the two fish communities. These results suggest agriculture ditches can serve as surrogate wetland habitats for lowland fishes as riparian quality may override negative effects of surrounding land use.

The estrogen metabolite, 2-MeOH, induces arterial dilation by increasing BK channel expression

Constance Renee Jordan
Faculty Mentor: Brent Hill

Abnormal coronary blood flow is associated with inhibition of Ca^{2+}-activated K^+ (BK) channels and/or stimulation of voltage-gated Ca^{2+} channels. Our lab previously demonstrated that the estrogen metabolite, 2-methoxyestradiol (2-MeOH) inhibits Ca^{2+}-dependent contractions. The objective of this study was to determine if 2-MeOH can induce coronary artery relaxation via BK channels. This study used right coronary arteries from hearts obtained from female pigs. The arteries were cut into 4 mm rings to measure isometric tension in response to a depolarizing KCl solution. The rings were exposed to 2-MeOH (1x10-6 M to 1x10-4 M) or its vehicle (ethanol) in the presence and absence of the BK blocker, tetraethylammonium (TEA, 1 mM). Physiological [2-MeOH] increased the KCl-induced contraction in the presence of TEA by 2-fold. Coronary arteries were also cut into longitudinal strips to determine BK protein expression using Western blots. The strips were incubated (37°C at 5% CO_2) for 24 hrs in 2-MeOH (1x10-9 M to 1x10-6 M) or ethanol. Densitometric analyses of the blots indicate that 2-MeOH increased BK channel expression 2-fold. Data from our study indicate that physiological concentrations of 2-MeOH induce vasodilation by increasing the protein expression of the BK channel.

Does availability of refuge affect macroinvertebrate communities in intermittent Ozark streams?

Julie Kelso
Faculty Mentor: Sally Entrekin

Intermittent headwater streams comprise over 60% of total stream length in northwest Arkansas. Forested intermittent streams may play a critical role in storage and transport of organic matter and maintaining connectivity between macroinvertebrate communities in downstream perennial segments. The importance of standing benthic organic matter (BOM) and microhabitat needed as refuge from drying and flooding is not yet fully understood. We predict stream segments with more bedrock and less BOM will provide less refuge than segments

with more coarse substrata and retained BOM. Additionally, those streams with greater discharge will have greater diversity and abundance of macroinvertebrates. We sampled substrate percent cover, debris accumulation mass, coarse benthic organic matter (CBOM), fine benthic organic matter (FBOM), and macroinvertebrates in 6 intermittent streams with 90% forest cover in December 2009 that had been dry for ~6 months. Sampled streams had a gradient of bedrock (<1-49%), coarse inorganic substrata (<1-30%), and organic matter (8-627g AFDM m^{-2}). We predict macroinvertebrate communities will be dominated by taxa capable of rapid recolonization (e.g. Simuliidae), the ability to survive intermittent pools (e.g. *Caenis*), or having drought resistant eggs (e.g. *Perlesta*). We will compare macroinvertebrate community structure along a gradient of drying and varied potential refuge.

Tardigrade diversity on the campus of the University of Central Arkansas.

M. Land, Adam Musto and J. Root
Faculty Mentors: W.R. Miller [2], Jeff D. Miller [1,3], and David Starkey [1]

College campuses with established trees act as *defacto* reserves in supporting the biodiversity and protecting the habitat of microorganisms. Tardigrades are small, middle metazoan animals that typically inhabit the moss and lichen that grows on trees, rocks, or on the ground. Although contiguous states have multiple reports of the occurrence of tardigrades, only three reports have dealt with these organisms and there diversity in Arkansas. These reports are based on collections made in the northwestern and western portions of the state and, to date, no reports exist on the occurrence of these organisms in central Arkansas.
Samples of moss and lichen growing on the bark and soil at the base of trees were collected on the UCA campus in Conway, AR. Of the nine genera of tardigrades previously reported from the state, four were found in the UCA campus samples; of the 25 species previously reported, five were found in the UCA campus samples. Two species (*Milnesium eurystomum*, *Macrobiotus polyopus*) are new records for the state; two specimens of *Echiniscus* (*arctomys* group) could not be identified to species and may be new to science. This report extends the known distribution of four genera and five species of tardigrades to the middle of the state of Arkansas. Further collections are underway to determine the extent of the diversity of these organisms across the UCA campus.

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The effects of increasing turbidity on the growth rate of Hyalella azteca (Amphipod)

Adam Musto
Faculty Mentors: Sally Entrekin

Sediment runoff to streams may increase depending on composition of surrounding land use. Sediment running into streams increases turbidity (ntu), which can alter the community structure of streams. I predicted that *Hyalella azteca* (amphipod) would have a reduced growth rate as turbidity increased, because the added sediment would increase the amount of indigestible material consumed by the amphipod. Six tanks were set up, with three being clear (<3 ntu) and three with a starting turbidity between 135 and 193 ntu that slowly decreased over time. Ten *H. azteca* were placed in each tank for the duration of one week. At the conclusion of the week length and mass measurements were taken to determine possible effects that the suspended sediment had on *H. azteca.* These data will be presented at the symposium.

An examination of parasitic beetles from South America

E.N. Naglak
Faculty Mentors: Don Gettinger and David Starkey

Beetles of the genus *Amblyopinus* have been identified throughout the western hemisphere and their range is thought to extend from Mexico to Brazil. *Amblyopinus* are parasitic and were thought to be living off their rodent hosts i.e., the host's blood was often found in the stomach tissues of these beetles. However, in the mid 1980s, Timm and Ashe published a series of papers suggesting an alternative hypothesis. Rather than parasites themselves, Timm and Ashe suggested the beetles were predators and lived off of the mites that lived on the surface of Oxymycterine rodents. These results changed the hypothesis from *Amblyopinus* as ecto-parasites (external parasites) to being "ecto-predators" i.e., engaging in a relationship with the rodents where both organisms benefit by the removal of the mites (mutualism). Preliminary studies have suggested that there is a tremendous amount of host specificity among these parasitic beetles. For example, if beetles from one rodent species are removed and place upon a rodent of another species the beetles are consumed. This result suggests that each rodent species might have a unique species of parasitic beetle. To investigate this hypothesis, we have examined beetles from 2 different South American rodents. Our preliminary results suggest, based upon morphology, that each of these beetles does represent a unique species. Studies are currently underway to increase the scope of these finding by including additional data (genetic data) to confirm these results.

An examination of parasite diversity in the snapping turtle, *Chelydra serpentina*

K. Nguyen
Faculty Mentor: David Starkey

The common snapping turtle, *Chelydra serpentina*, is present in virtually every aquatic habitat that can be found throughout Arkansas. These turtles are large and can reach nearly 50cm in length and adults can weigh between 30 and 60 lbs. These turtles are primarily nocturnal and spend large portions of the night in search of food, which can range from invertebrates and plant matter to carrion. Genetically, snapping turtles throughout the US show little divergence. As a result, all snapping turtles in the US are considered to be a single species. However due to the low population sizes that exist for these animals it is possible that there is a significant degree of structure within snapping turtle populations. To address this issue, we wanted to examine a co-evolved species. In order to determine an appropriate species for comparison, we have analyzed parasite diversity in 8 snapping turtles. For each specimen, the stomach, esophagus, large intestine, and small intestine were examined in order to determine the type and number of parasites present. For each specimen, parasites were only isolated from the small intestine. Overall, the number of parasites was nearly equal between males and females. However, adults were parasitized at higher levels than juveniles. We are currently isolating DNA from these parasites in order to assess their relationships.

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

Alyssa Papineau and Rachel Rosenbaum
Faculty Mentors: Steven W. 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.

Analysis of neuroanatomical connections of posterior parietal and somatosensory areas and comparison of fluorescent tracer techniques in rats

Monica Runge and Brad Cameron
Faculty Mentors: Jeffrey Padberg

The primary goal of this investigation is to provide further information concerning the organization of the posterior parietal cortex (PPC) and this area's relationship with the primary somatosensory cortex (S1) in rats. Although extensive research has been conducted concerning the structure and function of this region in primate species, the homology of PPC (both in function and structure) in the primate and rat brain remains unclear. Rats are an excellent model species for an investigation of PPC function and neural connections as this species exhibits dexterous use of the forepaw – a behavior thought to be mediated by the PPC. In order to further our understanding of these areas in rat brains, we have injected the S1 hind limb representation, S1 forelimb representation, and two divisions of posterior parietal areas with dextran amines or subunits of cholera toxins tagged with Alexa Fluor (AF) fluorescent dyes. Through the use of a microtome, we will cut each rat brain into sections before mounting, Nissl staining half of all sections. We will then analyze neural connectivity between these areas by using a Neurolucida microscopy system to assess anatomical S1 and PPC interconnectivity. Finally, we will compare the results from using the dextran attached AF tracer technique to the results obtained using the cholera toxin subunit B (CTB) tracer technique in order to visibly gauge the effectiveness of these two neuroanatomical tracer techniques.

Do aquatic macro invertebrates show a feeding preference between *Carex* and *Myrica gale* in Cordova Alaska wetlands?

Daniel Sniegowski
Faculty Mentor: Sally Entrekin

Copper River delta in South Central Alaska supports a diversity of wetland types that are a critical habitat for wildlife. The wetlands were uplifted following a large earthquake in 1961, resulting in changes in plant and animal composition in the wetland. Our goal is to understand how the alteration in plant and animal communities may be altering the ecosystem function of the wetlands. We studied two main wetland types: outwash and uplift. Decomposition of leaf litter was our chosen metric for ecosystem function. We measured decomposition rates by deploying leaf bags of *Myrica gale* and *Carex* in replicate wetland types in September 2009. We expected to see a greater diversity and abundance of macroinvertebrates feeding on *Carex* leaf bags over the *Myrica gale* leaf bags because *Myrica gale* has been shown to repel some insects while *Carex* can support a higher richness of macroinvertebrate species. Three leaf bags of each leaf species were placed in in each ofthree different sites per wetland type (outwash and uplift), for a total of 9 leaf bags per vegetation species per wetland. Leaf bags were collected at two different times, the first pickup was the short experiment where bags were both placed and picked up in late 2009. Then, for the long experiment, bags were placed in late 2009 and picked up in spring of 2010. Macro invertebrates were collected, counted and identified in order to collect diversity and biomass data. We will present decomposition rates and associated macroinvertebrate density, and species richness associated with the two wetland types and the two leaf species.

Identification of Genes Associated With Prickle Development in *Rubus*

Nicole Spencer
Faculty Mentor: J.D. Swanson

Prickles are a common but undesirable trait in cultivated crops such as raspberry and blackberry, which are members of the *Rubus* genus. The prickle trait has been shown to segregate in a Mendelian fashion in our study population suggesting control by a single gene. The goal of this study is to isolate a gene associated with the prickle trait in *Rubus*. Information gained through isolation of the prickle gene may provide insight into genes that control cell growth and proliferation and aid in the development of prickleless crops; furthermore, insights gained from this study may lead to interesting extrapolations to the control of human cell division and

cellular growth.

We are specifically looking at the University of Arkansas Fruit Research Station's "Prime-Jim" and "Arapaho" cultivars using an "Arapaho" (Prickleless) x "Prime-Jim" (Prickled) blackberry population. This phenotype shows a normal distribution from prickleless to hyperprickly due to gene dosage, which is a result of tetraploidy in *Rubus*. We are using bulk segregant analysis along with RAPD markers to identify segments of DNA that may be involved with the prickleless trait. Segments identified as possible genes of interest will be subject to further analysis using *in situ* hybridization and RT PCR.

Life History and Ecology of the Redfin Darter

Loren Stearman
Faculty Mentors: Ginny Adams and Reid Adams

The redfin darter, *Etheostoma whipplei*, is understudied ecologically. Little work has been directed at its habitat, and its long and troubled taxonomic history may have led to a confusion of the habitat preferences of it and its close relative the redspot darter. What ecological information is available is often limited to conflicting observations from various authors. The redfin darter is endemic to a small portion of the Arkansas River valley and adjacent upland areas. Almost the entire range of the species is subjected to potential disturbances from new mineral extraction processes including hydraulic fracturing in shale gas development. We conducted an analysis of redfin darters across much of the eastern portion of their range at 9 sites in the Arkansas Hills ecoregion and 5 sites in the Lower Boston Mountains ecoregion. Redfin darters were present throughout the study region at a gradient of densities. Redfin darter densities and biomass densities were negatively correlated with upstream catchment area and positively correlated with percent gravel substrate in riffles. Additional details of life history and ecology will be discussed.

Population genetic analyses of the Southern Red-backed Salamander (*Plethodon serratus*)

Benjamin Thesing
Faculty Mentor: David Starkey

I'll be looking at the species distribution of the Southern Red-backed Salamander, *Plethodon serratus*. Salamanders in the same family are some of the most diverse salamanders in the world with around 350 currently defined species. Many of the species

in the family look very similar but are genetically and biologically different. Until the 1970's the Southern Red-backed Salamander was considered a subspecies of the Eastern Red Back Salamander, *Plethodon cinereus*. Through genetic analysis it was determined to be a unique species that occupies four isolated areas. Currently the range of the Southern Red-backed Salamander is the Ozark Mountains, Ouachita Mountains, Southern Appalachian Mountains, and Central Louisiana. Each of the areas is separated by hundreds of miles, which for a 3-4 inch salamander could mean that each of the isolated areas is unique. I will be using more advanced genetic analysis to determine if each of the isolated populations is the same species. Second, I will be examining the structure of each population to determine how healthy it is. This research is important in helping conserve current biodiversity and further the understanding how speciation is achieved.

Seedling establishment versus clonal spread in the exotic, *Lonicera japonica*

Michael Uffenbeck
Faculty Mentors: Katherine Larson, Richard Noyes and Sally Entrekin

Japanese honeysuckle is a persistent invader in natural areas capable of negatively impacting native species. Previous studies in Arkansas have found low seed levels of seed set and pollination rates. These traits suggest vegetative growth may be pathway Japanese Honeysuckles uses to spread into natural areas. We sought to reconstruct and quantify the colonization pathway of Japanese Honeysuckle within a natural area. Amplified Length Polymphorism (AFLP) was used to identify genotypes in a riparian area and an upland site at Woolly Hollow State Park. Clones were assigned based upon Jaccard similarity values where the threshold was based upon replicated samples. We found a high level of genetic diversity within our study population where the overall average Jaccard similarity was 0.6805 and the Simpson's clonal diversity index was 0.9369 in the upland site and 0.9206 in the lowland site. The G/N ratio was similar in both upland and riparian habitats where it was 0.4444 in the upland site and 0.5278 in the riparian site. The average clonal unit length along the transects was 7.1 meters. In addition, we measured the rate of spread of three genotypes and found one genotype was no more invasive than the native honeysuckle. Although seed set is rare in Japanese Honeysuckle these results indicate sexual reproduction is still the most important colonization pathway within riparian and upland habitats.

Comparison of fluorescent neuroanatomical tracers conjugated with 10,000 MW dextran amine or cholera toxin subunit B

Micheal White and Kent Garner
Faculty Mentor: Jeffrey Padberg

Neuroscience has been using tracing techniques to map connections within the brain for nearly half a century. Fluorescent dyes have become the standard for determining connections of structures with the nervous system, yet there is a considerable lack of data demonstrating the consistent behavior of these tracer substances. Some fluorescent dyes (e.g., Fluororuby) are considered to be "more effective" than others (e.g. Flouroemerald), but a lack of supportive evidence for these types of claims presents an inconsistency across the literature concerning the efficacy of these commonly used tracers. The goal of this study was to compare the time course of transport and labeling efficacy of two different transport molecules tagged with the same fluorescent dye. Injections of .3 μl of AlexaFluor 555 conjugated to dextran amine, or to cholera toxin subunit B, were placed into identical locations in the brains of rats, and different sets of transport times were examined for each transport molecule. Neurons tagged by dye were then counted and compared across sections of the tissue. The majority of labeling was found to occur in S1, and S1BF, with the highest concentration occurring near the injection site. Consequently, the majority of label was in the cortex; much less was found within the thalamus. Also, ipsilateral labeling, as opposed to contralateral labeling, was much more prevalent. Finally, the migration distances of the tagged transport molecules, as well as the labeling efficacy of their tracers, were relatively similar for both the dextran amine and cholera toxin subunit B. This study is part of a long-term project that seeks to increase the utility of using neuroanatomical tracers by neuroscientist in the future.

Chemistry

Sustainability and Green Chemistry in the UCA Organic Chemistry Sequence

Mishal Benson
Faculty Mentor: Richard M. Tarkka

Sustainable chemistry, also called "green chemistry," is a growing movement in academic and industrial settings to minimize or eliminate the adverse effects of inefficient chemical processes and chemicals that are harmful to human health and the environment. In support of The University of Central Arkansas' commitment to the principles of sustainability, we have been "greening" the laboratory portion of the organic chemistry sequence. Our goals are twofold: improve the sustainability of the experiments and prepare our students for the current job market by raising awareness of green chemistry. Existing experiments have been modified to increase sustainability, and other green experiments have been adapted and implemented for the first time in the spring 2011 semester. Each experiment incorporates at least one of twelve principles of green chemistry: prevention of waste, atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, design for energy efficiency, use of renewable feedstocks, reduction of derivatives, catalysis and design for degradation, real-time analysis for pollution prevention, and inherently safer chemistry for accident prevention. Our poster will show the new experiments and demonstrate how they improve sustainability, lower costs, minimize hazards and reduce waste.

Immobilized boron-centered heteroscorpionates: Heterocycle metathesis and coordination chemistry

Brian M. Besel
Faculty Mentors: Patrick J. Desrochers, Richard M. Tarkka

A new resin-supported boron-scorpionate ligand and its nickel(II) coordination complexes are reported. Carboxylic acid-functionalized benzotriazole (Bzt) was coupled to polystyrene resin synthesis beads following the method of Paio *et al.* (*J. Comb. Chem.* **2001,** p. 354). Bead-Bzt reacts with KTp* (Tp* = hydrotris(3,5-dimethylpyrazolyl)borate) in hot DMF giving bead-Tp′K ({HB(resin-Bzt)(pz*)$_2$}K). This same method was validated in solution, and the resulting KTp′ salt was used to prepare (Tp′)$_2$Ni as *cis* and *trans* isomers. Significantly, bead-Tp′K readily binds nickel(II) from simple salts in methanol with minimal leaching. Bead-Tp′$NiNO_3$ binds cysteine thiolate (ethyl ester) imparting a green color to the beads characteristic of Tp^{R}NiCysEt. Bead-Tp′NiCysEt exhibits an oxygen sensitivity similar to Tp*NiCysEt (*Inor. Chem.***1999**, p. 5690). Readdition of unoxidized CysEt to oxidized bead-Tp′NiCysEt regenerates the green color. These methods of preparing covalently supported scorpionates should expand the utility of this established ligand class to broad applications of transition metal scorpionates including combinatorial methods.

Evaluation of Scorpionate Ligands for IMAC Applications

Brandi Bowlin
Faculty Mentors: Richard M. Tarkka, Patrick J. Desrochers, and Lance C. Bridges

Immobilized metal ion affinity chromatography (IMAC) is a commercial method of protein purification that exploits the specific binding of metal ions to certain amino acids. Proteins with markers such as a 6-His tag can be selectively removed from a mixture via column chromatography using immobilized metal ions. We are currently trying to improve this method by increasing the strength of the bond between the ligand and the metal, and by improving the specificity of the binding between the metal and the protein. To do this, we have immobilized a substituted boron-centered heteroscorpionate ligand on a polystyrene (PS) resin, and treated it with $NiNO_3$. The resin was exposed to a human recombinant 6-His fusion protein, which was expressed in *E-coli*. Its binding ability was determining and compared to a similar evaluation made with commercial Talon® resin.

Halogen Bonding in a multilayer of 4-iodobenzoate ions with CCl_4 adsorbed on silver nanostructures

TsungYen Chen, Katie Primm, Taylor Razer and Jennifer Shamburger
Faculty Mentor: Donald Perry

A combination of surface-enhanced Roman spectroscopy (SERS), surface-enhanced infrared adsorption (SEIRA) experiment, and density functional theory (DFT) calculations are used to investigate the adsorption properties of 4-iodobenzoic acid from a CCl_4 solution on silver nanostructures (AgNS). Previous research has shown that ionization of benzoic acid isomers such as 4-iodobenzoic acid often occurs well into the multilayer during adsorption onto AgNS. SEIRA demonstrated that CCl_4 was incorporated into the 4-iodobenzoate ion (4IBI) multilayer. These SEIRS results in conjunction with density functional simulations suggest that there could be several types of halogen bonding interactions between CCl_4 and 4IBI in the multilayer. This work will prove useful in several areas of research including nano-, biological, synthetic, medicinal, and environmental chemistry where halogen bonding interactions are important.

Microwave-Assisted Synthesis of Scorpionates

Phillip Cook and Tristan Phillips
Faculty Mentors: Richard M. Tarkka and Patrick J. Desrochers

Scorpionate ligands have found widespread utility in far-reaching applications, including use as radiopharmaceuticals, catalysts and enzyme mimics. Although microwave (MW) irradiation has been used extensively in chemical synthesis, reports of this technique being used to make scorpionates are extremely scarce. We report the use of MW techniques to synthesize scorpionate ligands. Potassium hydrotris(3,5-dimethyl-1-pyrazolyl)borate (KTp*) was cleanly synthesized on the 500 mg scale in 10 minutes at 200 °C by MW reaction of KBH_4 with excess 3,5-dimethylpyrazole. Similarly, MW reaction of excess molten pyrazole and NaH and phenylboronic leads to the desired scorpionate, sodium phenyltris(1-pyrazolyl)borate. ^{11}B NMR spectroscopy confirmed the desired scorpionate as the only boron-containing compound in these mixtures. When conventional techniques are used, the preparation of these third generation scorpionates, starting with arylboronic acids, is plagued by low yields. Details of these and other MW-assisted scorpionate syntheses will be presented.

Promoting chemistry in Arkansas

Mary Davis, Kristin Thorvilson, Brandi Bowlin, Brian M. Besel and Casey Thurber
Faculty Mentors: Karen L. Steelman and Faith Yarberry

The University of Central Arkansas student chapter promotes chemistry on campus and among the Arkansas community. On campus, we actively participate in an annual Major's Fair and Registered Student Organizations' Fair. We also host guest lectures and organize social activities. The opening of a new STEM (Science, Technology, Engineering, and Mathematics) Residential College provides additional opportunities to increase collegiality. Locally, we have presented chemistry workshops at the Museum of Discovery and demonstrations at schools geared towards exciting future chemists. Our goal is to illustrate ways that a student chapter can influence the future of the American Chemical Society.

Computational screening for cation-π interactions in RNA crystal structures

Elizabeth Dourlain
Faculty Mentor: Lori Isom

Cation-π interactions are important interactions that aid in DNA/protein stability and molecular recognition. Since cation-π interactions are prevalent in DNA and protein structures, RNA crystallographic structures were computationally analyzed to determine if magnesium (Mg) and calcium (Ca) ions participate in cation-π interactions with the nucleotides. RNA structures were selected in the PDB by applying the following criteria: contain either Mg or Ca, and have resolution equal to or better than 3 Å. The subset of RNA structures generated was further parsed by retaining the highest resolution structure for duplicates. After the screening of potential RNA molecules, they will be analyzed to determine if cation-π interactions between the ions and nucleic bases are present. To do so, the structures will be computationally screened for interactions that fall within the 5.0 Å and 50° angle geometric criteria and the resultant interactions will be characterized with respect to sequence specificity and/or deformation/stabilization induction.

Molybdenum(0) tricarbonyl complexes involving a new heteroscorpionate and resin-supported complexes

Jared R. Evanov
Faculty Mentors: Patrick J. Desrochers and Richard M. Tarkka

New molybdenum(0) tricarbonyl complexes, $LMo(CO)_3^{n-}$ (n = 0 or 1) will be described. L represents scorpionate chelates (Tp^{*-}: hydrotris(3,5-dimethylpyrazolyl)borate; Tpm: tris(pyrazolyl)methane; Tp'^{-}: hydrobenzotriazolyl-bis(3,5-dimethylpyrazolyl)borate). The complex ion $Tp^*Mo(CO)_3^-$ has been reported as its NEt_4^+ salt (*Inorg. Chem.* **1995**, p. 3801). It is here described for the first time as its PPh_4^+ salt along with the salt of the new complex, $Tp'Mo(CO)_3^-$. $LMo(CO)_3^{n-}$ complexes have distinct ^{13}C NMR, IR and electrochemical properties, effective handles for characterization when new chelates (L) are employed. The asymmetry of the Tp'^- heteroscorpionate is evident in spectroscopic measurements of the $Mo(CO)_3$ manifold. Heterogeneous resin-$TpmMo(CO)_3$ and resin-$Tp'Mo(CO)_3K$, will also be described for the first time. The importance of molybdenum complexes in areas as diverse as bioinorganic chemistry and industrial catalysis and the application of molybdenum-scorpionates in research applied to both mean the present work will contribute to new and varied heterogeneous molybdenum applications.

State-Specific Reactions of Gas Phase Ni^+ with CH_3X and CF_3X (X=Cl,Br,I): Evidence of Selective Halogen Abstraction

Kendall G Fancher, Ashley J Cooper 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) have been examined in a selected ion drift cell apparatus. State-specific product formation in these reactions 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 excited state Ni^+ abstracts X to form NiX^+. Excited state Ni^+ also participates in charge-transfer with all neutrals except CF_3Cl and CF_3Br. State-specific kinetic measurements display a broad range of reaction efficiencies for both ground and excited state nickel ions. Taken together with the observed products, this suggests that while several excited Ni^+ states may be present during these reactions, not all are capable of producing NiX^+ due to unfavorable thermochemical or quantum mechanical requirements.

The Effect of Troglitazone on Retinoic Acid Metabolism

Jessica Gamble, Brian Head, and Venusa Phomakay
Faculty Mentor: Melissa Kelley

Retinoic acid, an analog of vitamin A, plays an active role in many cellular processes such as cellular adhesion, apoptosis, proliferation, and differentiation. All-*trans*-retinoic acid (*t*-RA) and 9-*cis*-retinoic acid (9-*cis*-RA) serve as ligands for the retinoic acid receptor (RAR) while retinoid X receptors (RXR) are only activated by 9-*cis*-RA. The RXR coordinates with peroxisome proliferators-activated receptor gamma (PPARγ) to form a heterodimeric partnership. In the current study, we examined 9-*cis*-RA metabolism in the presence and absence of troglitazone in the human pro-red blood cell line K562. Troglitazone is a ligand for the PPARγ and has been used as diabetic drug. K562 cells were treated for a period of 72 hours with either 9-*cis*-RA, 9-*cis*-RA and troglitazone, troglitazone or ethanol. Retinoid metabolites were identified using liquid-liquid extraction and reverse phase HPLC with photodiode array detection.

Synthesis of Selenium-Containing Amino Acids

Judith Higgins and Zuzana Sisperova
Faculty Mentor: K. Nolan Carter

Free radicals are key intermediates in the damage of biological molecules such as proteins, DNA, and the phosphoglyceride components of the cell membrane. In order to gain insight into the mechanisms of radical-induced protein damage, our laboratory is synthesizing selenium-containing amino acids that generate radicals upon exposure to UV-light. Upon UV-irradiation, the labile C-Se bond is cleaved to produce an amino acid radical. This approach enables selective generation of specific amino acid radicals which serve as models for radicals generated within a protein. Work is currently underway toward the synthesis of selenium-containing derivatives of phenylalanine and valine. These compounds are being prepared from reductive amination of the corresponding α-oxoesters.

9-*cis*-Retinoid Acid Stimulated B-cell Adhesion is Attenuated Upon Corticosteroid Exposure

Jabin Miller
Faculty Mentors: Melissa Kelley and Lance C. Bridges

Cellular adhesion is a key event in a spectrum of biological processes, including gamete fusion, wound healing, and inflammation. Within immune cells, adhesion and proliferation are impacted by oxidative metabolites of Vitamin A known as retinoids. Our previous studies demonstrated that exposure of certain human lymphocytes to 1.0 μM 9-*cis*-retinoic acid augments B-cell adhesion. Our new results demonstrate that adhesion can be increased by concentrations of 9-*cis*-RA as low as 10 nM. We also examined if the cell adhesion persisted after retinoid stimulus was removed or if the presence of corticosteroids dampened the augmented immune cell adhesion. We report here that while adhesion persisted for briefly after retinoid removal, subsequent generations of cells did not exhibit elevated levels of adhesion. In addition, administration of the synthetic corticosteroids MPSS or dexamethasone potently inhibited retinoid-dependent adhesion. These data suggest that retinoids may be key modulators in adhesion events during inflammation.

C-H···O hydrogen bonding of substituted benzoate ions with alkanes on silver nanostructures

Taylor Razer, Jennifer Shamburger, TsungYen Chen, and Katie Primm
Faculty Mentor: Donald Perry

A combination of surface-enhanced Roman spectroscopy (SERS), surface-enhanced infrared adsorption (SEIRA) experiment, and density functional theory (DFT) calculations are used to investigate the adsorption properties of a range of substituted benzoic acid isomers deposited from volatile solvents onto silver nanostructures. Previous research has shown that ionization of those benzoic acid isomers to benzoate ions occurs well into the multilayers. Strong intermolecular attractions were observed between alkane deposition solvents (namely *n*-hexane and *n*-heptane) and the benzoate ion. Different substituents including $-NO_2$, $-NH_2$, -CN, -OH, and halogens (F, Cl, Br, and I) were seen to alter the intermolecular attraction in different ways. Evidence will be presented that the intermolecular attraction is between the carboxylate group and the alkane as a C-H···O hydrogen bond. This work will provide additional understanding to the fundamental intermolecular interactions that are important in many fields of science and technology including nano- and biotechnology, biochemistry, material and synthetic chemistry, and environmental chemistry.

Multi-sample plasma oxidation system for radiocarbon dating

Kaleb Smithson, Mary Frères and Lennon Bates
Faculty Mentor: Karen L. Steelman

Our laboratory utilizes an oxygen glow discharge to convert organic material in archaeological and environmental samples to carbon dioxide for accelerator mass spectrometry radiocarbon measurement. A typical plasma oxidation cycle for a single sample takes approximately two work days. In order to increase sample throughput, we designed a custom-built system using Conflat fittings, with a single radio frequency generator and a turbomolecular vacuum pump. Our initial goal was to build two separate sample chambers, with the ability to add additional chambers as desired. USGS coal (^{14}C-free) and ANU sucrose (modern) radiocarbon standards were used to test the accuracy and precision of our results. Being able to oxidize multiple samples at once will significantly increase laboratory productivity.

Chemical pretreatment and plasma oxidation of aboriginal paintings for radiocarbon dating

Casey Thurber, Jeremy Mackey, Josh Lowen and Lennon Bates
Faculty Mentors: Karen L. Steelman (UCA), Josephine McDonald (ANU), Peter Veth (ANU), Tom Guilderson (LLNL)

Plasma oxidation and accelerator mass spectrometry were employed to radiocarbon date ancient aboriginal paintings from the Western Desert of Australia. In contrast to combustion, plasma oxidation is below the decomposition temperature of carbon-containing minerals such as carbonates and oxalates; therefore, their inclusion in the dated extract is avoided for samples with a high mineral content. Paint samples were pretreated with one molar sodium hydroxide solution in order to remove humic acid contamination. Exposure to an oxygen glow discharge converted organic material in the sample to water and carbon dioxide, which is collected for ^{14}C measurement. Bayesian statistical calibration, SHCal04, produced ages ranging from 300 cal AD to modern. These results will allow archeologists to associate images on shelter walls with excavated cultural finds, as well as study the progression of artistic styles.

Computational Exploration of Mechanisms in the Reactions of $Au^+(^1S)$ with CH_3Cl and CF_3Cl

Benjamin K. Ward
Faculty Mentor: William S. Taylor

The reactions of $Au^+(^1S)$ with CH_3Cl and CF_3Cl 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 $AuCH_2^+$ and $AuCF_2^+$ respectively. Results indicate that elimination of HCl from CH_3Cl begins with the expected oxidative addition of Au^+ to the C-Cl bond. However, the most favorable mechanism for the elimination of ClF from CF_3Cl proceeds via activation of the substantially stronger C-F bond. Consistent with previous experimental work on these systems, the calculated reaction thermochemistry predicts that formation of $AuCF_2^+$ is significantly endothermic, while formation of $AuCH_2^+$ is essentially thermoneutral.

Using chromatography to identify ancient paint binders and vehicles

Derek Watts, Saki Fukuda and Michelle McClain
Faculty Mentor: Karen L. Steelman

Radiocarbon dating of ancient rock art relies upon the presence of an organic vehicle or binder added to an inorganic pigment. Identification of that organic material will increase confidence in radiocarbon results, as well as highlight the use of technology and natural resources by ancient cultures. For method development, modern paint samples made with iron pigments, deer bone marrow, and yucca root were separated into aliquots with differing sample preparations that radiocarbon samples might experience, such as acid-base-acid washes, base-only washes, and no pretreatment. In order to determine fatty acid content, we analyzed samples using both gas and liquid chromatography with mass spectrometric detection. For gas chromatography, both FAME and BSTFA derivatization were employed. Our results suggest that chemical pretreatment and derivatization techniques all play a pivotal role in measured values.

Computer Science

Sensitivity of Different Machine Learning Algorithms to Noise

Abhinav Atla
Faculty Mentor: Victor Sheng

Noise in data is an effective cause of concern for many machine learning techniques that are used in modeling data. Researchers have studied the impact of noise only on some particular learning algorithm, but only very few attempted to analyze the effect of noise on different ones. In this work, we study the noise sensitivity of four different learning algorithms under different intensities of noise. Particularly, we compare the noise sensitivity of decision tree, naïve bayes, support vector machine, and logistic regression. The algorithms are tested on different datasets that are artificially injected with different degrees of noise. The study helps us understand the impact of different levels of noise on the learning algorithms mentioned above. Furthermore, it also guides of choosing the learning algorithms. In general, naïve bayes is the most resistant to noise. However, it performs also the worst. The other algorithms perform much better than naïve bayes especially after the noisy level is lower than 40%. When we have approaches to improve the data quality (reduce the noise level), decision tree is the most preferred one, followed by support vector machine and logistic regression, not naïve bayes.

Multi-label Utilization in Supervised Learning

Abhinav Atla
Faculty Mentor: Victor Sheng

Data in real world is greatly exposed to multiple labels with multiple classifications attached to them. Hence, it both interesting and necessary to build solutions that can utilize the multiple labels with multiple classes. Estimating the ground truth through Preprocessing is a straightforward strategy, which transforms these multiple labels with multiple classes to generate a single label and single class. Based on this preprocessing concept, majority voting *(pre-MV)* is the most famous

approach which counts the number of labels for each example and then assigns the majority class as the class label. However this simple approach builds the training set by omitting certain visible or invisible information given by the multiple label set. In our work, we proposed a new approach named post-processing through majority voting *(post-MV)* which uses a previous approach of using an ensemble of training datasets and building models for each labeler separately. It then applies majority voting on all the generated labels to get the final training data set. We tested our approach on 20 different real world datasets with both binary labels and multiclass labels, results for post-MV approach had higher model accuracy than pre-MV approach, for about 17 datasets.

Standard Uptake Value / Volume Analysis in Head and Neck Cancers

Recep Avci
Faculty Mentors: Sinan Kockara, and Gal Shafirstein, UAMS

After the introduction of quantitative analysis of Positron Emission Tomography (PET) scan for monitoring the early response of tumors in breast cancers in 1993, Standard Uptake Value (SUV) has been used as a prognostic factor in cancer cases in addition to anatomical metrics of the tumor such as the volume or the growth rate. However, current studies have focused on using a single value like maximum SUV or mean of SUVs rather than whole distribution. Moreover, two important prognostic factors, volume and SUV distribution have not been studied together. In this on-going study, SUV distribution and the tumor volume are used to develop a prognostic model for head and neck cancers.

As a preliminary work, computed tomography (CT)-PET scans of a patient who had been diagnosed for head and neck cancer were used as source images. The CT-PET includes 263 scans of the entire head and shoulder with 2mm thickness and 256x256 resolution. Tumor regions in the PET scans (images) were segmented by using thresholding method. The intensity values of the tumor region were extracted from the PET images and the SUVs were calculated for each scan in the tumor. A three-dimensional volume of the tumor was constructed and the distributions of 2591 SUVs were plotted within the tumor volume. These values were within the range of 2.35-11.02 with a mean of 5.06. The volume of the tumor equals to 40.2 cm^3.

The final goal of this on-going research is to develop a prognostic model for head and neck cancers by analyzing SUV distribution and tumor volume.

Rate Control and Initial QP Selection for H.264/AVC Scalable Extension (H.264/SVC)

Christopher Kline
Faculty Mentor: Yu Sun

The rapidly growing demand for video communications has stimulated the advance of video compression technology. Compared with previous scalable video compression standard, the emerging H.264 Scalable Video Coding (H.264/SVC) has improved coding efficiency and provides scalability in the temporal, spatial and SNR dimensions. All of these make H.264/SVC suitable to accommodate heterogeneous video applications with diverse requirements in resolution, video quality and frame rate. As a critical component in video compression, rate control (RC) regulates compression bitrates and encoding quality within available network bandwidths. The initial quantization parameter (QP) selection has an important impact on rate control performance. However, how to determine the initial QP has not been well addressed in current H.264/SVC RC algorithms. In this research, we investigated the adaptive initial QP selection for H.264/AVC rate control. The experimental results demonstrate that our proposed initial QP selection approach outperforms the one adopted in the H.264/SVC reference software.

Normalized Distance Measure Incorporated DBScan for Border Detection in Dermoscopy Images

Sait Suer
Mentor: Sinan Kockara

Dermoscopy is one of the major imaging modalities used in the diagnosis of melanoma and other pigmented skin lesions. Automated assessment tools for dermoscopy images have become an important research field mainly because of inter- and intra-observer variations in human interpretation. One of the most important steps in dermoscopy image analysis is automated detection of lesion areas. In this study, we improved efficiency and performance of an existing dermoscopy border detection algorithm which has one the highest accuracy in the literature. This algorithm is called boundary driven fast density based clustering (BD-DBSCAN). We also developed and embedded a new distance measure to the existing algorithm. This in turn removed dependency of the existing algorithm to image segmentation algorithms in its prior computation steps so that over all process is speeded up. Moreover, developed measure helped to involve both color and position dependencies in the algorithm so that efficiency of the algorithm is increased. We tested our results with not only BD-DBSCAN but also dermatologist drawn ground truth images. Results show that our method is more accurate and efficient than existing method.

PAIRWISE COUPLING AND ONE-AGAINST-ALL FOR MULTICLASS COST SENSITIVE LEARNING

Rahul Tada
Faculty Mentor: Victor Sheng

In multiclass cost sensitive learning, the classes are rescaled or balanced according their costs. This can be done by weighting the examples or instances in proportion to their costs. In this research, we extended two well-known methods (Pairwise Coupling and One-Against-All), which are used for decomposing multiclass problems into a set of two class or binary problems, into cost-sensitive. Our comparison results show that cost-sensitive Pairwise Coupling performs much better than cost-sensitive One-Against-All, using the learning algorithms Decision Tree, Naïve Bayes and Support Vector Machine (SMO) available in the WEKA package.

Strategies of Utilizing Multi-Noisy-Labels for Supervised Learning

Rahul Tada
Faculty Mentor: Victor Sheng

In recent years, huge amount of research has been done on the supervised learning which deals with single label data. In single label data, each example in the training data is given a single label from a set of independent labels. But in real world, the training examples in some applications are associated with more than one label. Such data is called multi label data. And also the real world data is sensitive to noise. In our work, we discuss and describe different strategies of utilizing these multi-noisy labels for supervised learning. Labeling quality is one of the important factors of noise. We assumed that all the labelers have the same labeling quality. Pairwise Coupling and One- Against-All are two famous reduction techniques used to split multi-class data into sets of binary class data. We proposed a new approach which is a combination of ensemble technique and one of the reduction techniques to obtain multiple training data sets. Then we apply majority voting to get a final training data set. This approach is done using both the reduction techniques. A comparison of these strategies is done to know which one of these strategies perform better.

Optimizing Parallax Barrier Tilt Viewing Angles though Usage of Alternate Interlace Patterns

Marcus Truscello
Faculty Mentor: Yu Sun

Parallax barrier technology is becoming the new standard for consumer-level 3D display products but suffers from fairly restrictive tilt viewing angles. To improve these viewing angles, alternate interlace patterns were generated and tested using a script built in PHP utilizing the GD Image Library. These various patterns included concentric circles, diamonds, and semicircles, were used as comparisons against the standard of vertical interlacing. In addition to these patterns, a sharpening mask was applied to allow for a variable amount of grandniece between the generated interlace boundaries. A diverse sample set of parallel 3D images were used as a sample set and were interlaced using the aforementioned patterns. The experimental results showed that minor improvements can be made to a parallax barrier device's tilt viewing angle through usage of some of the proposed alternate interlace patterns while other patterns have a net negative effect on the viewing experience as a whole.

Mathematics

Fractals and Frieze Groups

Derek Anderson
Faculty Mentor: Fred Hickling

Friezes are commonly known to exist as relief sculptures on the entablatures of classic architecture. Less commonly known is that linear repeating patterns such as these mathematically go by the same name. It is know that there are seven distinct types of these linearly repeated patterns which are classified according to the collection of rigid motions which preserve the pattern. (Mathematicians refer to this as a group of transformations). This classification assumes that there is a smallest translation which preserves the pattern. If fractal patterns are used in the patterns and thus allow for scaling of the pattern as well as translations these fractal friezes fall into one of 11 or 14 families of group transformations. There are 11 families if the scale factor is even and 14 families if the scale factor is odd.

Air Flow Simulations around a Blended Wing Body Design

Matthew Hankins
Faculty Mentor: Clarence Burg

Over the past 20 years, there has been an increasing amount interest in unconventional aircraft design. The possibility of improved aerodynamic efficiency compared to today's aircraft has driven the industry to new innovative heights. Two of the most notable designs being researched are the flying wing and the blended wing body (BWB). The goal of this project is to build a mesh around three different variants of the flying wing aircraft, and three meshes of variants of the BWB aircraft. Each of the meshes were built with a constant volume in order to maintain a valid comparison between each model. Using computational fluid dynamic software, the lift-to-drag ratio of each configuration will be measured in order to determine the most efficient body design. A large portion of this project was inspired by the work done at the Universidad Politécnica de Madrid by Luis Ayuso Moreno, Rodolfo Sant Palma, and Luis Plágaro Pascual. In this study, both CFD testing and wind tunnel

testing were utilized for five different BWB configuration aircraft. In the future it would be preferable to make a greater variety of aircraft based on the most efficient models generated in this study. Changing the minor features in the most efficient design could lead to a greater understanding of aerodynamic principles of both the flying wing and BWB aircraft as a whole.

Drag Calculations for Different Truck Bed Configurations

Vinh Lu
Faculty Mentor: Clarence Burg

As any motor vehicle travels, it encounters air resistance. This can be simulated in a wind tunnel where wind is produced in a tunnel containing the vehicle. However, it can also be simulated on a computer. Computational Fluid Dynamics (CFD) allows simulations of multiple vehicles to be simulated without actually building the vehicles, allowing rapid testing of multiple different vehicle designs. The shape of the truck affects the flow of air around the vehicle, which affects air resistance. By observing these flows, one can design trucks with better fuel mileage by focusing on the truck bed. We have simulated 3 cases – tailgate up, tailgate down, and truck bed with a cover – with the goal of determining which one has the lowest drag, or air resistance.

Java-Based Interactive Computational Fluid Dynamics Simulation Platform

Mark Vander Lugt
Faculty Mentor: Clarence Burg

A portable educational tool has been developed for computational fluid dynamics (CFD) simulations using two-dimensional unstructured meshes. This Java-based software package consists of three distinct components that are integrated into a single framework and can be run on a wide range of operating systems and computational devices. The three components are the underlying CFD solver (currently compressible air flow), the visualization section that displays the flow variables, such as pressure, and a parameter input section, where the user can select the geometry, parameters such as the Mach number or angle of attack, and can zoom in or out of the solution. Being modular, the various components can switched out, so that different CFD solvers and the associated flow parameters can be easily plugged into the platform, creating new CFD simulators. Additionally, new geometries can be developed and included within the CFD simulator. Because of the

user friendly design and the portability and modularity of the platform, students should be able to learn this CFD simulation platform quickly and use it to investigate and understand a wide range of physical flow phenomena.

Simulating Urban Canyon Effects

Brandon McVay
Faculty Mentor: Clarence Burg

In the modern era, urban areas are developing rapidly. Towering concrete structures are filling the skyline. This urban design has replicated a particular phenomenon produced in nature. Traditionally, cities are built in a checkerboard zoning fashion. Tall buildings in urban areas create "urban canyons" in the streets below the buildings. On a windy day, these "canyons" filter the air from wind and actually amplify the magnitude of the pressure and velocity. Since the buildings are fixed, the flow direction is fixed, while the nominal air flow direction outside of the urban environment changes. We can then investigate the relationship between the nominal airflow and the increase in wind speed through the urban canyon. While this can cause a small breeze to feel like a gale, utilizing this "canyon effect" can yield useful applications for fields such as air quality, urban development, and alternate energy.

Interaction of Vortices Generated by Circles of Different Sizes

Tristan Odekirk
Faculty Mentor: Clarence Burg

Airflow past rigid bodies at low speeds creates alternating vortices behind the bodies. If there is more than one body, the vortices created by each body may interact. Research has been done on fluid flow around isolated rigid circles, paired rigid circles side-by-side and paired rigid circles one following the other, to understand the relationships between these objects and their vortices. In these studies, the circles were the same size. The current research aims to examine the effects of enlarging one circle and studying how the vortices interact. One application of this research is to study and understand the airflow about moving vehicles. The case of two circles of the same size could model two automobiles driving side by side, while the case when one circle is larger than the other could model a large tractor-trailer truck beside an automobile. These investigations would lead to a greater knowledge of the forces present due to air when driving.

Supersonic Flow Over a Serpentine Curve

Eric R. Sellers
Faculty Mentor: Clarence Burg

Oblique shocks are a fundamental physical problem in fluid dynamics that occurs when a supersonic flow of air comes into contact with a solid surface. Since the problem deals with a supersonic flow of air, then we can use the compressible Euler equations to model the flow. This type of problem has been thoroughly studied and numerically simulated in the case when the flow comes into contact with a linear wall, or wedge, at a given angle because that particular case has an exact solution. This configuration leads to a linear shock that comes of the wedge at a particular angle. However, if the wedge was a serpentine (quadratic) curve instead of a linear wall, how would that effect the shock wave that comes off of the blunt surface? Does this case have an exact, algebraically defined solution as in the case of the linear wall? In order to investigate the behavior of the oblique shock generated by a serpentine curve, we used a software package called OpenFoam. We have simulated both the linear wall and the serpentine curved wall cases, coming the linear wall with an exact solution and investigating the curved wall solution to determine the form of a possible exact solution.

Generalized Cross-Validation for Correlated Data

Rebecca Smith
Faculty Mentor: Patrick Carmack

Since its introduction by Stone (1974) and Geisser (1975), cross-validation has been studied and improved by several authors including Burman et al. (1994), Hart & Yi (1998), Racine (2000), Hart & Lee (2005), and Carmack et al. (2009). Perhaps the most widely used and best known is generalized cross-validation (GCV) (Craven & Wahba, 1979), which establishes a single-pass method that penalizes the fit by the trace of the smoother matrix assuming independent errors. We propose an extension to GCV in the context of correlated errors that has important implications about the definition for residual degrees of freedom, even in the independent case. The efficacy of the new method is demonstrated by simulation and application with concluding remarks about the heteroscedastic case and a potential maximum likelihood framework.

Modeling the Cause and Effects of Tsunami in the Deep Ocean

Jonathan Taylor
Faculty Mentor: Clarence Burg

Underwater mudflows can cause an enormous displacement in the surrounding water, resulting in dangerous tsunamis. A major tsunami was created by an underwater mudflow in Papua-New Guinea in 1998 which killed thousands throughout the India Ocean. In this two-dimensional study, the mudflow is represented by a sliced rectangle that rests vertically on a slope. The slope is adjoined on top and bottom to horizontal shelves, mimicking an idealized continental shelf, slope, and deep sea floor. The mudflow is assumed to be a fluidized material, so representation by the Navier-Stokes equations is valid. The study splits the problem into the mudflow, and the resulting wave. A two fluid model is used for both parts of the simulation. Results are compared to those found in previous studies under similar conditions. Mudflow deformation affects the surrounding water's pressure and velocity, resulting in conditions used to help construct the initial conditions for the wave simulation. Future studies should investigate the correlations between the two parts of the problem.

Zombie Population Dynamics: HIDERZ Model

Jonathan Taylor
Faculty Mentor: Long Le

Zombies have become a pop-culture staple of today's media. The idea of a re-animated corpse now encompasses a wide variety of zombie types with different characteristics. The ultimate goal of this project was to construct a mathemat- ical model that could represent and simulate a zombie outbreak in a human population, and serve as a base to build future models upon. This was done with a closed system of six differential equations and constraints that describe compartmentalized population movement through 15 distinct interactions.

The present HIDERZ model accounts for the interaction of zombies and four classes of humans. While the idea originates from novelty, the exercise demonstrates the flexibility and adaptability of compartmental mathematical modeling. The study focused on designing the model and performing initial test runs to analyze its performance. First rounds of simulation show extreme sensitivity to parameters, with final steady state solutions ranging human vic- tory to doomsday scenarios. A stable coexisting equilibrium between humans and zombies has not been found yet using this model. Future investigation includes sensitivity and stability analysis and new interaction models.

Simulating the Erosion Around a Waterfall

Taylor Vance
Faculty Mentor: Clarence Burg

Erosion occurs in several locations within a waterfall – at the waterfall lip, at the base of the waterfall and along the face of the waterfall. Haviv, et al, developed an algebraic model of the expected erosion amplification at a waterfall lip. They examined the interaction between erosion at the lip, retreat of the waterfall face, and profile evolution upstream of the waterfall. Rao, Li, and Amini used the smoothed particle hydrodynamics method for shallow water flows and hydraulic erosion to provide a solution to wave overtopping and erosion for an earthen levee, which is similar to the erosion at the base of the waterfall. As the water erodes the bottom of the pool, it also erodes the bottom portion of the face of the waterfall. As this face erodes, the rocks supporting the face of the waterfall are eroded away, eventually causing the entire front of the waterfall to collapse spectacularly. We simulate both the erosion of the lip of the waterfall and the erosion at the base of the waterfall, using a computational fluid dynamics software package that includes three different components – air, water and mud – within an incompressible solver. We plan to compare these numerical simulations with the results of Haviv, et al, and of Rao, Li, and Amini.

Physics and Astronomy

An Efficient Flood Basin Water Depth Sensor

Petey Bland
Faculty Mentor: William V. Slaton

An inexpensive yet efficient sensor package, designed to measure the depth of water in a flood basin over an extended period of time, was needed to replace the current units. The current units are not only very expensive, but are in danger of being lost during a heavy storm. They are also designed for a laptop to be brought into the field which creates another inconvenience and monetary risk. A budget was set at $200 and a sensor package consisting of pressure sensors and temperature sensors was built to be used with a HOBO type data logger to facilitate this need. A durable and weatherproof enclosure will be designed to house the sensor package and HOBO logger.

Archeoastronomy: Ancient peoples searching for the future

Renee Brock
Faculty Mentors: Debra Burris and William V. Slaton

Astronomy, the study of the heavens, is the oldest of the sciences. All over the world, ancient peoples looked to the skies for guidance, to keep up with the passing of time, and to mark major events. Many of them built observatories, from simple rock clusters to massive structures that are known as world wonders, like Stonehenge and the Pyramid of Giza. By studying and comparing many of these ancient astronomical observatories, one can determine many things about a culture, like whether or not they used a calendar based on the sun or the moon, their knowledge of cardinal directions, and what stars they used for guidance. Today, we have many tools discovered over time that are useful in the study of archeoastronomy. For example, by knowing the location of a star in the sky based on the year, it is possible, using an equation, to precess the location of the star back to a different time. This is useful in determining which stars our ancestors slept under at night. For this study,

emphasis was placed on a few locations: Chaco Canyon in New Mexico, Newgrange in Ireland, and Nabta Playa in Egypt.

Wave Experiments Using Low-Cost 24.5 kHz Ultrasonic Transducers

Caroline Davis
Faculty Mentor: William V. Slaton

Ultrasonic devices can be found in many everyday activities in medicine, industry, oceanography, and the home. The 24.5 kHz piezoelectric ultrasound transducer is one such device that converts energy into sound waves above the normal range of hearing, in other words, ultrasound. A transducer can be used to demonstrate wave phenomena, such as reflection and refraction, to help students better understand acoustics. The law of reflection is demonstrated by attaching a plastic cone to each transducer and reflecting the transmitting and receiving transducers on a flat vertical surface at specific angles until maximum reception occurs. At this point the incident angle is observed to be approximately equal to the reflected angle of the sound wave. A wave generator and an oscilloscope are used to visually observe the characteristics of the sound wave produced by the transducer. Additionally, sound waves are considerably slower than light waves. Therefore, using the basic equation $v = x/t$ and the oscilloscope, students can observe the lag in the sound wave transmitted from one receiver to the other.

Determination of Elastic Moduli in Brass, Aluminum, Wood, and Plastic Rods Using Resonance

Roy Truett French III
Faculty Mentor: William V. Slaton

This experiment investigated how to excite the Flexural and Torsional modes in Brass, Aluminum, Wood, and Plastic rods. The setup consists of a two channel dynamic signal analyzer, a power amp, an operational amplifier and high pass filter circuit. Two coils of copper wire act as transducers on each end of the rod. The rod is suspended with the transducer coils in strong magnetic fields provided by neodymium magnets. The signal analyzer sends a swept sine wave into the power amplifier which drives one transducer coil. The rod's response is measured with the op-amp circuit connected to the second transducer coil which is connected to the signal analyzer. The resonance peaks were found using the two channel dynamic

signal generator. With these peaks, the Flexural and Torsional modes can be determined, thereby allowing one to calculate the Elastic Moduli.

Testing system components for a low-frequency, impulsive Helmholtz Resonator

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

Infrasound can be used to probe a variety of physical systems; this includes the determination of ground characteristics, the detection of explosions, and the investigation of tornadoes and hurricanes. Infrasound detectors have been deployed around the world as part of the monitoring required by UN Comprehensive Nuclear Test Ban Treaty. A reproducible calibrations system would enable this network of sensors to be used for basic science. We describe work that is being performed to design an appropriate calibration system. A large, impulsive Helmholtz resonator appears to be an ideal candidate to serve as the sound source in a mobile, reproducible calibration system for infrasonic detectors. Efforts to date have focused on the development of a reproducible triggering mechanism. Measurements have been performed with the system that will constitute the throat of the planned larger oscillators. The resonator throat consists of 2-foot long stainless steel pipe, with an inside diameter of 4 inches, that is closed at both ends. Using a flange, we have securely sealed one end of the pipe. At the other end of the pipe, we use different thicknesses of sheet aluminum to form a diaphragm; the aluminum sheets are held on by an open flange. To create the sound pulse, we produce a vacuum in the pipe and trigger the resonator by puncturing the diaphragm, causing it to rupture. Work to date has concentrated on the development of the triggering mechanism. The various methods of triggering the resonator will be discussed. Some preliminary data will be presented.

Aeroacoustic Source Strength Measurement of Helmholtz Resonators

Asami Nishikawa
Faculty Mentor: William V. Slaton

The aero-acoustic excitation of a Helmholtz resonator with different neck geometries and the work done to sustain the excitation of resonance will be examined with an improved measurement technique. A Helmholtz resonator consists of a volume connected to a duct and has a well defined resonance frequency

which depends on the length of the duct, the volume of the resonator and the cross sectional area of the duct. In the system used during this experiment, two Helmholtz resonators have been positioned at opposite sides of a junction in a wind tunnel. The air flowing over the junction openings to the Helmholtz resonators can excite the acoustic resonance of the system. This is similar to blowing over an empty bottle's opening and creating a tone. The effect of the resonator's geometry has been seen in the measured acoustic amplitude and frequency in the resonator. And the work done by the aeroacoustic source of sound can also be determined through the measurement of the air speed in front of and behind the junction in the wind tunnel.

Angular Correlation of Two 511 keV Gamma-Rays from Sodium-22

Niravkumar Patel, Matthew Tubbs and Vinh Lu
Faculty Mentors: Rahul Mehta, Stephen R. Addison, and Carl K. Frederickson

The purpose of this experiment is to verify the 180° separation of gamma ray produced from Sodium-22 (Na-22). Na-22 decays by either emitting positrons or capturing electrons. The emitted positron generates a pair of gamma rays with energy of 511 keV. In-order to measure the angle between gamma rays, a fixed and variable NaI(TI) detectors were used. A gamma-ray source was placed in the middle of two detectors. Using the detectors and the maestro software, the net count was measured for energy of 511 keV gamma rays at various angles. Data was plotted as the net count vs. angular separation, which showed a bell shaped curve with a mode at 180°. The result suggests that gamma-rays from the Na-22 source travel in exactly opposite direction relative to each other.

*Acknowledgements: Venkata Kummari, Dr. Jerome L. Duggan from University of North Texas (UNT)

Study of Bone Tissue of Hind-Limb Suspended Rats Using the Scanning Electron Microscopy†

Niravkumar Patel and Alec M Watson
Faculty Mentors: Rahul Mehta, Parimal Chowdhury (UAMS), Michael Soulsby (UAMS), and Nawab Ali (UALR)

Elemental composition of the bone tissue of rats after exposure to Hind-Limb Suspension (HLS) can provide us with an insight into the affects of microgravity. Two groups of rats were used as control, while other two groups were subjected to

HLS. After one to two weeks of maturity, rats were sacrificed. The hard tissues were cleaned of soft tissues using dermestid beetles. The leg bones were cross sectioned dried and sputter coated. Prepared samples from hard tissue of the rats were observed using Scanning Electron Microscope (SEM) 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). Electron beam from 10 keV to 20 keV were used to investigate the production of x-rays from areas that ranged from about 100 $\mu m^2$to about 1000μm^2. 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 software that could also correct for ZAF factors namely Z (atomic number), A (X-ray absorption) and F (characteristic fluorescence). The dead time of the detector was generally kept below 10%. The control groups and experimental groups were analyzed on well defined parts of the bones. The elemental composition of different hard tissue indicates a strong relationship between the compositional ratios of calcium, carbon, phosphorus and oxygen with the location on the tissue.

†Supported by Arkansas Space Grant Consortium

Determining neutron flux of a plutonium-beryllium source using Neutron Activation of Indium*

Kristopher Watson, Jacob D. Fenske and Shuang Xu
Faculty Mentors: Rahul Mehta, Stephen R. Addison, and Carl K. Frederickson

Neutron activation is achieved by bombarding a sample with neutrons until the sample becomes saturated. From this activated sample many answer can be obtained about the sample based on the perimeters given. The goal in this experiment was to obtain the neutron flux (of the Pu-Be source), which is defined as the number of neutrons in an area (square centimeters) per second emitted that is shot at the sample. The sample that was used to obtain the neutron activation in this experiment was Indium (contains isotopes of In-113 and In-115). Once the sample was activated it was placed in front of a Sodium Iodide detector for beta and gamma ray. This detector was attached to the Maestro software, which displayed the spectrum showing the various energy gamma rays coming from activated indium sample(mainly In-114 and In-116 isotopes). The intensity of the peaks was related to the neutron flux that reach the detector. The sample was left in front of the detector for half of In-116's half-life. The net area of one of these peaks was recorded. From this peak and its net area, characteristics of the Indium sample, properties of the detecting process, and the length of the activation time, the neutron flux of the source could be obtained.

*Acknowledgements: Lucas Phinney, Venkata Kummari, Dr. Jerome L. Duggan from University of North Texas (UNT)

BalloonSat and HOBOware

Jonathan R. White
Faculty Mentor: William V. Slaton

Vernier's LoggerPro is versatile piece of equipment that can easily be used in the classroom, as well as in the field to collect and store data. With a wide variety of sensors one can measure temperature, pressure and Carbon Dioxide levels, all of which are perfect for high-altitude balloon experiments. A downside to using LoggerPro is that it the data logger and the sensors needed weigh nearly a kilogram and can be very expensive. A gas pressure sensor and a temperature sensor together cost $130. However a trip to the local electronic hobby store and a few short clicks on the Internet can fix this dilemma. In place of the LoggerPro a person can purchase and use a HOBOware data logger. A temperature sensor can be assembled using a LM 335 temperature sensor, a couple of resistors, and a stereo cable. Likewise a pressure sensor can be constructed using a pressure sensor from Mouser.com, an amplifier, a few resistors. The sensors work by measuring the voltage across two pins of each sensor, as the temperature or pressure changes the voltage across each sensor increases or decreases depending on the sensor. The HOBOware data logger measures and stores the voltage of each sensor. While the HOBOware data logger may cost as much as a LoggerPro unit, the two sensors total cost less than $20. In addition the HOBOware data logger and the new sensors only weigh 0.6 kilograms, a much lighter alternative.

Interdisciplinary

Effect of leaf expansion and growth temperature on photosynthesis and solute leakage in cotton

Daryl Chastain, Matt Odom and Daniel Brinker
Faculty Mentors: John Choinski and William Slaton

The effects of the environment on leaf temperature and morphology have been extensively investigated, but how the environment affects growing leaves is less understood. Prior research has indicated that young leaves may be better able to tolerate thermal stress as measured by solute leakage, when compared to mature leaves. Young leaves have also been observed to have higher surface temperatures than mature leaves with little decrease in photosynthesis. Cotton plants grown in controlled environments were used to investigate the effects of temperature on photosynthesis (as measured by chlorophyll *a* fluorescence), light response curves (constructed through mathematical analyses of fluorescence- irradiance data) and membrane thermostability (through solute leakage studies). The broader goal of this research is estimate the impact of leaf expansion on overall plant productivity, particularly during periods of rising temperatures. This research is timely as global temperatures are expected to rise and already some cotton production climate models (for Stoneville, Mississippi) project as much as a 9% decrease in future yields.

Effect of growth temperature on fatty acid composition and FAD gene expression in cotton

Matt Morgan and Trent Hall
Faculty Mentors: John Choinski, J.D. Swanson and Karen L. Steelman

Plants have the ability to regulate their temperature tolerance by manipulating the degree of saturation of fatty acids in their leaf cell membranes. The mechanism appears to be based on the differential expression of fatty acid desaturase (FAD) genes coding for enzymes that convert saturated fatty acids (*e.g.*, 18:0 stearic acid)

to unsaturated derivatives with one or more double bonds (*e.g.*, 18:3 linolenic acid). For example, it has been shown that juvenile leaf stages with generally higher surface temperatures have lower amounts of 18:3 fatty acids than do cooler mature leaves. This study will provide information about the degree of fatty acid saturation (as measured by GC-MS) of maturing cotton leaves at two different temperature regimes maintained in controlled environments which mimic a warm day with a peak of 30°C and a hot day of 40°C. FAD gene expression will also be measured by isolating RNA and performing RT-PCR at each leaf stage and growth temperature. It is hypothesized that at the cooler growth temperature, there will be less expression of FAD genes and higher levels of unsaturated fatty acids when compared with plants grown under warmer conditions.

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