13th ANNUAL STUDENT RESEARCH POSTER SYMPOSIUM

COLLEGE OF NATURAL SCIENCES AND MATHEMATICS

UNIVERSITY OF CENTRAL ARKANSAS

BIOLOGY

The Estrogen Metabolite, 2-methoxyestradiol Inhibits Calcium Influx in Porcine Coronary Arteries
Keith Babbs
Faculty Mentor: Brent Hill

Survival Times and Physiological Responses of Hatchling American Alligators (*Alligator mississippiensis*) to Forced Submergence in Cold, Normoxic Water
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Is *Rubus* an Adequate Model System for Prickle Development?
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Abundance and Distribution of Fishes in a Floodplain Wetland Mosaic of the Mississippi River
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Luis R. Suazo
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BIOLOGY

The Estrogen Metabolite, 2-Methoxyestradiol Inhibits Calcium Influx in Porcine Coronary Arteries

Keith Babbs
Faculty Mentor: Brent Hill

The purpose of this study is to gain important information about how a specific estrogen metabolite affects calcium channels in coronary arteries. This information could be instrumental in understanding cardiovascular risks in post-menopausal women. nEstrogen can be rapidly metabolized to 2-methyoxyestradiol (2ME) at the arterial wall. Like estrogen, 2ME has a relaxant effect on arteries; however, the exact mechanism is not known. We hypothesized that 2ME attenuates arterial tone by inhibiting calcium influx. Right coronary arteries were obtained from female pigs and sectioned into 3 mm denuded rings which were suspended in organ baths. A concentration-response relationship to KCl (15 mM-80 mM) was generated after a 60 min incubation in the presence and absence of various 2ME concentrations (10^{-7} M to 10^{-4} M). 2ME (10^{-4} M) significantly inhibited the KCl depolarizing concentration-response relationship. To determine the direct effect of 2ME on L-type calcium channels, a similar experiment was conducted using 10^{-5} M BayK8644, an L-type calcium channel agonist, to induce a contraction. Inhibition of the BayK8644-induced contraction was demonstrated after a 60 min incubation with 10^{-5} M and 10^{-4} M 2ME. Our results suggest that 2ME decreases coronary arterial tone by inhibition of calcium influx.

Survival Times and Physiological Responses of Hatchling American Alligators (*Alligator mississippiensis*) to Forced Submergence in Cold, Normoxic Water

Ruth Bland
Faculty Mentor: Steve Dinkelacker

During winter, aquatic reptiles must cope with cold temperatures as well as prolonged periods of submergence under ice cover. American Alligators (*Alligator mississippiensis*) reach the northwestern limits of their range in Arkansas, where bodies of water can and do freeze occasionally. Since little is known about the submergence physiology of crocodilians in general, we initiated a study to determine survival times and physiological responses of hatchling American Alligators to submergence in normoxic water. Eggs were collected from a nest in southeastern Arkansas and were incubated at 31ºC. Thirty-one alligators were cold-acclimated to 5ºC over a 4-month period. Nine alligators were euthanized and plasma and tissue samples were analyzed for concentrations of lactate, glucose, and calcium. Three alligators were subsequently

warmed to 25ºC over a period of several weeks to determine if cold-acclimation protocols were survivable. Nineteen alligators were then submerged in 4°C normoxic water until the LT_{50} was reached. The remaining alligators were immediately euthanized, plasma and tissue samples taken and analyzed for the same physiological variables. All hatchlings survived the cold acclimation protocol. Hatchlings reach an LT_{50} at 21 hrs using the protocols in this study

Is *Rubus* an Adequate Model System for Prickle Development?

Tatum Branaman, Allicia Kellogg, Jordan Haas
Faculty Mentor: JD Swanson

Many plant species have the ability to produce an added defense mechanism in the form of spines, thorns, or prickles. Prickles have been described as an outgrowth of epidermal tissue; however, there is currently no molecular data regarding the development of prickles. The genus *Rubus* contains many genotypes, including the two genotypes Heritage (prickled) and Camby (prickleless). The goal of this study is to examine the morphological differences between the Heritage and Camby genotypes and thus determine if these *Rubus* genotypes are an adequate model system for studying prickle development. Thus far, microscopic images have been collected using both light and scanning electron microscopy. In addition, comparisons have been made in reference to the number and size of prickles on the Heritage and Camby genotypes. This study of the morphological differences of the *Rubus* genotypes will provide the foundation for future genetic analysis regarding prickle development.

Abundance and Distribution of Fishes in a Floodplain Wetland Mosaic of the Mississippi River

B. Lainy Burkard, Brad Williams
Faculty Mentors: S. Reid Adams, Ginny L. Adams

Floodplain habitat connected to the Mississippi River has declined and is particularly rare in upper and middle regions of the basin. Further, difficulty of sampling structurally complex, floodplain habitats has resulted in a general lack of data on floodplain fishes. The Missouri Department of Conservation recently purchased a tract of floodplain habitat in Scott County having a diversity of aquatic areas (e.g., lowland stream, floodplain pond, and beaver pond) that periodically connect with the Mississippi River. Our objective was to survey fishes found in the study area and to determine fish distribution within the aquatic mosaic. During June and October of 2006, fishes were collected with a seine and mini fyke nets in the stream and associated floodplain pond and beaver pond. A total of 24 fishes were collected, and species richness ranged from 16 to 7 among sites and seasons. Community composition was highly represented by native species of lowland faunal regions (e.g., *Aphredoderus sayanus, Elassoma zonatum, Amia calva, Lepomis*

gulosus, and *Etheostoma gracile*). The beaver pond contained the most unique assemblage characterized by sunfishes and banded pygmy sunfish. The data suggest the floodplain area continues to support fishes typical of complex, floodplain habitat, and this structural complexity is enhanced by beaver activity.

2-Methoxyestradiol's Attenuation of Vascular Spasms

Adam Cox, Paige Henry
Faculty Mentor: Brent Hill

2-Methoxyestradiol (2-MeOH) is a breakdown product of the major hormone, estrogen, in females. The goal of this study is to determine if 2-MeOH can prevent the constrictive effect of known agents (endothelin-1 and acetylcholine) that can induce vascular spasms of coronary arteries, which may lead to heart attacks. Coronary arteries were dissected out of hearts from female pigs, sectioned into rings, and suspended in organ baths. Rings were incubated with either 10-5 M or 10-6 M 2-MeOH for 60 minutes before applying 10-7 M endothelin-1 or 10-5 M acetylcholine. The constriction induced by endothelin-1 and acetylcholine appeared to be attenuated with 10-5 2-MeOH and by lowering extracellular calcium (0 mM calcium) in the physiological bath solution. This suggests that 2-MeOH at pharmacological concentrations (such as with medicinal applications) may antagonize possible vascular spasms.

Does Multiple Paternity Exist in the South Arkansas Population of American Alligators?

Kyle Dixon
Faculty Mentor: JD Swanson

A generally accepted principle of animal behavior states that animals act in such a way to maximize reproductive success. Reproductive success can be defined as the number of surviving offspring produced by an individual. One suggestion is that multiple paternity is a strategy to increase reproductive success (Madsen 1992; Gray 1997). By mating with more than one male, a female increases the chance that the offspring will receive greater genetic variation and therefore, may potentially increase future survival of the progeny. Forty-nine (49) eggs from an *Alligator mississippiensis* (American Alligator) nest near Tillar, Arkansas were collected. In anticipation of further screening of many American Alligator nests from south Arkansas, an efficient working protocol to genotype Arkansas American Alligators at UCA was established. This was achieved by using the one clutch that already had been collected. We elucidated efficient ways to extract DNA from alligator tissue and to amplify polymorphic microsatellite loci using the polymerase chain reaction (PCR). These amplified fragments of DNA were then visualized on an agarose gel and used to determine if multiple paternity existed in the clutch. After sizing and analyzing the bands of the four different polymorphic microsatellite loci, it can be

implied that multiple paternity exists in the clutch analyzed. Using the same techniques that were used to find multiple paternity in this clutch, many more clutches from south Arkansas can be analyzed and multiple paternity can be further established as a potentially common reproductive strategy for this population.

Taxonomic Distribution and Ecological Function of Girdling by Caterpillars of Prominent Moths (Lepidoptera: Notodontidae)

Carissa Ganong
Faculty Mentor: David Dussourd

Many plants emit latex or resin from pressurized canals as a defense against herbivores. Insects that feed on these plants commonly circumvent the defense by cutting leaf veins and then feeding beyond the severed veins on unprotected leaf tissue. Surprisingly, some insects show similar behaviors on plants that do not emit defensive secretions. Caterpillars of prominent moths (family Notodontidae), for example, sometimes cut a circular ring (girdle) around the leaf petiole or stem before feeding. They feed on hardwoods such as oaks and maples that do not emit latex or other exudates. The ecological function of their girdling has not been studied. We plan to address four questions: (1) which notodontid genera/species girdle, (2) when do caterpillars girdle – i.e. during certain instar(s), at selected times of year, under certain weather conditions – and where and when on the leaf relative to feeding, (3) what plant vascular tissues are severed by girdling, and (4) what benefits do the caterpillars derive from girdling? Preliminary data indicate that girdling behavior occurs in at least two distinct branches of the notodontid family. Caterpillars typically girdle in the ultimate or penultimate instar, and environmental conditions appear to affect girdling frequency.

Do Estrogen Metabolites Elicit A Greater Arterial Relaxation Than Estrogen?

Sene Gebre, Edwin Muldrew
Faculty Mentor: Brent Hill

The incidence of coronary artery disease (CAD) increases dramatically in women following menopause. This increase in CAD has been linked to a decline in 17β-estradiol (most prevalent form of estrogen) levels in the bloodstream. One of 17β-estradiol's protective effects against CAD is its ability to dilate arteries. The purpose of our study is to compare the relaxant effect of 17β-estradiol, and its metabolites, 2-hydroxyestradiol, and 2-methoxyestradiol. Right coronary arteries were obtained from hearts of female pigs. The arteries were sectioned into 3 mm rings and suspended into organ baths. The artery rings were pre-constricted with a 60 mM potassium solution, thus causing

depolarization and a resultant contraction. Once peak contraction was reached, the concentration-response relationship ($3x10^{-7}$ to$1x10^{-4}$ M) was generated using 17β-estradiol, 2-hydroxyestradiol, 2- methoxyestradiol, and its vehicle control (ethanol). Arterial rings were incubated in each respective estradiol compound for either 30 or 50 minutes. Overall tone (contraction or relaxation) of the segmented artery rings was measured and recorded using the Dataq acquisition system. Preliminary analysis suggests that a 50 min incubation is necessary to elicit the full relaxation effect (in order of potency) for which 2- methoxyestradiol and 2-hydroxyestradiol are fairly equal, but both greater than 17β-estradiol.

Population Dynamics of Grotto Sculpin (*Cottus carolinae*) in Perry County, Missouri

Joseph E. Gerken, Bruce R. Moyer
Faculty Mentor: Ginny Adams

A population of *Cottus carolinae*, commonly referred to as Grotto Sculpin, appears to be in the process of adapting to the cave environment. The Grotto Sculpin, endemic to caves in Perry County, was listed as a federal candidate species in 2002 and assigned a priority number of 2, indicating an imminent threat to the species exists. Due to the unstable nature of the cave environment in Perry County, Missouri, it is imperative to obtain baseline data on the population ecology of Grotto Sculpin and factors influencing their ability to repopulate caves in response to a catastrophic event (e.g., a contaminant spill). One population (Running Bull Cave) was thought to be extirpated, possibly due to contamination of the cave stream by agricultural chemicals from a nearby sinkhole (Burr et al. 2001). This study examined Grotto Sculpin movement and growth using a mark-recapture study. Fish were marked using a variety of locations and colors in order to allow individual fish to be identified when caught on future trips. Growth curves were used to identify trends in individual growth. Most fish moved were found to be highly sedimentary, often moving less than 50 meters between recapture events. This study will allow for the quantification of important population/individual parameters (population size, longevity, growth rates and habitat use) of the Grotto Sculpin and will provide a baseline from which to monitor populations in the future.

Effects of Commercial Harvest on Alligator Snapping Turtles (*Macrochelys temminckii*): A Comparison of Population and Life History Characteristics of Protected and Non-protected Populations in Arkansas

Travis W. Henry
Faculty Mentor: Stephen A. Dinkelacker

With the possible renewal of a commercial harvest season for Alligator Snapping Turtles (*Macrochelys temminckii*) in the state, it is pertinent that our understanding of the effects of previous harvests on these animals. This project proposes to examine the population characteristics of Alligator Snapping Turtles in Holla Bend National Wildlife Refuge and to compare these results with those obtained at a commercially impacted site. Holla Bend National Wildlife Refuge is potentially important because the refuge may be one of the least impacted populations in Arkansas because it was created in 1957, which is almost a decade before harvesting reached its climax in the state. A study of Holla Bend National Wildlife Refuge will allow us to make a comparison of life history characteristics of a protected population to an exploited population at Cadron Creek. This study will take place during April through July of 2007. I will capture turtles using hoops nets baited with rough fish. The sex and mass of each turtle will be determined, reproductive status of the females will be confirmed via ultrasound, morphometric data will be collected, and ages will be estimated using the established methods. Nests will be located by searching the banks and shallow areas on foot. Reproductive characteristics such as clutch size, egg size, nest temperature, location, and disturbances will be recorded.

Habitat Distribution and Life History Characteristics of Arkansas Turtles

Kate M. Howard
Faculty Mentor: Stephen A. Dinkelacker

Every species occupying the same habitat fills a different niche in order to coexist with each other. A main feature that often separates niches is the morphology of a species because it can often account for specializations in lifestyle such as diet or habitat selection. For the Western Chicken Turtle (*Dierochelys reticularia miaria*), no studies have been published, so it is my objective to answer a question regarding the diet of *D. r. miaria* and its link to the characteristic long neck of the species. To accomplish this goal, I intend to flush the stomachs of three species of turtle and compare their diets and morphological features. The Red-Eared Slider (*Trachemys scripta elegans*) is found sympatrically (i.e inhabits the same space and time) with *D. r. miaria*, drawing the comparison of diet partitioning. The Spiny Softshell (*Apolone spinifera*) has similar long neck morphology that makes it a natural species for morphological comparison. After stomach flushing, a sample of each species (n=10) will be placed into a series of tanks intended to represent three major habitats encountered by turtles. Each tank will consist of clean water with a base of sand, however, one tank will also contain woody debris, another tank will have a mass of fake vegetation, and the third will remain open. Each tank will have 4 types of prey (crayfish, minnows, tadpoles, and insects (order: Orthoptera)) and a turtle will be placed in the habitat for 1 hour, after which prey will be removed and counted to determine which type each species was most successful at capturing and in which habitat.

Habitat Selection in Alligator Snapping Turtles (*Macrochelys temminckii*): Correlates of Sex, Reproductive Status and Thermoregulatory Requirements

Christopher A. Howey
Faculty Mentor: Stephen A. Dinkelacker

Reptiles thermoregulate in order to maintain body temperatures within a preferred range, which in turn increases metabolic rate. By increasing and maintaining metabolic rate, reptiles may provide more energy for daily activities (e.g., feeding, foraging, digestion, growth, and reproduction). Among these different activities, reproduction is the only one in which preferred body temperature may be dependent upon sex and reproductive status. Since the body temperature of a reptile relies heavily on surrounding environmental temperatures, habitat selection should differ between males and females. Furthermore, habitat selection should differ between gravid females and non-gravid females. Whereas most freshwater turtles leave the water to bask, the Alligator Snapping Turtle (*Macrochelys temminckii*) rarely exhibits this behavior (Pritchard 1989). Instead, Alligator Snapping Turtles may use warmer aquatic habitats when reproductively active. The goal of this project was to record habitat selection for this species and to determine if there are any differences in habitat use among males, gravid females, and non-gravid females. Towards this end, we used radio-telemetry to locate turtles throughout the year. Upon locating a turtle, habitat characteristics were recorded for that location and a random location. Habitat selection was determined by comparing random locations to turtle locations and habitat use was compared among the three groups (males, gravid females, and non-gravid females). Based on differences in habitat use among the three groups, inferences were then made on whether thermoregulatory requirements influence habitat use and selection.

A Closer Look at the Developing *Rubus* Prickle

Allicia Kellogg, Ben McMurry, Jordan Haas, Tatum Branaman, Felicia Plunkett
Faculty Mentor: J.D. Swanson

Plants and animals both have dermal tissue that serves to protect them from pathogens entering the body. Some plants have an additional line of defense arising from thorns, prickles, and spines, these can serve to protect the plant from herbivores. Surprisingly, there is very little known about a prickle's morphology and developmental and molecular mechanisms. To initiate studies on prickle development, we have selected as our model system the genus *Rubus*, which include the brambles. *Rubus* species are a very good choice for prickle development research since both prickle and prickleless varieties exist allowing precise genetic comparisons to be made. Generally, growth in plants originates from special groups of cells called meristems. Meristem cells maintain an embryonic state and continually divide throughout the life of the plant. Currently it is unknown if

prickles develop from a meristematic origin. The objectives of this research are to determine, in *Rubus*, the tissue layers and morphology of prickles at various times of development, and if prickles develop from meristems. To this end, we have completed both light and scanning electron microscopy studies to precisely determine various cell layers and morphologies of *Rubus* prickles. In addition, we have selected gene candidates that may be involved in meristem development of other plant organs, and we are extracting gene sequences specific to *Rubus* to determine if existent meristem genes play a role in prickle development.

Evaluation of Secondary Metabolites of Invasive and Native Honeysuckle Flowers for Antimicrobial Properties

Sang Lee, Tiffany Harris
Faculty Mentors: Umadevi Garimella John Choinski*

Increasing prevalence of multi-drug resistant bacterial pathogens in food safety necessitates search for newer indigenous plant resources with antimicrobial properties. One approach is to identify plants that are used in traditional medicines that have potential bactericidal/static activities. The search can then be extended to the same species growing in different habitats or to related plants in the same genus. In this study, Japanese honeysuckle, (*Lonicera japonica,* family Caprifoliaceae) a well known plant used in Chinese herbal medicine, and two related species, trumpet honeysuckle (*L. sempervirens)* and winter honeysuckle (*L. fragrantissima*), were compared for relative antimicrobial activity. The antimicrobial activities of petroleum ether, methanol, and water-based plant extracts were evaluated using the disk diffusion assay against seven bacterial strains (*Bacillus cereus, Bacillus subtilis*, *Enterococcus faecalis, Escherichia coli, Pseudomonas aeruginosa, Salmonella typhimurium and Staphylococcus aureus*). Preliminary screening of these extracts indicated that all three species exhibited antimicrobial activity against one or more of the tested microorganisms. The native honeysuckle, *L. sempervirens,* exhibited the highest antimicrobial activity when compared to the invasive, *L. japonica.* Overall, methanol and water extracts elicited a wider range of antimicrobial activity against tested pathogens. However, a petroleum ether extract of *L. fragrantissima* showed maximum inhibition of bacterial growth. This is the first investigation showing evidence of antimicrobial activity in extracts from trumpet and winter honeysuckle and also the first (to our knowledge) to compare the expression of antimicrobial activity in native and introduced species growing in same habitat.

* Collaborator and a mentor: Dr. Rajesh Nayak, Microbiology Division, National Center for Toxicology Research, Jefferson AR.

Effects of Hypoxia on Apoptosis Induction in MCF-7 Human Breast Cancer Cells

Students: Tony Manning, Kyle Basham
Faculty Mentors: Steven Runge, Patrick Desrochers

Recently there have been research efforts targeted at developing drugs that will treat platinum resistant tumors. One facet of these efforts has been aimed at the cytotoxic activity of dppe-phosphorous ligand compounds. The compound [dppeNiIICYSEt+] Cl-, developed in the laboratory Dr. Patrick Desrochers, has cytotoxic activity in the human breast cancer cell line, MCF-7. Preliminary experiments have shown the compound to induce apoptosis at concentrations at or above 5 _M.

Additional cancer research has focused on the complex microenvironment produced by solid tumors. Most notably, the microenvironment is characterized by hypoxia or the inadequate supply of oxygen. This oxygen deficiency is a result of poor vascularization, deteriorating diffusion geometry, severe structural abnormalities of tumor microvessels, and disturbed microcirculation within the tumor. This contributes to other problems commonly associated with tumor microenvironments such as decreased pH in both the cytosol of individual cells and the extracellular fluid. It is important to address these unique conditions in the testing of novel chemotherapeutic agents.

We have cultured MCF-7 cells under hypoxic and normoxic conditions as well as a variety of pH levels, and exposed them to the [dppeNiIICYSEt^{+}]Cl^{-} compound in order examine and compare its effects on the cells under realistic micro environmental conditions. Preliminary experiments have suggested that the compound will have greater efficacy when the cells are placed in more stressful (i.e. low pH, low oxygen) environments.

Scanning Electron Microscopy: Analysis of Endothelial Integrity After its Mechanical Destructionin Coronary Arteries.

Tiffany Mattingly, Lauren Sideroff
Faculty Mentor: Brent Hill

The endothelium is a single layer of squamous cells that lines blood vessels creating an interface between the blood and vessel wall. Theses cells secrete and modify vasoactive substances that contract and relax vascular smooth muscle. Removal of the endothelium allows for the direct study of smooth muscle. Current techniques for removing the endothelium include its scraping with a forceps, rubbing with a cotton swab, or using a chemical detergent. Our lab is currently using an alternative method of twirling a toothpick in the lumen of the artery to remove the endothelial surface. We believe our method is as effective as other methods, but less invasive. To test the effectiveness of this method, scanning electron microscopy (SEM) was used to analyze endothelium intact (+E) versus endothelium removed (-E; via a toothpick) coronary arteries. +E artery

samples had little surface damage and appeared as a smooth sheet of cells. The -E samples demonstrated many ridges and loose fibers, which shows that the endothelium was destroyed; however, the smooth muscle below was in good condition. Overall, SEM analysis confirms that we can effectively remove the endothelium of an artery using a toothpick.

Microwave Extraction of Alkaloids from *Lobelia cardinalis* Leaves: Method Development

Craig Oppel
Faculty Mentors: David Dussourd, Uma Garimella

To quantify levels of defensive compounds in leaf samples, leaves are typically dried, ground, and extracted with solvent. All information on the location and distribution of these compounds within the leaves are lost. This limitation was recently addressed by Nitao and Zangerl (2004), who described a novel method that allows visualization of the two dimensional distribution of compounds in leaves. They used microwaves to extract furanocoumarins from *Pastinaca sativa* (wild parsnip) leaves onto paper media. Here we report our modification of the microwave technique for visualizing and quantifying alkaloid distribution in leaves of *Lobelia cardinalis* (cardinal flower). We have experimentally modified the following variables to optimize alkaloid extraction and print resolution: 1) leaf harvesting methods, 2) extraction solvents, 3) leaf water content, 4) media type, 5) microwave oven extraction time, and 6) microwave oven power levels. Our final procedure produces high resolution leaf prints of alkaloid distribution on thin layer chromatography plates (Whatman silica-gel G -250μm). We use toluene as the extraction solvent and Dragendorff's reagent for visualizing *Lobelia* alkaloids. Image processing methods for quantifying alkaloid content based on the color intensity of the Dragendorff's reaction with alkaloids are discussed.

Temporal Patterns of Development in Southern Brook Lamprey (*Ichthyomyzon gagei*) in Cadron Creek, Arkansas

Sarah Pavan
Faculty Mentors: Ginny Adams, Reid Adams

Lampreys are one of the few living representatives of the ancient jawless fishes. Of the four species in Arkansas, three are nonparasitic, including Southern Brook Lamprey, *Ichthyomyzon gagei*. *Ichthyomyzon gagei* live for approximately 51 months and have a distinct larval and adult period. Subsequent to spawning, adults die due to loss of the digestive tract that occurs during adult transformation. Several prior studies have concentrated on *I. gagei* in other states but few have included Arkansas populations. Specimens were collected from September 2004 through April 2005 with a backpack electrofisher. Total body length and eye diameter were measured with digital calipers.

Weights of digestive tract, gonads, fat, and total body were measured with an Ohaus analytical balance. Eye diameter increased significantly throughout the collection period in both metamorphosing and non-metamorphosing individuals. Metamorphosing individuals developed a significantly larger eye compared to non-metamorphosing individuals. Gonadal development began in November and gonadosomatic index (GSI) peaked in January and remained high through February. In metamorphosing individuals GSI was negatively correlated with both visceral fat ($r = -0.73$, $P < 0.001$) and digestive somatic index ($r = -0.72$, $P < 0.001$). Digestive tract mass of metamorphosing specimens decreased sharply during early (September to November) metamorphosis to a nonfunctional remnant and feeding ceased. As a result, energy stored as fat is utilized for the large energy requirements of gonad development.

The Effects of Roadways on the Nest-site Selection of a Semi-aquatic Turtle Species

Sara Ruane
Faculty Mentor: Stephen A. Dinkelacker

Although the protection of wetlands is of critical importance to the survival of many species, the conservation of upland areas surrounding wetlands is often not legally required, or is simply overlooked. Many species of turtles require upland habitats to successfully complete their life cycles. For example, the Blanding's turtle (*Emydoidea blandingii*) is a species that depends upon upland habitats for successful nesting and, ultimately, population recruitment. Currently, it is unknown how nest-site selection and the demographics of remote populations compare to populations residing in wetlands bisected by man-made constructs such as roads. Beginning in summer 2005, Blanding's turtles were trapped in remote and roadside sites in western Nebraska. Through the use of radio-telemetry or direct observation, gravid females were followed to nest sites and habitat data were recorded, including distance from water, vegetation cover, and soil characteristics. Nest-site data were compared to random location data in order to help assess nest-site use compared with site availability. Preliminary analyses suggest that, during nesting, females at remote sites travel farther from their home wetland in order to nest than those at roadside sites, and that aspect may be an important component in nest-site selection. Comparisons with common snapping turtles (*Chelydra serpentina*) will also be made.

A Comparison of Turtle Populations in Arkansas and Nebraska

Geoff Smith
Faculty Mentor: Steve Dinkelacker

In turtle communities, species richness tends to decrease with increasing latitude. We studied the structure of two turtle communities, one in Nebraska and one in Arkansas. Only three species were found in Nebraska, and the predominant species, *Chrysemys picta belii*, comprised 78.5% of all turtles captured. Although six species were found in Arkansas, *Trachemys scripta elegans* represented 86.7% of all turtles captured. Given the generalist characteristics of both species, we questioned whether they had similar population characteristics. Although similar in size, the two dominate species were significantly different in terms of sex ratio and adult to juvenile ratios. The only species that inhabited both sites was *Chelydra serpentina*, but it had significantly larger populations and densities in Nebraska. In fact, only three were caught at the Arkansas site, compared to more than eighty in Nebraska. Two species of *Chrysemys* were captured during the study. *Chrysemys dorsalis* was caught in Arkansas, and *Chrysemys picta belli* was caught in Nebraska, albeit in different abundances and population structures. Results of this study suggest that the species composition of turtle communities changes with increasing latitude. Specifically, *Chrysemys picta belli* replaces *Trachemys scripta elegans* with a concomitant increase in *Chelydra serpentina* populations. Although explanations for this pattern are unknown, possible reasons could include physiological tolerances to cold, reproductive fecundity, or reduced competition

Developmental Differences in Leaf Temperature, Gas Exchange, and Photosynthetic Temperature Optima in Sumac

John Snider
Faculty Mentor: John Choinski

Previous investigations of leaf development have shown that young, not fully expanded tree leaves have lower photosynthesis rates and stomatal conductance than more mature leaves. We, thus, hypothesize that the resulting lower rates of evaporative cooling would also lead to higher mid-day leaf temperatures in young leaves, possibly promoting growth and expansion during cooler spring weather. To test these hypotheses, attached sumac (*Rhus glabra*, *R. copallina*) leaflet temperature was measured from April-June 2006 at two sites in Arkansas using an infrared thermometer; air temperature was monitored with a data logger fitted with a temperature sensor; and gas exchange measured using an infra-red gas analyzer. Growth temperature optima for photosynthesis of leaflets were estimated by measuring the dark recovery of variable chlorophyll fluorescence (F_V/F_0) in leaflet segments with a portable PAM fluorometer. We found that (at midday in full sun) young leaflets had significantly higher adaxial temperatures, lower leaf-air temperature differentials, stomatal conductance, and photosynthetic rates than did more mature

leaflets. Also, fluorescence data showed that young leaflets had a higher optimum temperature for F_V/F_0 recovery than more mature leaflets. Taken together, we interpret this data to mean that the higher temperatures exhibited by young leaflets in the spring promote growth and expansion through an effect on the temperature sensitive components of PSII (photosynthesis).

Mapping the Subplate: Where Does It Lead Us?

Terri Teague-Ross, James Hyde, Adam Lucas, Corrie Rowe
Faculty Mentor: Barbara Clancy

Subplate neurons are a special population of cells that are found in the white matter beneath the cortex of the brain. The cortex is the outer layer of the brain (gray matter). Cells of the cortex participate in cognitive function, while the white matter consists mainly of projections from the cortex and other cells, covered in a fatty substance called myelin. Subplate cells were once thought to disappear after development ended, however in our lab, we study a portion of subplate cells that persist across adulthood, maintaining long-range connections with the cortex. Since little is known about these seldom-studied cells, researchers are unsure what role(s) they may play in the mature brain, although we hypothesize they have importance, especially since they are disrupted in schizophrenia and other disorders. Because structure and function are known to be related in all biological systems, it follows that if we can map the normal three-dimensional (3-D) structure of the subplate population, we may be closer to discovering the role(s) these mysterious cells play in normal and abnormal brain function. We study the precise location and structure of these cells by use of microinjection, and light/confocal microscopy. We are currently mapping out the first 3-D computer models of the persisting subplate cells, and analyzing them statistically.

Structure-Function Analysis of Caf4 and Mdv1 to Reveal Their Discrete Roles in Mitochondrial Fission

Sara Weinberg, Emily Culbreth
Faculty Mentor: Kari Naylor

Mitochondria are double-membrane organelles responsible for cellular respiration. Respiration or breathing is the process that creates cellular energy in the form of ATP, thus mitochondria make ATP. This function is dependent upon a specialized structure; mitochondria are tubular and highly branched, quite unlike the jellybean structure shown in textbooks. This specialized structure is maintained by two classes of membrane events, known as fusion and fission. Fusion is the merging of mitochondria, where fission is the division of mitochondria. If these events are not balanced, the structure will be compromised, leading to mitochondrial disease, which may cause blindness and hearing loss.

In *Saccharomyces cerevisiae*, our model system, there are three proteins, Dnm1, Fis1, and Mdv1 required for mitochondrial fission to take place. A newly identified protein, Caf4, a homolog to Mdv1, has also been suggested to play a role in fission; however, little is known about its function. The purpose of these experiments is to determine the role of Caf4 in mitochondrial fission by determining the separate and distinct functions of Mdv1 and Caf4. Crude domain swapping between three domains of Caf4 and their corresponding domains of Mdv1 will be achieved using a yeast gap repair cloning method. The role of Mdv1 and Caf4 in fission will be analyzed by quantifying the number of fission events that occur in wild-type and several mutant yeast strains in the presence of each construct.

Currently, our work has focused on construction of the first plasmid, GFP-Caf4. Here we will present the techniques of gap cloning in yeast and explain mitochondrial dynamics. Results from this work will give us insight into the mechanism of mitochondrial fission and further understanding of the relationship between mitochondrial dynamics, structure, function and disease.

Patterns of Macroinvertebrate Community Structure and Diversity Across a Gradient of River-Floodplain Connectivity

Bradley S. Williams
Faculty Mentor: Reid Adams

A limited number of studies have examined the effects of river-floodplain connectivity on macroinvertebrate community structure and diversity, and even fewer have utilized a multi-spatial scale approach. This study is assessing these effects by sampling macroinvertebrates within the vegetated shoreline of 18 floodplain waterbodies with different degrees of connectivity to the Arkansas River. Present analysis includes core samples from 3 floodplain waterbodies contiguous with the main channel and 3 waterbodies intermittently connected during supra-bankfull flooding. Of the 61 taxa collected, 11 were only found in contiguous sites and 17 were only found in intermittent sites. Contiguous sites were characterized by taxa such as *Corbicula fluminea* and unionid mussles that are common in the main channel. Intermittent sites were characterized by a high diversity of Hirudinea, Coleoptera, and Odonata taxa. There was no significant difference in α diversity between contiguous and intermittent sites; however, the β-1 diversity index was higher in the intermittent sites (32.427) than contiguous sites (29.517). Results indicate that waterbodies with different degrees of connectivity have distinctive macroinvertebrate communities, and that the higher β -1 values for intermittent sites may be a result of variable flooding frequencies which range from every 1yrs to >15yrs.

CHEMISTRY

Using a Photolabile Precursor to Study Radical-Mediated Protein Damage

Trinh Thi Ba, Benjamin Frizzell, Tori Green
Faculty Mentor: K. Nolan Carter

Free radical intermediates are involved in the degradation of a variety of biologically and industrially significant materials. Radical-induced damage pathways are often initiated by reactive oxygen species such as hydroxyl radical (OH•). Sources of this reactive agent include ionizing radiation and decomposition of hydrogen peroxide produced as a consequence of metabolism. An hydroxyl radical reacts with amino acids by either addition or hydrogen atom abstraction. Both reactions are nonspecific: they can occur at multiple locations within a protein and at multiple sites within an amino acid Consequently, the pathways by which an hydroxyl radical damages proteins and other compounds are complex and difficult to unravel. Despite the significance of radical-mediated damage of biomolecules, many questions regarding this process remain unanswered. The objective of this project is to independently generate and characterize key radical intermediates in this process. This will be accomplished by the design and synthesis of modified selenium containing amino acids which are anticipated to generate the a primary and tertiary radicals formed from reaction of OH• with the valine isopropyl group.

Photolysis of the Pesticide Permethrin in Solution and Adsorbed on Surfaces: A Continuing Study in Environmental Chemistry Lab

Bridget Burkard, Stan Chivers, Michael Gray, Jeremey Mackey, Ram Pandey, Drew Pendergraft
Faculty Mentor: Donald Perry

One of the major issues environmental chemists face today is how pesticides break down in various environments under different conditions. Permethrin, a common pesticide derived from the chrysanthemum flower, was used as the primary compound of investigation. Fourier transform infrared spectroscopy (FTIR), in conjunction with an attenuated total reflectance (ATR) attachment and gas chromatography mass spectrometry (GCMS), were the instruments used to analyze permethrin breakdown as a function of exposure to ultra-violet light while in a methanol solution or adsorbed on either silver powder or sand. This study was performed for the first time this spring 2007 in the environmental chemistry laboratory (CHEM 4152), and represents a study future students will continue to build and approve upon in following years.

Surface-enhanced Vibrational and Mass Spectroscopic Investigation of Aromatic Isomers Adsorbed on Vacuum-Evaporated Ag Films and Ag Powders

Brittany Carpenter, Jacob Boucher, Krissy Posey, Ram Pandey, Nathan Shirley, Scott Cordova, Sean Oakley
Faculty Mentor: Donald Perry

Our recent work involving the adsorption of the aromatic isomers *ortho*-, *meta*-, and *para*-nitroaniline on vacuum-evaporated Ag films and Ag powders has been expanded to a host of other aromatic isomers in order to better understand the nature the chemical interaction of these isomers with solid surfaces. The isomers include the nitrophenols, aminophenols, aminobenzoic acids, nitrobenzoic acids, and halogenated (F-, Cl-, and Br-) benzoic acids. Surface-enhanced infrared absorption (SEIRA) and surface-enhanced Raman spectroscopy (SERS) are techniques that allow us to see how a thin layer of an organic molecule interacts with a surface by observing how specific molecules vibrate when adsorbed on the surface. The strength of the interaction of the aromatic isomers are also being explored using a mass spectroscopic technique called temperature-programmed desorption (TPD). TPD is a technique that allows us to determine how hot we must heat a surface in order to volatize an organic molecule sitting on the surface; the amount of heat it takes to volatize a given adsorbed compound correlates directly with the strength of the interaction of the molecule with the surface.

The Importance of Pi Bonding in Nickel-Cysteine Interactions

Davis Duong, Ariel Marshall
Faculty Mentor: Patrick Desrochers

Cysteine plays a significant role in the biological chemistry of metals. This amino acid binds nickel directly in two bacterial enzymes, abbreviated CODH and Hase; these enzymes catalyze the processing of hydrogen and carbon monoxide in bacteria. Because such reactions use industrially and commercially important raw materials and potential alternative fuels, there is continued interest in understanding the role that nickel-cysteine bonding plays in these systems. It is hoped that more efficient methods of producing and using hydrogen could emerge from such research. The results presented here involve newly synthesized phosphine-nickel-cysteine complexes, as models of similar groups in the above enzymes. We show spectroscopic evidence for the importance of nickel-sulfur (from cysteine) pi bonding in controlling the shape of the nickel-cysteine unit. Shape affects the movement of electrons through the nickel-cysteine bond, so this offers insights into the movement of electrons through both the CODH and Hase enzymes. This pi bonding also influences the reactivity of nickel-cysteine toward hydrogen ions, a key step in catalytic cycles for Hase. Results will be related to their implications for nickel-cysteine bonding in these enzymes.

Plasma Oxidation and AMS Radiocarbon Dating for the Chauvet Cave Multi-laboratory Intercomparison

Jacque DuPriest
Faculty Mentors: Karen Steelman (UCA),
Marvin Rowe (TAMU), Thomas Guilderson (LLNL), Hélèn Valladas (LSCE)

As part of an inter-laboratory comparison, three charcoal samples from la grotte Chauvet (Ardeche, France) were radiocarbon dated using plasma oxidation and accelerator mass spectrometry. Four other laboratories involved in the intercomparison employed acid/base/acid pretreatment and combustion. We tested different pretreatments including base only and acid/base/acid. Differences were found in the dates not associated with pretreatment but with the filtration process after pretreatment. We corrected our methods to obtain results that correlate with dates obtained on the same materials using combustion, agreeing with a weighted average of 32,000±100 years BP obtained by the other laboratories in the intercomparison.

Development of Peptidomimics as Sensors for Opiates

Ashley Evans, Nick Gleason, Tamara Binyon
Faculty Mentor: Richard Tarkka

Peptide mimicry is being used as a strategy for developing an opiate sensor. The amino acids implicated in the binding of opiates in the rat u-opiod receptor are adjacent Asp(147)-Tyr(148) and Trp(318)-His(319) residues. Our strategy is to build a parallel combinatorial oligopeptide library, in which the 170 amino acid sequence that connects the four binding amino acids (in the native protein) is truncated to four residues. The library members will be screened for binding by exposure to a colored opiate derivative and looking for visible color changes in the library members. The status of this project will be reported.

Analysis of Ancient Peyote by Alkaloid Extraction and Gas Chromatography

Bethany Glover, Kim Morrison
Faculty Mentor: Karen Steelman (UCA),
Martin Terry (Sul Ross)

Peyote use has been a part of Native American culture for 6000 calendar years, according to radiocarbon dating done by our laboratory. Artifacts labeled as peyote in the Witte Museum collection appear to be modified due to the presence of woody tissue. A high mescaline content would identify the artifacts as containing peyote. We used three

different extraction protocols to determine the method detection limit for alkaloids from modern peyote. Standards were used to construct a calibration curve to quantitate mescaline levels using gas chromatography / mass spectrometry. Once isolation procedures are perfected for the smallest viable sample size, peyote from the only two archaeological sites where the cactus has been found will be analyzed.

Radiocarbon Dating of Western Australian Rock Paintings

Josh Loewen, Jeremy Mackey
Faculty Mentors: Karen Steelman (UCA),
Josephine McDonald, Peter Veth (ANU), Thomas Guilderson (LLNL)

Along the Canning Stock Route in the Western Desert of Australia, there are approximately 140 known rock art sites in the Calvert and Carnarvon Ranges. We seek to place these rock art images in the context of human endeavor through time. Twenty-six samples from Aboriginal rock paintings were collected for chemical pretreatment, plasma oxidation, and accelerator mass spectrometry radiocarbon dating. An age of 745 ± 45 years BP was determined for charcoal painting of a phytomorph. This result is consistent with known human occupation patterns in the area from archaeological excavations. Future work will concentrate upon further analysis of charcoal and inorganic-pigmented paint samples.

Measurement of ^{14}C Content in Mexico City Atmospheric Aerosol

Amanda MacMillan
Faculty Mentor: Karen Steelman (UCA),
Jeffrey Gaffney, Nancy Marley (UALR), Thomas Guilderson (LLNL)

Radiocarbon concentrations were measured on eleven atmospheric aerosol samples to determine the carbonaceous source, whether fossil fuel or biomass. Samples were collected on quartz filters at El Centro Nacional de Investigación y Capacitación Ambiental in Mexico City during April 2003. Collection occurred on the rooftop of the main laboratory building using high-volume air samplers equipped with a with a 1 micron cutoff. A plasma oxidation apparatus was used to oxidize the aerosol samples to carbon dioxide and water. The radiocarbon content in the carbon dioxide was then measured using accelerator mass spectrometry to determine the contribution from fossil fuel. Radiocarbon levels showed an average 68% modern biogenic carbon to fossil carbon ratio. Potential biogenic sources may include: fires in the Yucatan; inter-city trash burning; and oxidation of monoterpenes and sesquiterpenes from a nearby fruit-drying facility.

Separation and Isolation of Metabolites of *N*-(4-hydroxyphenyl) Retinamide (4-HPR) After Incubation With Sprague-Dawley Rat Liver Microsomes

Emily Malcolm
Faculty Mentor: Melissa Kelley

Vitamin A and its analogs, retinoids, are essential for many critical life processes including vision, reproduction, and cellular development. N-(4-hydroxyphenyl)-retinamide (4-HPR) is a retinoid currently being tested for its anti-cancer activity. Currently, 4-HPR metabolites have been isolated but the enzymes responsible for its metabolism are unknown. The cytochrome P_{450} family is responsible for the metabolism of many xenobiotics, including retinoids. The overall goal of this study is to determine if cytochrome P_{450} is responsible for the metabolism of 4-HPR. In our study, Sprague-Dawley male rat microsomes were incubated with 4-HPR for one hour in combination with a NADP regenerating system. The sample components were separated and isolated using reverse-phase HPLC with PDA detection. The parent compound was identified with a retention time of 14 minutes and a maximum absorbance of 360 nm. Current work includes identifying possible metabolites and determining which cytochrome P_{450}'s are responsible for the metabolism of 4-HPR.

Investigation of DNA Damage Induced by the Chemotherapeutic Drug Cyclophosphamide

Akhil Mehta, Jacob Smith
Faculty Mentor: Nolan Carter

This work seeks to investigate the mechanism by which cyclophosphamide, a widely used chemotherapeutic agent, damages DNA. Like many anticancer drugs, cyclophosphamide results in the covalent linking of tumor DNA strands. This research investigated the extent to which other species present in cells affect the efficiency of this process. Glutathione, which is often present at high levels in tumor cells, is known to result in inactivation of cyclophosphamide. This study used a model system to investigate the competition between the beneficial DNA damaging reaction and the undesired deactivation of the drug by glutathione. The reactive species formed from cyclophosphamide in vivo was obtained by chemical synthesis. Imidazole and 2'-deoxyguanosine were used to model the nucleophilic sites found in the DNA double helix. At high glutathione concentrations, deactivation of the drug becomes significant; an observation which should guide the design of new treatments.

Reactions of $Cu^+(^1S, ^3D)$ With CF_3X (X=Cl, Br, I)

Scott R. Musial, Cullen C. Matthews
Faculty Mentors: William S. Taylor, Micah L. Abrams

State-specific reactions of $Cu^+(^1S)$ and $Cu^+(^3D)$ with CF_3X (X = Cl, Br, I) have been carried out in a selected-ion drift cell apparatus. $Cu^+(^1S)$ participates in association exclusively with all three of these neutrals, whereas $Cu^+(^3D)$ abstracts X to yield CuX^+, which subsequently abstracts X^- in a secondary step. All bimolecular processes are consistent with known thermochemical and quantum mechanical requirements. Kinetic studies reveal that CF_3Cl reacts with $Cu^+(^3D)$ at approximately 7% of the ADO rate, indicating a kinetic barrier to reaction. By comparison, CF_3Br and CF_3I react at essentially the ADO limit with this Cu^+ state – suggesting the possibility that significant mechanistic differences may exist between CF_3Cl and the other two neutrals despite analogous product formation. Quantum chemical calculations have been employed to determine the stationary points along the reaction coordinate of $Cu^+(^3D)$ with CF_3X in an effort to explain differences in the observed rates of reaction and shed light on possible reaction mechanisms.

Site Specificity and Geometry of H_2O Interactions with the Conjugated Pi Systems of DNA Bases

Tori O'Bannon, Mikaela Stewart, Garen Holman, David Holland
Faculty Mentor: Lori Isom

This study investigates water interactions with DNA bases, called water-pi interactions. Due to water's high dipole moment, δ+ charged H atoms interact with the DNA pi systems. The Protein Data Bank was screened for DNA structures and specific selection criteria were applied. Pymol was used to generate symmetry related waters that could potentially interact with the DNA. We used Visual Basic programs to determine the distance and angle between each water molecule and the centroid of every DNA base ring. Waters with an angle less than 55° and a distance less than 5.0 Å from a centroid were found in all structures analyzed. These interactions were analyzed for sequence specificity and major/minor groove patterns. It is concluded that water-pi interactions are common in DNA, sequence dependent and, potentially unstack DNA bases, contributing to the DNA distortion / flexibility important in many cellular processes such as transcription regulation.

Attachment of Tris(pyrazolyl)Methane Ligands to Synthesis Beads

Adam Phelan, Leah Thompson, Tiffany Linz, Erin Mangum
Faculty Mentor: Richard Tarkka

Pyrazolylborates, and the isoelectronic pyrazolylmethanes, are versatile ligands known for more than 30 years. However, there are no reports to date of these ligands being attached to polystyrene synthesis beads for use as solid-phase materials. Our aims are as follows: functionalize a tris(pyrazoyl)methane ligand so that it can be attached to a PS synthesis bead; attach the ligand to a synthesis bead using standard peptide coupling techniques; derivatize the ligand with Ni(II); characterize the properties of the solid-phase ligand system and compare them to those of the ligand in solution. We will report our progress on this project to date.

Surface Coating of Nafion® Membranes with PAMAM Dendrimers

Celia Proctor
Faculty Mentor: Kyle Felling

Nafion® membranes treated with polyamidoamine (PAMAM) dendrimers of varying generations and ethylenediamine were characterized by x-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM), and attenuated total reflectance spectroscopy (ATR). The results show the interaction between the sulfonic acid groups in the Nafion® membranes and the terminal amine groups in the PAMAM dendrimers. They also indicate the influence of dendrimer generation on the degree of surface coating in the Nafion® membranes after treatment. These different degrees of surface coating result in different influences on the orientation and distribution of the sulfonic acid clusters in Nafion®. These morphological changes will affect the transport properties of water, methanol, and other organics through the membranes.

Synthesis and Direct Fluorination of Dendritic Monomers

Lindsay Read, Daniel Hall
Faculty Mentor: Kyle Felling

Dendrimers are highly branched molecules consisting of a central core from which regular repeat units emanate to form a globular, monodisperse macromolecule. Fluorinated dendrimers are a class of molecules which have very unique properties compared to normal dendrimers because of the strong electron-withdrawing influence of the fluorine atoms. They have considerable potential applications as optoelectronic materials, surfactants, solvents, and drug delivery agents. Direct fluorination, a process in

which elemental fluorine is used to replace hydrogen atoms in organic/inorganic compounds with fluorine atoms, has many advantages for commercial and large-scale production of fluorocarbons with high yields. In this study, the perfluorinated analogues of polyether, sulfur-containing and poly (propylene imine) dendrimer frameworks are produced using the Exfluor-Lagow direct fluorination technique. Subsequent characterization is also discussed.

A Surface Science Investigation of the Adsorption Properties of the Active Ingredients in Three Common Painkillers: Aspirin (Acetylsalicylic acid), Tylenol (Acetamidophenol), and Motrin (Ibuprofen)

Merritt Smith, Steve Baker, Hye-Jin Son, Amanda Garner
Faculty Mentor: Donald Perry

In recent years there has been an increase in the amount and variety of pharmaceuticals released into the waterways of America (presumably most of what is detected has gone down the toilet). Gas chromatography mass spectrometry (GCMS) is the standard method for detecting trace levels of organic pollutants such as pharmaceuticals in the environment. Unfortunately, methods that are used to prepare environmental samples for GCMS analysis are typically harsh, and much information about how the pharmaceutical in question interacts with the environment is lost. Surface-enhanced infrared absorption (SEIRA) and surface-enhanced Raman spectroscopy (SERS) are two techniques that can be used to trace amounts of organic molecules directly in water or adsorbed to a surface without intrusive chemical treatments. As a model system to prove the utility of SERS and SEIRA in detecting trace amounts of adsorbed pharmaceuticals, SERS and SEIRA have been used to detect and analyze three common painkillers often found as pollutants in the environment: ibuprofen, acetylsalicylic acid, and acetaminophenol after the molecules have been adsorbed to Ag films. Temperature-programmed desorption (TPD) is a mass spectroscopic method that was also employed to explore the strength of adsorption of the pharmaceuticals to Ag.

Detection and Characterization of DNA Distortion Induced by Cation-Pi Interactions

Mikaela Stewart, Tori O'Bannon
Faculty Mentor: Lori Isom

Cation-pi interactions occur when a bound ion interacts with the aromatic face of a DNA base. Many high resolution DNA structures have been deposited in the Nucleic Acid Database (NDB) since the initial publication describing DNA cation-pi interactions. A survey of the NDB produced 8 structures with resolution 1.6 Å or higher that contain

groove-bound cations but no significant chemical modifications or bound ligands. Using Visual Basic for Application programs to calculate the distances and angles between base centroids and bound cations, cations at distances of less than 5.5 Å and angles less than 55 degrees from a base centroid were isolated as cation-pi interactions. Seven of the eight structures analyzed contained cation-pi interactions, which were found to occur in the major and minor grooves, sequence specifically, with all four DNA bases, and to induce DNA base unstacking. We conclude cation-pi interactions are common and that they induce DNA distortion.

Ammonia Controls Facile Solid-phase Halide Exchange at Nickel(II)

Chris Sutton
Faculty Mentors: Patrick Desrochers, Micah Abrams

Ammonia is an established industrial and agricultural commodity as well as a potential alternative fuel of the future. There continues to be a need, therefore, to safely handle and sense this very useful small molecule. Nickel compounds develop in this laboratory, abbreviated Tp*NiX, rapidly bind ammonia gas. This reversible ammonia binding is accompanied by vibrant color changes, from deep pink/purple to very pale lavender; such changes could be exploited as a selective colorimetric sensor for this gas. Theoretical and experimental evidence suggests that the expansion of Tp*NiX with ammonia binding is oriented mostly along one direction in the solid, a result that, if true, could lead to new capacitor-based sensors for ammonia. An added benefit of ammonia binding by Tp*NiX is the freedom this allows for the exchange of the original halogen (X) with a second different halogen. This allowed the formation of $(Tp^*NiF)_2$, a synthetic milestone as the first complete Tp*NiX halogen series (X = F, Cl, Br, I). While liquefied ammonia is well known, there may be advantages to solid forms of stored ammonia such as compounds seen in our lab, if used in small, confined, portable applications.

COMPUTER SCIENCE

Parallel, Distributed, and Efficient I/O for Grid Computing

Scott Dancer, Kevin Griffin, Erich Peterson, Thomas Stamps
Faculty Mentor: Han-Chieh Wei

The amount of data being generated is staggering in both e-sciences (computational chemistry, physics, bioinformatics, astronomy, etc.) and customer-centric applications (data warehouse). It is common for such kinds of applications to process terabytes (TB) or even petabytes (PB) of data. It has been a challenge on storing, searching, and

indexing relations of such huge datasets. Current database management systems (DBMS) are not yet able to efficiently handle extremely large relations. The concern over index sizes stems mostly from the mechanism of representing and storing the index - the B^+-tree. It is typical that significant portions of a B^+-tree index reside in main memory. Thus, for extremely large relations, this memory footprint (sometimes several times larger than the data size) can quickly become too large for the B^+-tree to be a viable solution. Moreover, if the query involves multiple-dimensions, the cost of building and searching in B^+-tree is exponential. Grid computing provides distributed storage and parallel processing for large datasets. In this Acxiom-funded research project, we adopt Bitmap index mechanisms to solve the data search problem. Data retrieval is accomplished in a parallel fashion by using the parallel I/O interface, ROMIO, in the Message Passing Interface library MPICH2. Large datasets are distributed on the Parallel Virtual File System (PVFS2).

Optimization Algorithms for Interval-Weighted Graphs

Meaghan Dellar, Ping Hu
Faculty Mentor: Chenyi Hu

Weighted graphs have been broadly employed in various kinds of applications. Typical applications include finding shortest paths, a minimum spanning tree, and a maximum flow on a capacity flow network with minimum cost computationally. Traditionally, weights associated with edges in a graph are constants. However, in real world applications, these weights can vary within ranges rather than be fixed values. To model such kinds of uncertainty or variability, we propose interval-weighted graphs. In order to be able to compare two general interval weights, we have established fuzzy partial-order relations for intervals. Applying the fuzzy ordering relations, we have extended the well-known Dijkstra's shortest path algorithm (1959) and Kruskal's minimum spanning tree algorithm (1956) for interval-weighted graphs. We also have extended the Edmonds-Karp maximum flow and minimum cost algorithm (1972) to optimally schedule tasks on a capacity flow network with interval temporal uncertainties.

Rapid Generation of Unique Pseudo-Random Keys Using Smart Cards

Jennifer M. Rullmann
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Smart cards are credit card sized plastic cards that include an integrated circuit that can process information. Because of their small size, resistance to tampering, and ability to perform functions such as encryption, they have wide applicability in security and authentication. Their ability of generating keys without relying on outside resources can be applied to enable them as a secure environment even when communicating with an un-

trusted computer or server. In this research, we investigate some of the many applications of this function through close examination of existing research, and speculate about future work in the field. In particular, we focus on 1) enhancing an existing smart card based cryptographic file system for Linux, 2) using smart cards to securely search encrypted databases, and 3) investigating the potential benefits of replacing the University of Central Arkansas's magnetic stripe identification cards with smart cards. Through this research we hope to contribute to the growing community of researchers focused on finding and enhancing applications for smart cards.

Performance Evaluation of MPEG-4 and H.264/AVC

Chris Shelton, Jared Shoptaw
Faculty Mentor: Yu Sun

The Internet and its usages are now entering a revolutionary period in which a wireless and mobile paradigm is replacing the "primitive" wired network that connected desktop computers to the Internet via a cable. One of the objectives now is to create, deliver, and access multimedia information *anywhere and anytime*. Advanced video compression, allowing transmission of huge amounts of video information over heterogeneous band-limited networks, is extremely important to facilitate achieving this goal. Without compression, it is impossible to have cost-effective multimedia applications.

The recent standards, MPEG-4 and H.264/AVC, represent the start-of-the-art video compression technologies. MPEG-4 was initiated for multimedia applications. It first adopted the object-based concept in video compression. H.264/AVC, the most recent standard, aims to provide high compression performance and high quality video through the inclusion of a number of new features and capabilities. In this research, we are going to systematically study these two compression standards, and then conduct performance evaluation between them in terms of the rate, quality/distortion, and computational time, etc. Based on the performance testing results, we will start our research on the rate-distortion relationship for advanced video compression schemes, which will form a solid foundation for our future research.

A Frame Skipping Method for H.264/AVC Rate Control

Jared Shoptaw
Faculty Mentor: Yu Sun

Digital video applications are becoming increasingly important in our everyday life. HDTV, DVD, video surveillance, video streaming, videophone and video conferencing are just some examples. Since video data files are very large, video compression, which allows the transmission of large amounts of video information over heterogeneous band-limited networks, is extremely important to facilitate cost effective networked video applications. Rate control is one of the most crucial techniques for video compression and communication. It regulates the output bit rate of a video encoder in order to obtain

optimum visual quality within the available budget of transmission bit rate. For networked video applications, because of the limited and/or time-varying network bandwidths, rate control is vital to achieve the best tradeoff between encoding quality and bandwidth utilization.

The overall goals of this research are to: 1) solidly understand the principles of video compression with emphasis on "Rate Control"; and 2) improve the existing work if possible. Since the current rate control scheme of the newest compression standard H.264/AVC doesn't provide a frame skipping mechanism, its control abilities are not powerful enough, especially in dealing with low bitrate applications. In order to enable frame skipping and improve rate control accuracy, we propose a simple frame skipping method for H.264/AVC rate controller. Experimental results demonstrate that our proposed method is very effective.

Resource Allocation for Service Provisioning in Grid Computing Systems

Yun Zhou
Faculty Mentor: Qiang Duan

The rapid growth of the Internet, along with the availability of powerful computers and high-speed networks as low-cost commodity components, has enabled the utilization of a wide variety of geographically distributed computational resources, including computers, storage systems, data sources, and special devices, as a unified resource. This new paradigm that has evolved is popularly termed "Grid" computing. The federation of highly distributed heterogeneous resources to deliver better-than-best-effort services is a key feature of Grid computing. In the service-oriented Grid architecture, each Grid service publishes a service description. When an application needs to utilize the Grid infrastructure, a service broker discovers a service that meets the application requirements, and then binds the service with the application. In order to provide a certain level of quality of service to the Grid application, a Grid service must allocate a sufficient amount of resources to the application, including CPU computing capacity, data storage space, and network bandwidth. In this research project, we apply the GridSim software, a simulation tool for Grid computing systems, to study the impact of the resource allocation in a Grid service on the achievable performance of the service to an application. Our simulation results show that the average service delay performance for an application is associated with the amount of resources available in the Grid service and the work load for the service.

MATHEMATICS

Growth and Survival Models for the Alligator Snapping Turtle

Timothy Bennett
Faculty Mentor: David Peterson

The alligator snapping turtle is the largest freshwater turtle in North America. It has a broad distribution in 14 states, primarily in Arkansas, Louisiana, Mississippi, and along the Gulf Coast. It is an almost entirely aquatic and rather secretive species such that little is known ecologically about the species considering their range. Their population has been severely reduced due to habitat loss and harvesting. For these reasons, they are feared to be a threatened species and have come under study. The focus of this project is to formulate a growth and survival model for the species based on two years of capture/recapture data from Cadron Creek in Faulkner County, Arkansas. Previous research has shown that any departure from the stable value of adult mortality rates will result in a decline of the species population. It will be shown that as long as the mortality rates for juveniles and adults are within a certain range, the population will be stable. The model presented will be analyzed for the stability of its equilibrium. The collected data will then be analyzed through statistics to obtain an estimate for the death rate of adult turtles. This estimate will be used to estimate the mortality rate of juvenile turtles. Lastly, the model will be represented through simulations based off the information estimated from the data.

Using Richardson Extrapolation to Increase the Spatial Accuracy of Existing Computational Solvers

Taylor Erwin, Jonathan Johnson
Faculty Mentor: Clarence Burg

Improving the accuracy of computational tools for solving science problems has been a key focus of a wide variety of research teams, knowing that second-order spatial accuracy does not provide sufficient resolution of important physical features. Richardson extrapolation is a generic methodology for increasing the accuracy of solutions. In numerical analysis, Richardson extrapolation is typically used to generate more accurate finite difference stencils and for improving numerical integration, such as in the Romberg algorithm. Since Richardson extrapolation only deals with the output from numerical codes, it can be applied to any numerical result. We propose a new methodology in which Richardson extrapolation is applied to the solutions of the solvers to obtain a more accurate solution. While this methodology is effective for parabolic partial differential equations, problems arise with solutions of hyperbolic systems of equations due to possible phase shifting of the solution. Therefore, we propose a methodology in which Richardson extrapolation is applied within the code, thereby increasing the accuracy of

the solution without directly changing any aspect of the numerical approach. As such, this methodology can be applied to any computational solver as long as the solution scheme is properly implemented and achieves the theoretical accuracy. We demonstrate these methodologies on three different 1D PDE solvers – the heat equation, the wave equation, and the St. Venant equations (a nonlinear hyperbolic system). Through these new approaches, we hope to develop a methodology for improving the spatial accuracy of existing computational codes that requires minimal alteration of the original code.

Symmetry Analysis of the Variable Beam Equation

Ethan Hereth
Faculty Mentor: Danny Arrigo

A symmetry analysis of the Bernoulli-Euler beam equations is performed in the case where the beam's density, cross-sectional area, moment of inertia and Young's modulus are all allowed to vary spatially. We will show that there are particular classes of these four varying functions such that the governing equations admit special symmetries. We further exploit these symmetries to reduce the governing partial differential equations to ordinary differential equations and in some cases we solve explicitly giving rise to exact solutions.

Effects of Adverse Experiences at Birth on Behavior in Late Adulthood

Susan Lantz, Amber Fason
Faculty Mentors: George Bratton, Barbara Clancy

Anesthetic drugs are not typically administered to human infants during painful interventions for many reasons, primarily because conventional views hold that adverse experiences at birth do not harm developing nervous systems, while anesthetic drugs are harmful. Using a rat model, Dr. Clancy's lab has shown that pups exposed to pain without anesthesia at birth exhibit alterations in behavior and cognition (Radial Maze, Elevated Plus Maze, Hot Plate) at young adulthood (2 mo), mitigated by the use of anesthesia (Ketamine). Pups exposed to the anesthesia alone also exhibit some mild alterations in behavior at early adulthood. No previous study has ever tracked rats (or humans) exposed to pain and/or anesthesia at birth into late adulthood (1 yr in rats). UCA afforded us the unique opportunity to do just that. We hypothesized that neonatal pain without anesthesia would still be evident on a behavioral level at these late ages. However, at 1 year there was no overall significant effect of treatment group on conventional behavioral variables, suggesting the developing brain can recuperate from pain at birth, with or without the use of anesthesia. When Dr. Bratton's lab used blind cluster analysis on the Radial Arm data (numerical taxonomy), the rat behavior clustered into 3 distinct groups: a high activity group (all controls were in this group, n=5, as were

2 of the rats that received pain alone), a medium activity group (3 rats that received pain w/Ketamine and 2 rats that received pain alone) and a low activity group (all animals that received Ketamine alone fell into this group, n=4, as did 2 of rats that received pain alone and 1 rat that received pain w/Ketamine). These data suggest that after a lifetime, rats may recover from the effects of pain without anesthesia at birth, but clearly the long-lasting effects of Ketamine at birth need further study.

A Mathematical Determination of Competitive Feedback Inhibition Rates in Branched Metabolic Pathways

Christopher Pickens, Luis Jimenez
Faculty Mentor: Weijiu Liu

In this paper, we consider the problem of mathematically determining the feedback inhibition rates in multi-branched metabolic pathways. To solve the problem, we model the system with a series of nonlinear ordinary differential equations by using the law of mass action without the usual quasi-steady state assumptions. Through an equilibrium analysis, we develop formulas to calculate the feedback inhibition rates in terms of the concentrations of end-products and regulatory enzymes at equilibrium. We then prove that the linearized system of the nonlinear system at its equilibrium is exponentially stable by applying Routh's stability criterion, thus the equilibrium of the nonlinear system is locally exponentially stable. This local stability proves that the feedback inhibition rates determined by our formulas are effective in regulating the end-products. The feasibility of these feedback inhibition rates is further tested numerically using both randomly generated data and biological data.

Stress Distributions Within Ratholes in Conical Hoppers

Katie Reynolds, Jason Torrence
Faculty Mentor: Danny Arrigo

The governing equations for a Columb-Mohr granular solid are considered and are used to study the stress distributions within rat-holes in conical hoppers. A rat-hole is a general term used to describe a stable cavity that frequently occurs in storage hoppers, that prevents further material from falling through its outlet. We show that in the highly frictional limit, where the angle of internal friction is assumed to equal ninety degrees, the governing equations simplify and can be linearized. With this vast simplification, we find that we are able to easily recover the few known exact solutions presently available in the literature. Our investigations show that these solutions unrealistically predict stresses above the fixed rat-hole boundary. We further show that with the introduction of new exact solutions for a new class of rat-hole boundary, this limitation is overcome.

Symmetry Analysis of the Two-Dimensional Diffusion Equation?

Luis Suazo, Bode Sule
Faculty Mentor: Danny Arrigo

The classical and nonclassical symmetries of a linear diffusion equation with a nonlinear source term in 2 + 1 dimensions are derived using Lie's invariance method. We show that there are a variety of source terms that involves the dependent variable and its derivatives that admit a nontrivial classical symmetry. We further show that the nonclassical method simply recovers the classical method showing that there are no nonclassical symmetries. Several examples are considered where reductions to 1+1 dimensional equations are obtained.

PHYSICS AND ASTRONOMY

Aeroacoustic Excitation of Acoustic Resonance

Christa Fisher, Stephanie Lanier
Faculty Mentor: William Slaton

During the course of research, sound generated through the aeroacoustic driving of a Helmholtz resonator was investigated. Helmholtz resonators consist of a large cavity of air connected to a smaller diameter neck. Acoustic resonance of this system can occur when air is blown over the open neck of the resonator for a particular range of velocities. A glass pipe wind tunnel with two Helmholtz resonators connected perpendicular to it was built to explore this phenomenon. Data was taken for different cross junction combinations of an elbow bend and a straight length of pipe. The flow velocities in the wind tunnel were varied and the frequencies of oscillation and acoustic pressure inside the flask were recorded for each set-up. The vortices that are shed at the opening of the neck of the Helmholtz resonator resemble a driving force. This system simulates that of a driven, damped harmonic oscillator where the air in the volume of the flask behaves like a spring, while the air in the cross section acts like a mass. The data was used to model the vortex driving function.

Revisiting Zirconium: A New Look at Elemental Abundances with Improved Oscillator Strengths

Marilea Jones, Rebecca Nichols
Faculty Mentor: Debra L. Burris

The element Zirconium is produced via neutron capture (n-capture). It resides in the mass range where there is uncertainty about the production mechanism at early time. The rapid n-capture process (r-process) was believed to be responsible for the production, but no study (Burris et al 2000, Gilroy et al 1988 and others) has been able to successfully use the r-process to reproduce the abundance signature for elements in this mass range for metal-poor halo stars. It has been suggested (Sneden and Cowan 2003) that there may be an undiscovered component to the r-process. New transition probabilities for Zr II have been reported by Malcheva et al (2006). We utilize these values to make new abundance determinations for Zr in the Sun and the metal-poor halo star BD +17 3248.
* This work is supported in part by the AAS Small Grant Program, the Arkansas Space Grant Consortium and the UCA Undergraduate Research Council

Kinematical Scattering Factor for Alpha and Carbon Ion Beams Incident on Target Films

Sharon Jones, Holly Smith, Steven Stoll
Faculty Mentors: Stephen Addison, Rahul Mehta

When a beam of energized ions comes into direct contact with a target sample, the atoms of the sample experience an elastic collision with the incident ions. The energized ions are scattered back onto a detector, which measures their collective energy. The kinematical scattering factor is a ratio of the incident energy and the energy of the backscattered ions. Based on the physics of an elastic collision, the kinematical scattering factor can be described as a function of the masses of the target atoms and incident ions and the scattering angle relative to the incident beam. One can determine the atomic mass of the target atoms by knowing the masses of the incident ions and target atoms as well as the scattering angle. In this series of experiments performed at the University of North Texas Accelerator Lab, a 1.5 MeV alpha beam, produced by a Van de Graaff accelerator, was incident upon a thin carbon-12 film, and a 3.0 MeV carbon ion beam, produced by a Tandem accelerator was incident upon a thin praseodymium film. The energies of the scattered beams were measured for a range of scattering angles, and the kinematical scattering factors were calculated and compared to known values. Once the kinematical scattering factors had been obtained, the thicknesses of both films were determined.
* Acknowledgement: University of North Texas Accelerator Lab, Prof. J.L. Duggan, Khalid Hossain, Lee Mitchell

Identification of Unknown Specimens Through Elemental Analysis by X-Ray Fluorescence (XRF)

Robert Kemper, Ryan Lane, Luis Suazo
Faculty Mentors: Stephen Addison, Rahul Mehta

XRF is a technique used to identify material composition. Samples are exposed to high-frequency radiation to cause electron orbital transitions in the sample's atoms (transition between orbitals and ejection). These post-transition elements are unstable. When the atom returns to a stable state photons are produced. These photons are element specific, thus identification of a sample's composite elements can be carried out by analyzing the x-rays emitted from the sample.

The experiment was conducted using the XRF equipment at Ion Beam Modification and Analysis Laboratory at University of North Texas. The source of incident x-rays used in the experiment was Cadmium 109. A Si(Li) detector connected to a multi-channel analyzer was used to collect the sample x-rays. PCA3 spectrum analysis software was used for real-time viewing and later, data analysis. Before data was taken, the software was calibrated using samples of gold and vanadium. After calibration, a variety of prepared samples were analyzed. The samples contained diverse elements from lead and zinc to titanium. The samples were identified by elemental analysis and visual inspection. The identified objects ranged from common steel to lead-based paint chips.

* Acknowledgements: J. L. Duggan and Mangal Dhoubadel for assistance in performance of the experiment.

Studies of Hard and Soft Tissue Elemental Compositions in Mice Subjected to Simulated Microgravity

Ryan A. Lane
Faculty Mentor: Rahul Mehta

The effects of microgravity on mammalian physiology are not thoroughly known. To further investigate these effects, the elemental composition of the femur and skull bones as well as pancreatic tissue and muscular tissue from head in mice that have been subjected to NASA certified hind-limb suspension (HLS) to simulate microgravity are being compared to similar bones and tissues from non-HLS control mice. The surface structures of the bones and tissues are also being studied using Scanning Electron Microscopy (SEM). Electron beam energy of 10-20 keV and magnification in the range 250 x to 10,000 x provide information on features up to few microns in size. SEM in the Energy Dispersive Spectrometry (EDS) mode is being used to study K- and L-shell x-rays, mostly from low to mid atomic number (Z) elements. X-Ray Fluorescence and other techniques are being used to investigate the presence and qualitative ratios of elements with Z greater than twenty-five.

Weight percentages of the elements and oxides in a standard chemical sample together with the elemental analysis (using Flame software) indicate a variation in the compositional ratios of calcium, potassium, and carbon in the femurs and skulls of the HLS versus control specimens. These variations showed dependence on sample position in the bone relative to the hip joint and the sutures for the samples from the femur and skull samples, respectively.

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Lemon Cells in Series and Parallel: A Demonstration

Jeremy Lusk
Faculty Mentor: William Slaton

Classroom demonstrations of concepts in physics and chemistry are important to a student's understanding of the physical sciences. There are many such experiments that have, through the years, become staples in secondary and college-level classes. One such experiment is the lemon cell battery. This basic demonstration of electrochemistry and circuit design uses an ordinary lemon and electrodes of copper and zinc to create a rudimentary battery. Previous research has utilized the voltage of lemon cells in series for low-power applications such as calculators, LED's, piezo buzzers, and LCD clocks. We are measuring the potentials and currents for large arrays of lemon juice cells, connected in series and parallel, in order to design a cost-effective classroom demonstration of circuit design. By discharging the array through a resistor, the stored charge of a lemon cell array (defined as the time integral of current) can be calculated from the voltage and resistance.

Rutherford Back Scattering of Alpha and Carbon Ions From Carbon and Praseodymium

Sule Olabode, Stephanie Lanier, Andrew Woodward
Faculty Mentors: Stephen Addison, Rahul Mehta

Rutherford back scattering is an analytical technique that is used to determine the composition and thickness of a target sample. It involves measuring the number and energy of ions that back scatter after colliding with the atoms of the target. The backscattering of ions is due to Coloumbic repulsion by the nucleus of atoms in a target but can be accurately approximated by treating the interaction as an elastic collision. The energy loss of the back scattered ions can be determined from the kinetic factor. Two experiments were conducted at the University of North Texas accelerator lab: in the first carbon ions produced by a Tandem particle accelerator were aimed at a Praseodymium source and in the second a beam of alpha particles from a Van de Graff accelerator were directed at a Carbon source. The elastically scattered ions were detected and measured by

a particle detector. The prediction of the cross section by Rutherford scattering was tested against the measured cross section. Thickness of the sample is then determined from the area under the peak from the elastic scattering, the number of incident ions, the solid angle, and the Rutherford scattering cross section. Using this method, we were able to achieve satisfactory results.
Acknowledgements: Dr. J.L. Duggan, Khalid Hossain, Dr. Lee Mitchell for their assistance in performing the experiments

Thermoacoustic Quality Factor Enhancement

Holly Smith
Faculty Mentor: William Slaton

A Helmholtz resonator consists of a hollow neck attached to an empty chamber. This resonator can be modeled as a spring-mass system, in which the air moving inside the neck acts as the mass and the gas inside the chamber acts as the spring. Every Helmholtz resonator has a characteristic quality factor that is dependent upon the total mechanical resistance present. A system with low resistance will have a narrow peak on its amplitude versus frequency graph and a high quality factor, whereas a system with high resistance will have a broader peak and a low quality factor. In this experiment a porous ceramic substrate is inserted into the neck of a Helmholtz resonator. Introducing this substrate into the neck causes the mass and the resistance of the resonator to change, thereby altering the resonance frequency and the quality factor of the resonator, as well. By applying a temperature difference across the substrate and slowly increasing this temperature over a range, this experiment investigates the conditions in which the quality factor for the resonator will increase.

Ultrasonic Gait Characterization

Bradley Stroud
Faculty Mentor: Carl Frederickson

A person's gait may be characterized by using ultrasound and the Doppler Effect. When a moving person is ensonified by sound of a specific frequency, the reflected signal will contain multiple frequencies related to the transmitted frequency and the velocity of the person. If a person increases his/her speed relative to the transmitter, the difference between the frequency of the reflected and transmitted signal will increase. All parts of the body uniquely contribute to the reflected signal's array of frequencies and amplitudes. The amplitude of a reflected signal will depend on the surface area of the body part reflecting that signal. If one were to use ultrasound on different individuals, one could distinguish the signature of one person compared to another. In the lab, a bowling ball and a rod have been used as pendulums in a model system. A spectrogram of the dual system clearly distinguishes the motion of each pendulum. From understanding the behavior of pendulums, one may make the leap to oscillatory human motion and develop

a method of biometric identification.

Symmetries of Electromagnetism in Arbitrary Dimensions

Luis R. Suazo
Faculty Mentor: Balraj Menon

A symmetry of a system of differential equations is a transformation that maps any solution of the differential equation to another solution. In the latter part of the nineteenth century the Norwegian mathematician Sophus Lie developed techniques that allow one to determine all the symmetries of a system of differential equations. The applications resulting from the determination of the system are numerous. The symmetries can be used to obtain transformations that take advantage of specific characteristics of a physical system and simplify the underlying differential equations. Also, symmetries play an important role in the determination of local conservation laws admitted by a physical system.

Although symmetry analysis has been applied extensively to various nonlinear partial differential equations, their application to partial differential equations involving tensor fields is rather limited. Tensor fields play a pivotal role in the description of all the fundamental forces in the universe. As a first step in that direction, Lie's symmetry group methods are applied to a generalization of the source-free Maxwell equations describing the electromagnetic field in a Minkowski spacetime with arbitrary spatial dimensions. Necessary conditions satisfied by the symmetries of this system of equations are derived and specific symmetries like the gauge transformations, the solutions of the Killing equation (which gives rise to the Poincaré group of transformations in four dimensions) and solutions of the conformal Killing equation (which generates the conformal group of transformations) are discussed.