

**13<sup>th</sup> ANNUAL STUDENT RESEARCH  
POSTER SYMPOSIUM**

**COLLEGE OF NATURAL SCIENCES AND MATHEMATICS**

**UNIVERSITY OF CENTRAL ARKANSAS**

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*Faculty Mentor: Brent Hill*

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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. Estrogen can be rapidly metabolized to 2-methoxyestradiol (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



*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 17 $\beta$ -estradiol (most prevalent form of estrogen) levels in the bloodstream. One of 17 $\beta$ -estradiol's protective effects against CAD is its ability to dilate arteries. The purpose of our study is to compare the relaxant effect of 17 $\beta$ -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 ( $3 \times 10^{-7}$  to  $1 \times 10^{-4}$  M) was generated using 17 $\beta$ -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 17 $\beta$ -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*

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

# **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<sup>+</sup>] Cl<sup>-</sup>, 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  $\mu$ 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<sup>+</sup>]Cl<sup>-</sup> compound in order to 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 Destruction in 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. These 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



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 nest-site Selection of a

# **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 bellii*, 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 dominant 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 bellii* 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 bellii* 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*,

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,

## 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

# **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



## **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), Hélène 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  $32,000 \pm 100$  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-opioid receptor are adjacent

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 <sup>14</sup>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 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*

## Reactions of $\text{Cu}^+(^1\text{S}, ^3\text{D})$ With $\text{CF}_3\text{X}$ ( $\text{X}=\text{Cl}, \text{Br}, \text{I}$ )

*Scott R. Musial, Cullen C. Matthews*

*Faculty Mentors: William S. Taylor, Micah L. Abrams*

State-specific reactions of  $\text{Cu}^+(^1\text{S})$  and  $\text{Cu}^+(^3\text{D})$  with  $\text{CF}_3\text{X}$  ( $\text{X} = \text{Cl}, \text{Br}, \text{I}$ ) have been carried out in a selected-ion drift cell apparatus.  $\text{Cu}^+(^1\text{S})$  participates in association exclusively with all three of these neutrals, whereas  $\text{Cu}^+(^3\text{D})$  abstracts X to yield  $\text{CuX}^+$ , which subsequently abstracts X<sup>-</sup> in a secondary step. All bimolecular processes are consistent with known thermochemical and quantum mechanical requirements. Kinetic studies reveal that  $\text{CF}_3\text{Cl}$  reacts with  $\text{Cu}^+(^3\text{D})$  at approximately 7% of the ADO rate, indicating a kinetic barrier to reaction. By comparison,  $\text{CF}_3\text{Br}$  and  $\text{CF}_3\text{I}$  react at essentially the ADO limit with this  $\text{Cu}^+$  state – suggesting the possibility that significant mechanistic differences may exist between  $\text{CF}_3\text{Cl}$  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  $\text{Cu}^+(^3\text{D})$  with  $\text{CF}_3\text{X}$  in an effort to explain differences in the observed rates of reaction and shed light on possible reaction mechanisms.

## Site Specificity and Geometry of $\text{H}_2\text{O}$ 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,  $\delta^+$  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  $55^\circ$  and a distance less than  $5.0 \text{ \AA}$  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<sup>®</sup> Membranes with PAMAM Dendrimers**

*Celia Proctor*  
*Faculty Mentor: Kyle Felling*

Nafion

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 Exflour-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



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



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

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

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

these methods  
scheme is prop

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.

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## **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 the p,kdlk

# **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.

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# **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 (Snedden 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.





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

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.