15th ANNUAL STUDENT RESEARCH SYMPOSIUM ABSTRACTS

COLLEGE OF NATURAL SCIENCES AND MATHEMATICS

UNIVERSITY OF CENTRAL ARKANSAS

APRIL 24TH, 2009

2:00 p.m. – 4:00 p.m.

McCASTLAIN HALL BALLROOM

Introduction from the Deans office.

This book contains the abstracts for the 15th Annual College of Natural Sciences and Mathematics Student Research Symposium. The symposium highlights graduate and undergraduate student research projects undertaken under the guidance of faculty in the departments of Biology, Chemistry, Computer Science, Mathematics and Physics and Astronomy. This event has grown every year. This year's program includes 63 abstracts with 110 student authors and 41 faculty mentors. The opportunity to apply knowledge to real problems is an important component of the education that students receive at UCA. This symposium is an occasion to celebrate the scientific achievements of our students.

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BIOLOGY

Cloning by Yeast Gap Repair to Determine the Different Functions of the Homologous Proteins Mdv1 and Caf4.

Justin Allen and Elizabeth Huett
Faculty Mentor: Kari Naylor

Mitochondria are double-membrane organelles responsible for production of ATP- a cell's energy source. Mitochondrial 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. If these events are not balanced, the structure will be compromised, possibly leading to mitochondrial diseases, such as blindness or muscular weakness. In *Saccharomyces cerevisiae*, our model system, there are three proteins required for mitochondrial fission: Dnm1, Fis1, and Mdv1. 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 differences between Caf4 and Mdv1. Crude domain swapping between three domains of Caf4 and their corresponding domains of Mdv1 will be achieved using a yeast gap repair cloning method. Presented here is the technique of gap cloning in yeast. 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.

Determination of FtsZ Dynamics in Dictyostelium discoideum to understand the evolutionary link between mitochondria and eukaryotes.

LaRhonda Apata and Dean Turbeville
Faculty Mentor: Kari Naylor

Dictyostelium discoideum has emerged as an important model organism in the study of cytokinesis and other membrane scission events. D. discoideum's optical clarity, high capacity for gene-marker tagging, and the simplicity of its life cycle make it a prime candidate model organism for our research studying mitochondrial fission. Our goal is to study the fission proteins of D. discoideum to understand their function in the fission process and ultimately understand the mechanism of fission in all eukaryotes. We will use reporter genes such as Green Fluorescent Protein (GFP) to visualize proteins such as FtsZ to determine its localization and dynamics in live cells. These visualization studies will be accompanied by knockout experiments of the various fission proteins. The combination of the knockout and the visualization/localization experiments will give us a greater insight into the structure and function of fission proteins in D. discoideum, which could lead to a better understanding of the evolutionary link between D. discoideum and other eukaryotes.

Characterization of Persisting Subplate Cells in Normal Development and in Parkinson's Disease

Danielle Atwood, Lalita Oonthonpan, Adam Kilgore, Kristi Erbach, Tommie Reddick, Lilia Lee, Stacy Baldwin, Courtney Davis, Amanda James, Terri Teague-Ross
Mentors: Barbara Clancy, George Bratton, Susan Lantz, and Syed Ali

Our lab studies a group of brain cells we call "persisting subplate neurons." These cells are not well studied past initial development, when they help guide the initial organization of the cortex, the outer layered region of the brain involved in cognition. In conventional models of cortical function, persisting subplate cells are considered a "remnant" because their role in development is completed, but a subset remains in adult brains across aging, in positions in, below, and above white matter (connective pathways), projecting into cortex . We reconstructed the persisting subplate population in rat brains across maturity and aging, using conventional tracing techniques and a three-dimensional imaging hardware and software system. At all ages, the subplate is apparent beginning in the anterior portion of the brain and ending in posterior visual cortex, although the thickness and distribution of this neural population is non-uniform. Cell counts, volumes, and areas were also collected and compared across ages. The persisting subplate population appears to be remarkably resilient and stable at all ages studied, suggesting a clear role in mature cortical function.

A subset of these persisting subplate cells has receptor sites for dopamine. Because conventional models for Parkinson's disease (PD), a dopamine-related disease, fail to account for the abnormal behaviors associated with this devastating disorder, it is now suspected that cortical involvement may drive some of the abnormal behaviors. There are few other dopaminergic candidates located in the cortex except persisting subplate cells, and we began a collaboration with Syed Ali from the National Center for Toxicology Research (NCTR) to test for possible involvement of the persisting subplate system. 1-methyl 4-phenyl 1, 2, 3, 6-tetrahydropyridine (MPTP; a byproduct of heroin) was used to induce Parkinson-like changes in the brains of mice and we are currently preparing slides of these brains so that we may investigate the persisting subplate cells and other non-cortical brain regions implicated in PD, including the caudate-putamen, the substantia nigra, the nucleus accumbens, and the hippocampus. We will then analyze the distribution, volume, and number of persisting subplate cells and the other brain regions in the same way we have investigated them in normal brains. This work will have fundamental research value, as it will produce the first three-dimensional images of these Parkinson-related brain regions in rodents.

Will Gibberellic Acid promote early flowering in important plants of interest?

Tatum J. Branaman, John W. Cauldwell
Faculty Mentors: J.D. Swanson

Gibberellic acid (GA) is a key hormone for many developmental processes and has been used to promote early flowering in *Arabidopsis thaliana*. Early flowering via the addition of GA is the result of early expression of the floral meristem identity gene, *LFY*, where GA interacts with the *LFY* promoter. However, it is unknown if early flowering is obtainable when adding GA to other plants. We have thus far concluded that a GA concentration of 30 uM is required for *Arabidopsis* to produce viable flowers at approximately 27 days in moderate conditions. We intend to investigate if the promotion of early flowering is applicable to other important plants of interest, specifically *Theobroma cacao*, the chocolate tree, *Gossypium hirsutum*, cotton, and *Populus trichocarpa*, the tree model species. Moreover, we have several suspected sequences we believe to be *LFY* and plan to confirm through sequence analysis and observation of *LFY* function, which will be measured by flowering time after GA treatments. Upon acquiring and comparing their *LFY* genes, we plan to create transgenic *Arabidopsis* that express the *LFY* genes of our plants of interest. We can then determine if early flowering via additional GA is unique to wildtype *Arabidopsis* by observing the flowering time of *LFY* transgenic *Arabidopsis*. From there, phylogenetic comparisons can be made among our plants of interest using the *LFY* genes and the *LFY* transgenic *Arabidopsis*' response to GA.

Analysis of Population Genetic Diversity in a Threatened, Subterranean Fish

Shawn Brummett
Faculty Mentor: David E. Starkey

Grotto sculpin are unique populations of banded sculpin (*Cottus carolinae*) endemic to cave systems underlying Perry County, Missouri. These troglomorphic (cave-adapted) fish are state-threatened and a Federal Endangered Species Candidate. Burr et al. (2001) examined fish from all caves grotto sculpin inhabit and found significant morphological differences between epigean (surface) and hypogean (cave) populations, including smaller eyes, reduced number of pelvic fin rays, reduced pigmentation, and enlarged cephalic lateralis pores. Due to the unstable nature of the cave environment, grotto sculpin are highly susceptible to pollution via suspected agricultural and waste runoff. It is therefore imperative that we understand, on both ecological and evolutionary time scales, the degree of connectivity characteristic of these fish. We used a multilocus phylogeographic analysis using DNA sequence from the mitochondrial control region (760bp) and a nuclear intron locus, α-enolase (443bp) to address possible subspecies boundaries, and provide substantial means of inference as to the dispersal potential and genetic connectivity for this threatened cavefish. Samples from twenty-three cave, spring branch, and surface sites within and surrounding Perry County were collected and sequence data from both markers analyzed using parsimony, maximum likelihood, and Bayesian analyses. Our data indicate a

marked divergence of grotto sculpin from surface populations of banded sculpin. We found a substantial degree of dynamic population genetic structure within Perry County, suggesting gene flow may be restricted between certain sites, but fluid among others.

Examining the Potential Apoptosis-Inducing Effects of dppeNiCysEt on MCF-7 Human Breast Cancer Cells

Zachary Byars and Kandice Strickland
Faculty Mentors: Steven Runge, Patrick Desrochers

Ni(II) bis-(phosphine) complexes may interact very specifically with proteins that trigger or participate in apoptosis and are promising new compounds for anticancer potential in clinics. Previous experiments have involved using a compound, dppeNiIICYSEt+Cl^-, that was developed in the laboratory of Dr. Patrick Desrochers in the Chemistry Department at the University of Central Arkansas. This compound induces cell death in MCF-7 human breast cancer cells at concentrations at or above 5 μM. Unfortunately this concentration is at the upper threshold of what is considered practical for treatment in humans. In a follow-up experiment designed to mimic the tumor environment, MCF-7 cells were cultured in normoxic (normal oxygen), hypoxic (low oxygen), low pH, and a combination of low oxygen and low pH environments. The cells that were adapted to the hypoxic and low pH environments were unaffected by the addition of the dppeNiIICYSEt+Cl^-. In an attempt to increase efficacy, a modified compound is being assessed. The cysteine amino acid form is being used directly and the ester is now a free carboxylate making the compound neutral overall and hydrophobic molecule as opposed to the hydrophilic dppeNiIICYSEt+Cl^-. The modified compound, dppeNiCys, may more easily cross the cell membrane and we predict that this new complex will induce apoptosis at lower concentrations, thus showing more efficiency at cell killing than the parent compound. This study will first try to expand on the previous experiments in comparing the activity of the dppeNiCys with the apoptosis-inducing activity of dppeNiIICYSEt+Cl^- under normal physiological conditions. By finding a lower effective concentration, the potential usefulness for this compound as a chemotherapeutic drug increases tremendously. Future studies will involve making the compound more effective at entering cells in the unique tumor microenvironments. The outcomes of this study will determine which chemical modifications should be further investigated.

Analysis of B-cell Antibody Gene Segment Use in response to Mercury Treatment

Heather J. Clarke
Faculty Mentor: Ben Rowley

A.SW congenic strain mice have been used for three decades as a model of chemically-induced autoimmunity. When introduced with mercuric chloride ($HgCl_2$), a defined autoimmune response results in these mice, characterized by antinucleolar antibodies (ANoA) of the IgG1 and IgE

isotypes. Although many studies have been conducted utilizing this mouse model, none have examined specific antibody heavy-chain gene segments of mature, circulating B-cell receptors (BCRs) which are selected in response to mercury treatment. Using nested polymerase chain reaction (PCR), individually sorted B-cells from treated and sham-treated were examined for heavy-chain material which could be amplified. This method was then followed by sequence analyses of gel-purified products in order to identify individual V(D)J gene segments used by B lymphocytes from treated and non-treated mice.

Contaminant Concentration Analysis of Cave Streams Utilized by Grotto Sculpin (*Cottus carolinae*) in Perry County, Missouri.

J. Tyler Fox
Faculty Mentors: Ginny Adams and Karen Steelman

Recent studies have employed polar organic chemical integrative samplers (POCIS) and semipermeable membrane devices (SPMDs) to assess contaminant levels in aquatic ecosystems. The current study is among the first to use these sensitive, *in-situ* samplers to monitor water quality of subterranean streams. These two types of passive samplers rely on either a solid phase sorbent mixture (POCIS) or synthetic lipid (SPMD) to sample bioavailable dissolved aqueous-phase contaminants. Streams chosen for contaminant assessment represent the only known habitat for the Grotto Sculpin (*Cottus sp., sp., nov.*), a rare hypogean fish allocated to the Banded Sculpin (*Cottus carolinae*) complex, and a species of high conservation concern. Of particular interest to this project is the widespread use of sinkholes in Perry County, Missouri for disposal of various agricultural, industrial and domestic wastes. Intensive agriculture, petroleum products manufacturing and wood curing operations are also suspected sources of contaminants. Thin or unconsolidated soil layers underlying many Perry County sinkholes allow contaminant-laden rainwater to flow directly into caves without adequate filtration and remediation. As a consequence, water quality can quickly and severely decline with rapid transmission of pollution from the surface into caves and conduits of the karst aquifer. In order to assess contaminant levels, perforated stainless steel canisters containing three POCIS and three SPMDs were deployed in five cave streams for a period of 30 days during May 2008 and again during June 2008. Upon collection, accumulated chemicals were extracted and purified in preparation for qualitative and quantitative analysis by gas chromatography (GC) – mass spectrometry (MS), and GC – electron capture detection (ECD). Concentrations of individual contaminants present in the samplers will be used to calculate and compare time-weighted average concentrations of contaminants present in each cave stream. Data will also be used by researchersm private landowners, and resource managers to develop conservation measures and best management practices for the Grotto Sculpin and its habitat.

Distribution and function of girdling by caterpillars of prominent moths (Lepidoptera: Notodontidae)

Carissa Ganong
Faculty Mentor: David Dussourd

Many insect species encircle stems or leaf petioles with a ring of cuts or stylet punctures, often before ovipositing beyond the girdle. Few studies have examined girdling by caterpillars. We determined the distribution of girdling in notodontid caterpillars by sleeving larvae in the field. Girdling occurred in two major branches of the Notodontidae, suggesting that the behavior evolved early in notodontid evolution or independently at least twice. Prominent girdlers included members of *Schizura, Heterocampa, Hyperaeschra*, and *Nadata*. The caterpillars typically girdled in the ultimate or penultimate instar. Girdles were produced in members of five tree families, including in oaks, hickory, elm, birch, and cherry. The frequency of girdling in our studies varied between seasons, years, and host plant species, but was not affected by switching larval food plants partway through larval development. Five-hour observations of *Schizura leptinoides* on pecan documented that feeding usually, but not always, occurs distal to girdles. Histology of girdle cross-sections indicated that girdling usually severs the phloem and cortex. We conclude that girdling behavior is widely distributed within the Notodontidae and may serve to improve leaf nutrition and/or prevent the influx of defensive compounds into leaves.

The Tissue Culture and Transformation of *Rubus*

Nadine Gates and Kayla Parker
Faculty Mentor: J.D. Swanson

Transformation is the genetic alteration of a cell resulting from the uptake and expression of foreign genetic material (DNA). Genetic transformation techniques have been in existence for less than thirty years and have already made a huge impact on agriculture. The benefit of transgenic agriculture includes herbicide-tolerance and Bt-crops for pest management, altered ripening/oil content, increased vitamin level, and higher yields, as well as resistance to disease. In our laboratory, we are currently working towards the transformation of *Rubus spp*, an excellent system for studying the genetics of agriculturally and economically important crops; the United States is the third largest producer of bramble (Rubus) fruit crops, accounting for 13% of the total world crop and a $300 million industry. The ability to perform transformation is a technique that has yet to be accomplished in blackberry. To this end, we used *Agrobacterium*-mediated transformation techniques to transform the blackberry (*Rubus spp*) in tissue culture. PCAMBIA, a vector containing a GUS reporter gene, was used to produce transgenic plants. Results thus far have revealed the successful transformation of blackberry callus and studies are ongoing. We intend to use this system to enable further study into the molecular mechanism of cell-to- cell communication regulating growth and development in blackberry tissues.

Acetylcholine and Endothelin-1 Mediated Arterial Constriction are Mediated by Different Calcium Sources

Ross Gray, Audra Finley, Bonnie Schlicker, and Whitney Philamlee
Faculty Mentor: Brent Hill

Endothein-1 (ET-1) and acetylcholine (ACH) are agonist peptides associated with vasospasms of coronary arteries. Vasospams are triggered by excessive calcium influx from outside the cell and/or calcium release from internal organelle(s). We evaluated the contribution of each of these calcium sources to the ET-1 and ACH mediated contraction using a physiological saline solution (PSS) containing 0 mM and 2 mM calcium. Right coronary arteries were obtained from female pig hearts, sectioned into 3 mm rings, and suspended into organ baths containing PSS (0 or 2 mM calcium). Compared to rings exposed to the 2 mM calcium PSS, the absence of extracellular calcium significantly reduced the ET-1-induced contraction, but had little effect on the ACH contraction. Next, the arterial rings were exposed to 10 μM estrogen and its metabolites, 2-methoxyestradiol and 2-hydroxyestradiol for 60 minutes before the application of ACH or ET-1. In the presence of 2 mM calcium PSS, estrogen and its metabolites decreased the ET-1 and ACH contraction. The inhibition of extracellular calcium influx by estrogen and its metabolites was confirmed using the selective calcium channel agonist, BayK8644. Our data suggests that ET-1 mediates its contractile effect from external and internal calcium sources. In contrast, ACH induces its contraction from internal calcium stores. Estrogen and its metabolites inhibit the ET-1 contraction by inhibiting the influx of calcium into the arterial smooth muscle cell.

Geography and phylogeny of sexual and apomictic *Erigeron tenuis* (Asteraceae)

Dulcinea V. Groff
Faculty Mentor: Richard Noyes

The geographical and evolutionary relationship between sexual populations of *Erigeron tenuis* and *E. strigosus* is explored. *Erigeron tenuis* is the presumed sister species to *E. strigosus* and previous chromosome counts suggest that it comprises diploid and polyploid populations. Analyses of pollen grains from 530 herbarium specimens were used to estimate the distribution of diploid and polyploid populations. The analyses reveal that diploids are restricted to Eastern Texas while polyploids are widely distributed. This pattern is consistent with distributions in other apomictic complexes. Chromosome counts confirm $2n = 18$ for plants collected from a sexual population while counts for polyploids from two populations reveal $2n = 27$. Ovule development of sexual diploid *E. tenuis* is tetrasporic and diplosporous for polyploids. To explore the relationship between diploid *E. tenuis* and diploid *E. strigosus*, the ITS and ETS spacer regions of nuclear ribosomal DNA were used to construct a phylogeny. The phylogenetic analysis nests *E. tenuis* within *E. strigosus*, which implies that *E. strigosus* is paraphyletic. This result has implications for our understanding of apomixis in the group.

Population Ecology, Growth, and Reproduction of Grotto Sculpin (*Cottus carolinae*), an Imperiled Cave Fish Endemic to Perry County, Missouri

Clint R. Johnson and Julie L. Day
Faculty Mentor: Ginny Adams

Troglomorphic species are considered one of the most threatened groups of organisms worldwide due to their limited range, specific habitat requirements, and limited biological information. Available data is usually limited to single season descriptive studies due to the logistically demanding cave environment. This project focused on long term seasonal length-frequency trends to determine critical life history characteristics including growth, longevity and timing of reproduction that may help conserve this unique fish threatened by pollution and invasive species. Grotto sculpin are a unique population of banded sculpin (*Cottus carolinae*) endemic to Perry County, Missouri and are believed to be in the process of adapting to the cave environment. Grotto sculpin were sampled in two caves and their corresponding resurgence sites every four to twelve weeks beginning in August 2005. Fish were measured (SL, TL, weight and eye length) and implanted with an elastomer tag for mark-recapture analysis. Growth rates, analyzed using FiSat, were found to be up to twice as high in surface populations compared to cave populations. Along with greater observed maximum lengths from fish found in caves, this growth data suggests that fish residing underground are longer lived than their above ground counterparts. Large numbers of young-of-year fish were observed at surface sites from spring through fall (May-October) before disappearing, presumably into nearby caves. We believe grotto sculpin are using these resurgence sites as nursery areas to allow young fish to grow quickly before entering into the caves, minimizing chances for cannibalism by larger sculpin after migration underground.

The Function of Sodium Hydrogen Exchangers in MCF-7 Tumor Cell Survivability

Willis Johnson, Kevin McElhanon, and Tara Havens
Faculty Mentor: Steven Runge

Tumors are often marked by insufficient blood vessel formation due to rapid growth that creates hypoxic and acidic regions (due to the accumulation of acidic metabolic waste). Apoptosis is normally induced by these conditions, yet some cancerous cells are able to survive. A selective pressure is created in the tumors favoring those cells able to adapt to the adverse conditions. Questions still remain as to how intracellular pH is regulated in cancerous cells experiencing theses conditions. This project examines a possible mechanism responsible for cancer cell survival through regulation of intracellular pH. Identification of the survival mechanism may reveal a strategy to induce apoptosis in solid tumor cells a clinical setting.

The sodium hydrogen exchanger (NHE) family of proteins function in cellular pH regulation. Under stress, the mRNA expression of some isoforms changes and several isoforms are

trafficked to the cell membrane. We will expose MCF-7 human breast cancer cells to differing levels of hypoxic and acidic stress and observe temporal changes in whole cell and membrane protein expression for three NHE isoforms.

Cells will be subjected to both stresses (hypoxia and acidification), solely to hypoxia, or solely to acidification to determine the factor(s) leading to modulation of NHE isoforms. Harvesting will take place after 6 hours or 2 days of exposure to hypoxia and/or acidification to measure acute and adaptive responses, respectively. Samples of whole cell expression and cell membrane expression will be analyzed to determine if NHE trafficking, protein synthesis, or both are involved in the adaptive response.

Calcium Channel Expression Differs Between Rat Mesenteric Arteries And Veins

C. Renee Jordan and Keshari Thakali
Faculty Mentors: Brent Hill and Nancy J. Rusch

In the circulatory system, blood pressure is regulated by arteries and veins. Antihypertensive drugs including the calcium channel blockers that inhibit calcium influx, dilate arteries but not veins. Thus, we hypothesized that the pore-forming α1C subunit of the calcium channel is expressed in both arteries and veins but only is functional in arteries. Western Blots compared the amount of α1C between mesenteric arteries and veins. Also, a fluorescent label was used to localize α1C in the smooth muscle cells. Our Western blots revealed more calcium channel α1C protein in arteries than veins when normalized to total vessel protein. However, when normalized to α -actin, a smooth muscle cell marker, the amount of α1C was similar between arteries and veins. Fluorescent images revealed a dense expression of α1C on the surface of arterial muscle cells, its functional site to mediate calcium influx. In veins, α1C was limited to the cytosol. Therefore, although calcium channels are expressed in arteries and veins, they are not situated at the surface membrane in veins. The fewer functional calcium channels in veins suggest that other mechanisms provide calcium for contraction. These pathways represent targets for the development of novel antihypertensive drugs that act on veins.

Identifying Stage One Prickle Development Genes

Allicia Kellogg and Meghan Thompson
Faculty Mentor: J.D. Swanson

Most organisms rely on dermal tissue for protection from pathogens and predation. Some plant species have an added defense mechanism utilizing specialized dermal tissues in the form of spines, thorns, or prickles. Prickles are defined as an outcropping of proliferated epidermal tissue, and very little is known about their molecular development. Our lab has developed a staging model for prickle development, which suggests that early stage prickles are simply glandular trichomes that have received a cell proliferation signal that will cause a prickle to

develop from a trichome. This project aims to identify genes involved in very early stages of prickle development. Stage one prickles are defined as a mass of proliferating cells emerging from the stem epidermis usually growing to a size less than 22 μm in diameter. We hypothesize that trichome initiation genes identified in *Arabidopsis* have similar functions in *Rubus* and may possibly be involved in stage one of prickle development. We have several potential gene candidates, including: *GL1*, *GIS*, *ETC1*, *SIM*, *GL3*, *GL2*, *TRY*, *CPC*, and *EL2*, all of which are involved in the molecular pathway of *Arabidopsis* trichome development. We will subject our gene candidates to functional analysis including *in situ* hybridization, whole mount *in situ* hybridization and RT-PCR to determine their function in *Rubus.*

Examination of *Alligator mississippiensis* Populations in Arkansas for Multiple Paternity

Nicole E. Knox
Faculty Mentor: J.D. Swanson

American alligators may increase the genetic variability of their offspring through a reproductive strategy known as multiple paternity. Multiple paternity means that a clutch of eggs may include the progeny of more than one male. This study may lead to insights into the mechanisms and reproductive benefits of this strategy. Alligator eggs were collected from locations in southern Arkansas and analyzed through a process of DNA extraction and amplification of polymorphic microsatellite loci. Amplified DNA fragments were separated and visualized using agarose gel, then sized and analyzed using genotyping software. This project is ongoing, but the data suggests that multiple paternity exists in at least one Arkansas population of American alligators. Future studies on multiple paternity will expand to include comparison of phenotypic data, growth factors, and survivability of hatchlings between clutches exhibiting multiple and single paternity to determine if there is an advantage to this strategy. If multiple paternity is found to increase reproductive fitness in American alligators, *Alligator mississippiensis* may be used as a model that can explain some factors of mammalian courting behavior and mate selection.

DIFFERENTIATING THE ROLES OF *PAL 1* AND *PAL 2* IN LATE PRICKLE DEVELOPMENT IN *RUBUS*

Ben Magie, Coleman Little, Nate Jones, and Jennyfer Delvasto
Faculty Mentor: J.D. Swanson

The study of genus *Rubus* (blackberry and raspberry) is important for multiple reasons in both the medical and agricultural realms. The genus *Rubus* contains antioxidant properties that can be used to counteract radical agents present in biological systems. Our lab has applied a novel system using prickles as a model to understand cell-cell communication in terms of cell growth and proliferation. Prickles are epidermal growths in plants that serve as a physical first line of defense against herbivores, and can be found in many plants, including *Rubus*. For example, we hypothesize that lignification and subsequent hardening of the prickle marks the end of prickle

development. The gene products PAL 1 and PAL 2 are known to play a role in the lignification pathway, and have been targeted for functional analysis in this study due to their potential role as stop signals in prickle development. These genes have been subjected to functional analysis using *in-situ* hybridization and real-time PCR. These functional analysis studies suggest that *PAL 1*, but not *PAL* 2, plays an important role in initiating prickle lignification. Furthermore the way that prickle lignifications takes place between blackberry and raspberry also differ. This suggests that the study of *PAL 1* in genus *Rubus* could lead to viable information in the process of cell-cell communication with an emphasis on how cell growth and proliferation is stopped in plants.

Does the herbicide atrazine increase toxicity of nitrate in *Hyallela azteca* (Amphipoda) in laboratory exposures? Initial progress and preliminary tests

Ram Pandey
Faculty mentors: Laurie Warren and Ginny Adams

Pesticides and other chemical contaminants rarely occur in the environment as single compounds but as mixtures. While an extensive database exists indicating the effects of single toxicants on aquatic organisms, only recently have effects of contaminant mixtures found in most aquatic ecosystems been investigated. Atrazine is one of the most commonly detected herbicides found in mixtures with other contaminants such as nitrates. Atrazine application in agricultural areas often coincides with fertilizer use, resulting in the presence of both atrazine and nitrate in surface and groundwaters. Atrazine toxicity data are available for many organisms but combined effects of atrazine and nitrate have not been investigated with any invertebrates. This study is aimed at examining combined effects of atrazine and nitrate with the freshwater amphipod, *Hyallela azteca*. Acute and chronic effects are being investigated using mortality, growth and reproduction as measure of toxic effect. Preliminary tests with adult amphipods indicate that they are moderately sensitive to nitrate. The LC50 (concentration that kills 50% of organisms) determined from a 96-hour water-only exposure with adult *H. azteca* is 100 mg/L. This study is expected to provide data valuable for determining potential effects of agricultural activities on aquatic ecosystems.

Estrogen Increases the Regulatory Protein Kinases of the Sarcoplasmic Reticulum Ca^{2+}-ATPase Pump

Andreya E. Reed, Tramaine Shepard, and Jamie Dalton
Faculty Mentor: Brent Hill

Protein kinase A (PKA), protein kinase G (PKG), and Ca^{2+}/calmodulin-dependent protein kinase II (CaMKII) are the three kinases known to increase SERCA activity to attenuate the intracellular [Ca^{2+}] in vascular smooth muscle cells. However, it is not known if the kinases also influence SERCA expression. Our lab has previously demonstrated that estrogen (E2) increases

SERCA expression in coronary arteries, thus giving the cells the capacity to limit intracellular Ca^{2+} levels to protect against the development of coronary artery disease in women. The aims of this study were to investigate: (1) the effect of E2 on PKA, PKG, CaMKII expression, (2) if the kinases influence SERCA expression, and (3) if the known E2-induced increase in SERCA expression is dependent on the E2 receptor. The distal portion of right coronary arteries obtained from female porcine hearts were cut into longitudinal strips and incubated for 24 hours in 1 nM E2, 1 pM E2, and the EtOH solvent for E2. When appropriate, the specific inhibitors for PKA, PKG, and the E2 receptor were added during the incubation period. Antibodies reactive to SERCA2b, PKA, PKG, and CaMKII were used to determine their immunoreactivity in homogenized tissue after the 24 hours of treatment. Our results suggest that E2, independently, increases SERCA2b, PKA, PKG and CaMKII expression. It appears that the E2-induced increase in SERCA2b happens via the E2 receptor and is due to the elevated expression of PKG.

Analysis of Signal Transduction in Mercury Treated EL4 T Lymphocytes

J. Leigh Reno
Faculty Mentor: Ben Rowley

Mercury (Hg), is a widespread environmental toxin encountered in a range of situations. Mercury has well-documented neurotoxic and immunological effects on humans and mice, which has led to in-depth research about its mechanisms of action and consequent cellular responses.

This study will be concerned with the effect of Hg on lymphocyte signal transduction, particularly that of EL4 T lymphocytes. The effects of mercury (Hg) on signal transduction are of particular interest because of its prevalent low-level ecological deposition and well-established toxicity - this study is significant because of the concern with low, biologically relevant levels of Hg that have not been researched before. This study will test Hg concentrations from 5 μM (deemed heavy biological exposure) to a more biologically pertinent 0.01μM. Preliminary studies have recently been performed to determine which concentrations may induce either apoptosis or necrosis within exposed cells.

The goal of this study is to investigate the impact of acute (12 hour) exposures to low concentration inorganic Hg on EL4 T cell signal transduction. It is hypothesized that such exposures will lead to impairment in the capability of T cells to activate. Analytical flow cytometry is used to assess intracellular activation-induced phosphorylation events in the presence or absence of mercury.

The Development of Genomic Resources in *Rubus*

Madeline Richmond
Faculty Mentor: J.D. Swanson

The genus *Rubus,* which contains raspberry and blackberry plays an integral role in a multi-million dollar produce industry, which is linked to health benefits. The berries from these plants produce ripe, vibrant fruits that contain antioxidants that are thought to improve health by eliminating the body's free radicals. Breeders of these crops face hardships including poor berry quality, pathogens, and climate tolerance. Despite their importance, the genus *Rubus* has few genomic resources available. Our lab at UCA is working to increase these genomic resources. To this end, we have implemented molecular markers for patent infringement, investigated individual gene expression using cDNA libraries, and have recently developed a genomic library in red raspberry, the first in the United States. Each genomic resource aids in developing a more complete understanding of the genetics and genes behind important traits in *Rubus* that could lead to healthcare breakthroughs in the future.

RAPD Markers for Evaluating Paternity in Plants

Aaron Roberds
Faculty Mentor: Richard Noyes

In experimental crosses using hermaphroditic organisms such as plants, unintended progeny may be produced that are the result of self- rather than cross-fertilization. Fortunately, DNA markers can be used to differentiate the two classes of progeny. In this experiment RAPD markers were used to identify the origin of diploid progeny that were produced in a complex sexual diploid and apomictic triploid cross. Eight RAPD markers were used to screen thirty-eight diploid individuals. The presence of parental bands in 15 plants (39%) indicates they are of hybrid origin. The absence of paternal bands in 23 (61%) indicates that they probably resulted from self-fertilization.

Behavioral and Function Analysis of Caf4 in *Saccharomyces cerevisiae.*

Jacob Seiter and Annette Wilkins
Faculty Mentor: Kari Naylor

Mitochondria are organelles that provide the cell with chemical energy in the form of ATP. Mitochondria have a dynamic, branching tubular structure which is maintained by constant fission and fusion. Any imbalance of the fission and fusion processes can alter the mitochondrial structure and result in mitochondrial deficiencies which can lead to diseases such as blindness. Mitochondrial fission requires three proteins: Dnm1, Fis1, and Mdv1. Mdv1 functions as a molecular adapter connecting Fis1 and Dnm1 to form the fission complex. Fis1 is the transmembrane protein that targets the entire complex to the mitochondrial membrane, and Dnm1 ultimately mediates the fission event. A fourth recently identified protein, Caf4, an Mdv1

homolog, also serves as an adapter between Dnm1 and Fis1. Caf4 is not necessary for fission to take place; over-expression of Caf4 blocks fission suggesting that Caf4 is a negative regulator. We hypothesize that Caf4 and Mdv1 switch places in the fission complex depending on if the cell needs to carry out fission to maintain proper mitochondrial structure. Using confocal microscopy we aim to better understand the role Caf4 plays in fission, by observing when Caf4 is on the membrane, and specifically at what point during fission this occurs. For example, if Caf4 is present before the fission event and absent during fission, it will support our hypothesis that Caf4 is a negative regulator of mitochondrial fission.

Exploration of the Role of Gingko Biloba Extract in the Prevention of Prostate Cancer in an Animal Model

Jantzen Slater, Rose Willett, Alexandra Kaelin, Megan Millican, Austin Plumlee, and Emily Simon

Faculty Mentor: Wen Wang and Steven Runge

Introduction

Prostate cancer affects one in every six men in the United States. Our goal is to discover dietary supplements that can prevent prostate cancer. Ginkgo, a commonly used dietary supplement, possesses potent anti-oxidative and anti-inflammatory properties. While these properties could be utilized for reducing the risk of prostate cancer, Ginkgo's role is still unknown. Using a prostate cancer cell model, we have discovered that Ginkgo can selectively inhibit the growth of human prostate cancer. Our goal for this pilot study was to assess the anticancer efficacy of Ginkgo against early stage human prostate cancer cells in an animal model.

Methods

The animal model was established by injecting the early stage human prostate cancer cells, LnCap, to the back of male athymic nude mice. The animals were randomized into three experimental groups including control, pre-treatment, and post-treatment groups. Ginkgo (100mg/kg animal weight) was administrated by intravenous injection two-weeks prior to LnCap injection (pre-treatment group) or two-weeks after LnCap injection (post-treatment group). The tumor volume and animal weight were monitored for 8 weeks after tumor injection. The tumors from three groups were harvested at the end of the study. The animal experimental protocol is approved by UCA IACUC.

Results

Our results indicated that treating mice with Ginkgo two weeks after the tumor cell injection significantly promoted LnCap cell growth in comparison to the control group. In addition, the tumor volumes were significantly higher in the post-treatment group comparing with those of the pre-treatment group. There was no significant difference in tumor growth curves between the pre-treatment group and the control group. The end of study tumor weight analyses demonstrated that tumors in pre-treatment group were smaller than those of the control group, while the tumors in post-treatment group were larger than those in both control and pre-treatment groups. Furthermore, the tumor weight was significantly higher in the post-treatment group in comparison to the pre-treatment group.

Conclusion
Our preliminary findings demonstrated that Ginkgo post-treatment promoted cancer growth in the LnCap prostate cancer animal model, while Ginkgo pre-treatment shown some level of inhibitory effect on the prostate cancer cell growth. Our results may suggest a significant clinical impact in that consuming Ginkgo may promote cancer growth in patients diagnosed with prostate cancer. These current findings warrant further pre-clinical studies and the clinical investigation on the impact of Gingko consumption and prostate cancer development and progression.

Aspects of the Reproductive Biology of Shortnose (*Lepisosteus platostomus)* and Spotted (*Lepisosteus oculatus)* Gar in the Fourche LaFave River

Evan Soper, Robert Wade, and Tommy Inebnit
Faculty Mentor: Reid Adams

Historically, gars were often thought of as worthless and destructive predators, making them less popular for biological study. As such, gar life history and reproductive biology are less understood relative to other fishes, and data comparing the biology of different gar species from the same drainage are lacking. We collected reproductive data on two similar-sized gar species for comparative purposes and to gather information on the understudied shortnose gar. Shortnose and spotted gar were collected from the Fourche LaFave River between February and July of 2007. Each gar was dissected and had its gonads removed and preserved in 10% formalin. Each ovary was weighed and a subsample of 15% of that mass was removed. From that subsample, each egg was counted and the total fecundity was extrapolated. Thirty shortnose gar (53-69 cm total length) and thirty-four spotted gar (54-79 cm total length) were examined, and we found that total fecundity ranged from 3,773 to 19,613 eggs and 1,387 to 21,827 eggs, respectively. We found strong asymmetry in mass and egg count in ovaries of both species, where the left ovary was larger and had more eggs. For both species, there was a positive correlation between total length and total fecundity. Preliminary analyses indicate these two sympatric gar species have a similar pattern of total fecundity/body size relationship. Further, total fecundity estimates of our Arkansas population of shortnose gar are comparable to shortnose gar studied in Illinois. We are continuing to analyze other reproductive data (e.g., GSI, spawning season, and egg diameter).

Coevolutionary Patterns of a Threatened, Troglomorphic Fish and its Acanthocephalan Parasites

Sarah Vestal
Faculty Mentor: David E. Starkey

Phylogeographic analyses of parasites are extremely limited in number and scope, though their usefulness has shown great potential. Comparative studies of parasites and hosts can be useful for illuminating underlying mechanisms of speciation, dispersal, gene flow, effective population size, and evolutionary patterns that might otherwise remain obscure. Grotto sculpin are unique populations of banded sculpin (*Cottus carolinae*) endemic to cave systems underlying Perry County, Missouri. These troglomorphic (cave-adapted) fish are state-threatened and a Federal Endangered Species Candidate. Burr et al. (2001) examined fish from all caves grotto sculpin inhabit and found significant morphological differences between epigean (surface) and hypogean (cave) populations, including smaller eyes, reduced number of pelvic fin rays, reduced pigmentation, and enlarged cephalic lateralis pores. Prior genetic work was unable to fully resolve the evolutionary relationships among sculpin inhabiting cave, spring branch, and surface streams, suggesting that data from a co-evolved species could be beneficial. For this study, we are investigating the population ecology, divergence, and structure in the Acanthocephalan parasites of grotto sculpin in an effort to elucidate otherwise cryptic dispersal patterns. To examine the frequency of Acanthocephalan parasitism, digestive tracts were removed from preserved sculpin. Worms were extracted and enumerated by sampling locality. For our genetic study, we are employing a multi-locus phylogeographic analysis combining DNA sequence data from CO1, ITS 1, and ITS 2 markers to address possible novel, cryptic species boundaries. This will provide a substantial means of inference as to the dispersal potential and genetic connectivity for both host and parasite when analyzed comparatively. Preliminary prevalence, intensity of infection, and abundance for each sculpin population will be presented.

Food Habits of Sympatric Spotted (*Lepisosteus oculatus)* and Shortnose (*Lepisosteus platostomus*) Gar during Flooding of an Arkansas River Tributary

Richard Walker, Justin Benton, and Tommy Inebnit
Faculty Mentor: Reid Adams

Gars are generally thought to be avid predators, predominantly feeding on fishes, and to a lesser extent, invertebrates. Though southern river systems typically contain multiple gar species, few studies have examined feeding characteristics of sympatric populations. Further, little information exists on food resources of shortnose gar *Lepisosteus platostomus*. We report results of an examination of diet in shortnose gar and spotted gar *Lepisosteus oculatus* from the Fourche LaFave River in Arkansas. Stomachs were dissected and examined from 74 adult spotted gar (46 - 81 cm TL) and 91 adult shortnose gar (49 - 76 cm TL) collected during May to July 2007, corresponding to back-flooding from the Arkansas River. Forty-seven (64%) spotted gar and 54 (59%) shortnose gar contained identifiable prey items. Considering frequency of occurrence,

important food resources of spotted gar were fish (74%), crayfish (26%), aquatic insects (11%), and terrestrial insects (9%). Similarly, fish (59%) was the most commonly occurring food item in shortnose gar, but they consumed aquatic (24%) and terrestrial (35%) insects more frequently than spotted gar. Additionally, shortnose gar utilized amphibians (17%) as prey. Our analyses suggest similar-sized, sympatric spotted gar and shortnose gar had different feeding habits where shortnose gar utilized a wider variety of prey, including both aquatic and terrestrial food resources.

Flow Cytometry Analysis of Mercury Affected B Cell Activation

Kara Weigand
Faculty Mentor: Ben Rowley

Humans are exposed to several forms of mercury through their diet and environmental contamination. This exposure affects the immune system in a variety of ways, including causing the production of autoantibodies. Autoantibodies, a type of antibody that targets and damages the tissues of the body, are characteristic of diseases such as lupus and systemic sclerosis. The mechanisms that allow this to occur and dosage levels that cause autoantibodies are unclear. B cells, lymphocytes that secrete antibodies and fight extracellular infection, require a cascade of events that allow the cells to become activated and participate in the immune response. An antigen is recognized by the B cell and the cell begins internally phosphorylating proteins along a pathway to activate the cell. These phosphorylated molecules can then serve as a means to measure B cell activation effectiveness. Previous investigation found that exposing B cells to a non-lethal level of mercury weakens their B cell receptor-mediated activation, specifically at the Syk kinase protein. To further understand these mechanisms, preliminary tests were conducted on the 70Z mouse B cell line using flow cytometry to identify toxic doses of mercury for acute (12 hours) exposure. After determining toxic levels of mercury exposure, initial experiments were performed assessing activation at, and below, these mercury concentration levels.

Do cardenolides and pyrrolizidine alkaloids protect eggs of the monarch, *Danaus plexippus*?

Justin D. Wright
Faculty Mentor: David Dussourd

The monarch butterfly (*Danaus plexippus* L., Lepidoptera: Nymphalidae) sequesters both cardenolides and pyrrolizidine alkaloids from plants and is thought to allocate these toxic compounds to their eggs for protection. In this study, we will test this hypothesis through diet manipulation so as to produce eggs with both cardenolides and pyrrolizidine alkaloids, eggs with only one of these compounds, and eggs with neither. Cardenolides in the eggs will originate from *Asclepias curassavica*, a milkweed with high levels of cardenolides. Eggs that lack cardenolides will come from individuals reared on *Cynanchum leave*, a monarch host plant thought to lack cardenolides. Adult monarchs assigned to produce eggs with pyrrolizidine alkaloids will be

given access to manually crushed leaves of *Heliotropium indicum*, a boraginaceous plant known to contain the pyrrolizidine alkaloid lycopsamine. The four egg categories will be presented to the parasitoid wasp *Trichogramma pretiosum* and two egg predators, the adult lady beetle *Coleomegilla maculata* and the larvae of the green lacewing *Chrysoperla rufilabris*. A field test will also be conducted with each of the four egg categories placed on native milkweed in the Conway, Arkansas area during the spring migration of monarchs. Though several studies have demonstrated chemical defense in insect eggs, this study is unique in its potential for showing a synergistic chemical defense system.

CHEMISTRY

Expression Profiling of Retinoic Acid Nuclear Receptors in Human Blood Cell Lineages

Maggie Block
Faculty Mentors: Melissa Kelley and Lance Bridges

Vitamin A (retinol) and its derivatives, retinoids, participate in a spectrum of biological events including the establishment and maintenance of immunity. Retinoids influence cell proliferation, differentiation, and adhesion by binding to a family of nuclear receptors known as retinoic acid receptors (RAR) and/or retinoic X receptors (RXR). Upon binding retinoid, RAR and RXR nuclear receptors homo or heterodimerize. These receptor dimers subsequently activate or silence genes that possess retinoic acid response elements (RARE) within their promoter regions. In our lab, we have recently shown that 9-*cis* Retinoic Acid (9-*cis* RA) potently induces integrin-independent B-cell adhesion to select immune ligands. However, the specific nuclear receptor(s) involved in this novel retinoid-dependent adhesive pathway is unclear. By reverse transcriptase PCR expression profiling of RXRs and RARs in multiple human blood cell lines, we provide insight into the specific receptors that may be required for cells to utilize 9-*cis* RA for regulating adhesion. We compare the retinoic acid nuclear receptor expression in cell lines that respond to 9-*cis* RA with respect to adhesion to expression in nonresponsive cell types. Since 9-*cis* RA can augment expression of its own nuclear receptors, we additionally compared the level of expression in cells treated with vehicle to cells exposed to 9-*cis* RA. This study sheds light on the retinoic acid nuclear receptor repertoire a cell must possess in order to alter its adhesive properties when exposed to retinoids.

Direct synthetic routes to unencumbered single-scorpionate nickel complexes

Adam Corken and Brian Besel
Faculty Mentors: Patrick Desrochers and Richard Tarkka

Complexes of metal atoms with the so-called “scorpionate ligands” have made significant contributions to metal catalysis and metalloprotein models. The major difficulty in synthesizing the important single-ligand complexes, which are coordinatively unsaturated, is that the undesirable thermodynamic two-ligand products (L_2M) are usually formed instead. To make the single ligand metal-scorpionate complexes, chemists have had to either use intermediate thallium complexes or place bulky substituents on the scorpionate's pyrazole rings. We have successfully prepared $TmNiCl_2(OH_2)$, the first reported single-Tm nickel complex. The kinetic control necessary for the synthesis of this compound was achieved using excess chloride ligands and nitromethane as the solvent. This method also proved useful for the preparation of more challenging synthetic targets, Tp*NiX. This preparative method does not require thallium(I)-scorpionate precursors, even for these least sterically encumbered scorpionates, and it should become a preferred method for preparing such complexes for many first row transition metals.

Synthesis of Amino Acid Radical Precursors

Daniel Fields, D.J. Martin, and Cory Stogsdill
Faculty Mentor: Nolan Carter

Radicals derived from proteins are produced by ionizing radiation as well as endogenous mechanisms related to metabolism. Radical damage pathways often involve a complex sequence of reactions initiated by reactive oxygen species such as hydroxyl radical which react by hydrogen atom abstraction to produce protein-centered radicals. These intermediate protein-centered radicals can in turn react with oxygen to produce peroxyl radicals that undergo subsequent reactions. The study of this process is complicated by the fact that hydroxyl radical is nonselective and can attack a particular amino acid at multiple sites, leading to multiple protein-centered radicals. To aid the study of this type of reaction pathway, we have designed photolabile amino acid radical precursors that generate specific radicals upon photolysis. This will provide insight into a biologically significant issue.

Screening of proteins to test for correlation of phosphate collapse around cationic protein residues and DNA bending

Bryce Grant
Faculty Mentor: Lori Isom

Protein/DNA complexes from the Protein Data Bank were screened to select complexes that could be used to test the theory that cation interaction with DNA phosphate groups results in partial charge neutralization. These interactions may induce DNA bending and minor groove narrowing. X-ray crystal structures of protein/DNA complexes provide the best structural information for DNA and proteins to quantify the effect of monovalent cation binding on DNA structures. 309 DNA/protein structures were screened based upon having a resolution of 2.0 Angstroms or higher. In the case of duplicates, the higher resolution was retained. Structures with at least ten base pairs (one full helical turn), continuous, and unmodified were also retained. Structures that would involve additional helix/helix interactions, such as histones, were excluded. To be considered continuous, the DNA phosphate backbone of the strand could not be broken and the base pairs could not be unstacked. The DNA also had to be double-stranded. The proteins that met the preceding criteria will be used to determine the relationship between cation interactions with DNA phosphate groups in the future.

Investigation of DNA Bending Induced by Mg^{2+} Sequestration By 2-Methyl-2,4-Pentanediol

Courtney Huff and Jade King
Faculty Mentor: Lori Isom and Nolan Carter

The mechanism of DNA bending has long been debated and results from solution studies and x-ray crystallographic methods are often conflicting. Solution studies suggest that MPD, which is added to DNA crystals during growth, removes bends from DNA. The present study seeks to elucidate the mechanism by which MPD affects DNA curvature. If DNA bending is induced by cation binding, it is proposed that chelation of Mg^{2+} by MPD could sequester the ions away from the DNA thereby decreasing its curvature. To test this hypothesis, UV-Vis and NMR methods have been applied. Competition experiments between MPD and the indicator Eriochrome Black T (EBT) for Mg^{2+} ions have been used to probe for Mg^{2+} chelation by MPD. A characteristic shift in the absorbance maximum of EBT was consistent with competitive removal of Mg^{2+} from EBT by MPD. NMR experiments have also been conducted in an attempt to corroborate these results.

9-*cis*-Retinoic Acid Metabolism in Human K562 Cells

Andrea Kirkpatrick and Chelsa Painter
Faculty Mentor: Lance Bridges and Melissa Kelley

Vitamin A (retinol) exists in two biologically active forms, all-*trans*-RA and 9-*cis*-RA. Theses retinoids are essential for many critical life processes including immune cell function. However, the role of retinoids in immunity is poorly understood. Currently, all--*trans*-retinoic acid has been demonstrated to augment cell adhesion in select human immune cell lineages. However, the retinoid involved in stimulating cellular adhesion has not been identified. Oxidative metabolism of 9-*cis*-RA will produce products that are less biologically active, and potentially less effective in regulating immune function. In the current study, we examine 9-*cis*-RA metabolism in the human pro-red blood cell line K562. K562 cells were treated with 1 micromolar 9-*cis*-RA or equal volume of ethanol for 24, 48 or 72 hours. K562 media was subjected to liquid-liquid extraction techniques and high performance liquid chromatography. Metabolites of 9-*cis*-RA were present at 72, 48, and 24 hours. Our study is the first to identify 9-*cis*-retinoic acid metabolites in K562 human cells.

Steelman Research Group

Martin Sharum, Jesse Waid, and Sarah Stoeckel
Faculty Mentor: Karen Steelman

The Steelman Research Group utilizes advances in analytical chemistry to help archaeologists answer questions about the past. A main focus involves advances in sample preparation for

accelerator mass spectrometry radiocarbon dating. We use plasma chemistry to separate organic carbon from samples that contain large amounts of mineral carbon. This allows the radiocarbon dating of ancient cave paintings and other unique samples that are not amenable to traditional combustion methods. Samples currently being dated include rock paintings from France, Australia, Texas, and Arkansas. In addition, the laboratory is developing gas chromatography/mass spectrometry analytical methods for the extraction of alkaloids from excavated peyote cacti and the identification of organic material in rock painting samples.

We are also collaborating with Dr. Ginny Adams in the Biology Department to conduct a water quality study using semi-permeable membrane devices (SPMDs) and polar organic chemical integrative samplers (POCIS) to evaluate concentrations of potentially harmful chemicals present in Missouri cave and surface streams. These devices mimic bioaccumulation in fish for compounds below the method detection limit obtainable with grab water samples. Gas chromatography with ECD and MS detection is being utilized for the analysis.

Reversible Binding of Nitrogen Donors on Nickel(II) Scorpionates

Kristin Thorvilson and Ade Osinowo
Faculty Mentor: Patrick Desrochers

For the past two years we have been investigating the reversible binding of ammonia at the nickel(II) center, Tp*NiX. Here Tp* is the established scorpionate, hydrotris(3,5-dimethylpyrazolyl)borate, and X represents one of three halogens (Cl, Br, or I) or the hydrogen-rich anion, BH_4. The pertinent general chemical reaction is

$$\underset{\textit{deep pink/purple}}{\text{Tp*NiX}} + \text{3N-donors} \Leftrightarrow \underset{\textit{pale lavender}}{[\text{Tp*Ni(N-donors)}_3\text{+, X-}]}$$

N-donors refer to molecules possessing a nitrogen atom that can act as a Lewis base and bind the Lewis acid center, Tp*Ni, in the above reaction. Two bases investigated in this work include ammonia (NH_3, used in its gaseous form) and acetonitrile ($NCCH_3$), a common solvent that shows similar binding to ammonia but in liquid solutions. Ammonia is an established industrial and agricultural commodity as well as a potential hydrogen-rich alternative fuel. There continues to be a need, therefore, to safely handle and sense this very useful small molecule. As indicated by the reaction above, Tp*Ni reversibly binds N-donors like ammonia and acetonitrile. This reversibility means that Tp*NiX systems are recyclable, reusable, and therefore potentially catalytic in their interaction with molecules like ammonia. This reversible ammonia binding is associated with vibrant color changes, from deep pink/purple to very pale lavender; such changes could be exploited as a selective colorimetric sensor for this gas. Results will be presented that demonstrate the effect of varying X on the kinetic and energetic characteristics of this reaction. Kinetic issues would effect the response rate of an ammonia sensor based on this system. Energetics determine the minimum ammonia concentration that can be sensed and the conditions necessary to reset the sensor or release ammonia in a fuel-storage application. Not surprisingly, the energetics for acetonitrile and for ammonia binding appear to be quite similar, allowing us to

extrapolate the results for acetonitrile to the more interesting and commercially useful ammonia system.

Metabolic Profiling of 9-cis-retinoic acid in Human Blood Cell Lines

Tyler Staten
Faculty Mentor: Lance Bridges and Melissa Kelley

Vitamin A and its analogs, retinoids, are essential for many critical life processes including vision, reproduction, cellular development, and immune function. Biological active retinoids, all-*trans*-retinoic acid (*t*-RA) and 9-*cis*-retinoic acid (9-*cis*-RA), act as ligands for retinoic acid receptors (RAR) and retinoid X receptor (RXR) that are involved in regulating immune function. Currently, *t*-RA and 9-*cis*-RA have been demonstrated to augment cellular adhesion in the human B cell line RPMI 8866, and pro-red blood cell line K562, but not in a human T cell line Jurkat or human B cell line Daudi. However, the mechanism by which these retinoids enhances cellular adhesion is unclear. In the current study, we examine 9-*cis*-RA metabolism in RPMI 8866, Daudi, Jurkat, and K562 cell lines. Retinoid metabolic profiles were analyzed using liquid-liquid extraction and reverse-phase HPLC with photodiode array detection. Retinoid metabolites were not detected in RPMI 8866 Daudi, or Jurkat; however, 4-oxo-retinoic acid was detected in K562 cell media. Our study is the first to demonstrate retinoid availability plays a role in augmenting cellular adhesion in select blood cell lineages.

COMPUTER SCIENCE

Volatile Data Predictive Analysis with Interval Methods

Guanchen Chen
Faculty Mentor: Chenyi Hu

Massive data filled in our world usually do not provide us meaningful information explicitly. The objective of this study is to investigate and develop interval computing methods that analyze volatile dataset, extract useful knowledge, and make quality predication.

In this study, we develop interval computing approaches that improve the quality of predictions, especially for volatile datasets. Specifically, we investigate dataset interval representation, spectrum analysis for interval time series, window size selection and radius adjustment in rolling interval least squares (RILS). Applying them in predicting annual stock market with real world macroeconomic data from 1930-2004, we justified the strategy and results published recently. Our integrated interval forecast algorithm can be useful in predictive analysis for other real world volatile datasets.

Intelligent traffic lighting system

Matthew Johnson and Thomas Winters
Faculty Mentor: Vamsi Paruchuri

The traffic lighting systems used to regulate today's trafficking system, although an integral part of the system, are inefficient by today's standards. This inefficiency contributes to the increased cost of transportation while also contributing to the levels of pollution emitted as a result of human transportation needs. In addition to these detriments, this inefficiency also wastes the traveler's time. In this project, we propose and study a new method for the regulation of traffic using intelligent traffic lighting system. This method involves the development of communication protocols for sharing information between individual traffic lights and the development of an algorithm for the intelligent operation of the lights as a result of the data being shared. Variables such as traffic flow changes correlated with time of day will be analyzed to develop this new algorithm in an attempt to reduce the amount of time any given traveler spends in transit.

Protein Local 3D Structure Prediction by Super Granule Support Vector Machines (SGSVMs)

Matthew Johnson
Faculty Mentor: Bernard Chen

Understanding the sequence-to-structure relationship is a central task in Bioinformatics research. Adequate knowledge about this relationship can potentially improve accuracy for local protein structure prediction. One of approaches for protein local structure prediction uses the conventional clustering algorithms to capture the sequence-to-structure relationship. The cluster membership function defined by conventional clustering algorithms may not reveal he complex nonlinear relationship adequately. Compared with the conventional clustering algorithms, Support Vector Machine (SVM) can capture the nonlinear sequence-to-structure relationship by mapping the input space into another higher dimensional feature space. However, SVM is not favorable for huge datasets including millions of samples. Therefore, we propose a novel computational model called Super Granule Support Vector Machines (SGSVMs). Taking advantage of both theory of granular computing and advanced statistical learning methodology, SGSVMs are built specifically for each information granule partitioned intelligently by the clustering algorithm. This feature makes learning tasks for each SGSVM more specific and simpler. SGSVMs modeled for each granule can be easily parallelized so that SGSVMs can be used to handle complex classification problems for huge datasets. The prediction accuracy for local protein 3D structure is over 70%, which indicates that the generalization power for SGSVMs is strong enough to recognize the complicated pattern of sequence-to-structure relationships.

P3HR: Privacy-aware Portable Personal Health Records using Smart Cards

Pavan Roy Marupally
Faculty Mentor: Vamsi Paruchuri

Personal health records (PHRs) offer significant potential to stimulate transformational changes in health care delivery and self-care by patients. There is a gap between today's personal health records (PHRs) and what patients say they want and need from this electronic tool for managing their health information. Current barriers to PHR adoption among patients include cost, concerns that information is not protected or private, inconvenience, design shortcomings, and the inability to share information across hospitals/organizations. We propose a novel architecture to bridge the gap based on Privacy Preserving Portable Health Record (P3HR), a device that incorporates a smart card into a USB flash drive which provides encrypted flash memory for secure mobile data storage. The salient features of the proposed Privacy Preserving Portable Health Record (P3HR) include: strong multifactor authentication using biometrics, public key infrastructure to verify the credentials of the applicants, SSL based authentication protocol suite for authorization and secure online updates, local backup to store patient data which ensures that

the patient will have access to data in case of P3HR theft, lost device, hardware failure, software failure or a Computer virus.

Video Segmentation for Wireless Video Transmissions

Joshua D. Stancil
Faculty Mentor: Yu Sun

With the increasing bandwidth in wireless systems and rapidly growing demand for video communications, wireless video transmission has received much attention recently. Due to limited bandwidths and time-varying characteristics of wireless channels, how to obtain good subjective visual quality of wireless videos is a challenging task. Video segmentation which divides a frame into different regions is usually adopted to address this issue since it can reduce the amount of information to be transmitted to match limited wireless bandwidths while keeping good subjective quality of videos. In this research, we study video segmentation techniques and explore real-time video segmentation approaches for wireless video transmission. Our experimental results show that our approach is simple and effective.

A Research of Three-Dimensional, Virtual Reality Display Using the Nintendo Wii Remote

Marcus Swope
Faculty Mentor: Yu Sun

A basic goal of Human-Computer Interaction is to improve the interactions between users and computers by making computers more usable and receptive to the user's needs. Recent success of experimentation by Johnny Chung Lee of Carnegie Mellon University with the Nintendo Wii Remote has generated a lot of interest in the subject of human-computer interaction in the open source development community. One of Lee's experiments was to create a three-dimensional virtual reality desktop display using the Wii Remote. However, his project had some limitations including the inability to adjust the algorithm based on specific user environments which limited the total spatial sensitivity of the Wii Remote. Also, his project had a very low frame rate and very high load and initialization times. Furthermore, his project is also only available to those that use Windows, Microsoft DirectX and C#. Our research objectives are to increase performance and spatial sensitivity of the project as well as make the project more widely available to end-users and open source developers. In this study, we have implemented the project in Linux using OpenGL and C++. We have also added the ability to change variables to optimize the Wii remote performance. This allows for more precise triangulation of the user in relation to the Wii remote by knowing the specific distances between different elements within a given user's physical environment. Experimental results show that these changes vastly improve the frame rate and reduce load times as well as greatly increase the amount of spatial volume in which the Wii remote is sensitive to the user.

A New Rate-Complexity Model for H.264/AVC Video Rate Control

Xin Yin, Ling Tian and Joshua D. Stancil
Faculty Mentor: Yu Sun

Rate control is crucial in controlling compression bitrates and qualities for network video applications. In this research, we propose a new intra-only rate control algorithm for H.264/AVC video compression. There are a number of new features of the proposed algorithm. First, we introduce the geometry gradient information as a new complexity measure to accurately represent the complexity of an intra-frame. Second, unlike existing rate control algorithms which do not directly model the relationship between the encoding rate and the complexity, we develop a linear rate-complexity model which takes the model intercept into consideration to improve prediction accuracies. Third, we develop a new target bit estimation approach. Experimental results demonstrate that, when compared with JVT-W042 rate control algorithm of H.264/AVC compression standard, the proposed algorithm achieves more accurate rate regulation, decreases quality fluctuations, provides more robust buffer control, and finally, improving coding quality by up to 0.35 dB.

Towards Painter Identification Using Balls Hierarchy

Vincent Yip
Faculty Mentor: Sinan Kockara

Even though much progress has been made on image processing algorithms and technologies, it is still very difficult to identify artist from his/her paintings. There are some certain attributes or features in paintings that uniquely identify their artists. Our objective in this study is to open up a pathway to graph algorithms for painter identification. In our framework, painting is converted to a hierarchical proximity graph called balls hierarchy. We treat image pixels as nodes in the graph so that proximity relations among both pixels' colors and positions are kept in the balls hierarchy. Balls hierarchy creates multiresolution hierarchical subgraphs that reflect a great deal about the pixels while maintaining all the existing proximity information.

Evaluation of Methods Used for Measuring Individual Performance on Group Projects

Vincent Yip and Pavan Roy Marupally
Faculty Mentor: Paul Young

Group-based software engineering projects are an important part of Computer Science and Information Technology curricula. Evaluating the overall performance of the group on such a project is fairly straightforward; however, fair assessment of individual contributions to group-based projects remains a challenging problem. Educators teaching software engineering face two core challenges in this assessment responsibility: provide a fair grade to the individual that is

reflective of their contribution to the project while at the same time avoiding the significant managerial overhead such an undertaking generally requires. Dr. Coppit proposes one solution to the challenge: the adaptation of the web-based task management system Issue-Tracker for managing and evaluating a semester-long project involving the entire software engineering class. In this paper we attempt to evaluate the effectiveness and fairness of Issue-Tracker in assessing the individual performance of students participating in such a software engineering group project.

MATHEMATICS

Iteratively Reweighted Generalized Least Squares Cross Validation

Derek Damron
Faculty Mentor: Patrick Carmack

Cross validation is a well established method commonly used to select model tuning parameters. It accomplishes this by withholding a data point, estimating the model with the remaining data, and using the fit model to predict the withheld data point. The tuning parameter which produces the lowest sum of squared errors is then declared the best. The technique works well when errors are independent, but performs poorly when errors are correlated. Carmack et al. (2008) proposed a modification known as far casting cross validation (FCCV) where neighborhoods about the point of prediction are deleted. While FCCV is an improvement over ordinary cross validation, the omission of the neighbors is not statistically efficient. A new approach that combines ordinary cross validation with iteratively reweighted generalized least squares is proposed, which is robust to correlation like FCCV and statistically efficient like ordinary cross validation.

Application of LaSalle's Invariance Principle to Stability of a Calcium Dynamic System

Jing Voon Chen
Faculty Mentor: Weijiu Liu

Calcium ions play a central role in controlling cellular activities including muscle contraction, cell proliferation, and cell death. Mathematical models for the intracellular calcium ion dynamics have been established to help understand these control mechanisms. Stability analyses about these models are of practical importance in understanding transient behaviors of calcium ion dynamics subject to initial or extracellular calcium ion perturbations. Using the LaSalle's Invariance Principle, we show that the calcium ion dynamics model is asymptotically stable for zero input and nonnegative initial conditions. This theoretical result explains why the calcium ion concentration can reach its resting level quickly after an initial perturbation and then maintain within a narrow range near its resting level.

Interactive Computational Sciences Website

Dane Womack and Ethan Hereth
Faculty Mentor: Clarence Burg

NASA's education mandate includes the recruitment and retention of talented students interested in studying and addresses the physical issues related to NASA's research mandates. Many of these research areas involve fluid dynamics, including the flow of air through aircraft and spacecraft and the fluid dynamics of atmospherics systems of planets, of stellar objects such as stars and gas clouds. These complicated systems are modeled via mathematical equations that are solved computationally. In three-dimensions, these equations require supercomputers and large amounts of computational resources. However, in two-dimensions, simplified simulations can be performed in a reasonable amount of time on modern personal computers. The goal of this project was to provide students access to these tools by porting existing two-dimensional

fluid dynamics simulations tools to a web-based interface. Students can then use these tools within formal educational settings such as high school science classes and for informal educational settings such as science museums and high school science fair projects. Three distinct tools were developed – the parameter input interface, the computational solver and the visualization interface. The parameter input interface gave the investigator the ability to choose the test case and the physical parameters, such as the Mach number and the angle of attack. The computational solver solved the governing equations via standard mathematical algorithms – in particular, the inviscid compressible Euler equations. The visualization interface showed the variables as they evolved through the solution process within the two-dimensional domain. These tools were developed via JAVA and Windows-based executables and are available online at http://faculty.uca.edu/clarenceb/ComputationalScience/ComputationalSciences.html . This project has formed the basis for future projects, developing appropriate educational content, extending the range of computational capabilities and increasing the database of example cases that can be simulated.

PHYSICS AND ASTRONOMY

Verification of Rutherford Scattering (atomic number, energy and angular dependence)

Saroj Adhikari and Caroline Davis
Faculty Mentors: Rahul Mehta and Stephen R. Addison

Rutherford scattering is the elastic coulomb scattering of the incident beam when a target nucleus is bombarded by a beam of charged particles. Early experiments on the scattering of α-particles led to the discovery of the nuclear structure. To verify the dependence of the scattering rate on the atomic number, energy, and scattering angle of the incident particle beam in the Rutherford formula, we bombarded singly ionized Helium ($_2He^+$) beams at various targets, and measured the scattering energies and rates. First, we investigate the linearity of the scattering rate with the square of the atomic numbers to verify the atomic number dependence as predicted by the Rutherford formula. For this, we used $_2He^+$ beams with incident energy of 1.5 MeV at $_{22}Ti$, $_{26}Fe$, $_{29}Cu$, $_{47}Ag$, and $_{79}Au$ targets. We also investigate the inverse square dependence of the scattering rate on the kinetic energies of the incident He^+ beams, for which we used a $_{29}Cu$ target with energies of 0.6, 0.7, 0.8, 1.0, 1.25, and 1.5 MeV. In both of these experiments, we used a constant scattering angle of 150°. Finally, we used 1.5 MeV incident beams on a $_6C$ target at scattering angles of 20°, 40°, 60°, 80°, and 110° to investigate the $1/\sin^4(\theta/2)$ dependence of the scattering rate. In all the cases, we find the experimental data agree with the theory, which verifies the Rutherford formula.

Acknowledgement: University of North Texas Accelerator Lab, Prof. J.L. Duggan, Dr. Khalid Hossian, Mangal Dhoubadel, and Venkata Kummari.

A Study of Elemental Composition of Hard Tissues of Rats Subjected to Simulated Microgravity*

Hannah M. Fitch and Michael C. Kitchens
Faculty Mentor: Rahul Mehta

The effects of microgravity on the skeletal system of rats are assessed using the NASA validated Hind Limb Suspension (HLS) model, which simulates a microgravity environment. Electron Dispersive Spectroscopy on an equipped Scanning Electron Microscope, along with FLAME software, was used to analyze the elemental composition of samples from the femur, tibia, and joint tissue from HLS and control rats with periods of suspension of 7 and 14 days. A correlation in the distribution of the primary elements found in the bone tissue as a function of position along the leg were observed, as well as differences in these patterns among HLS and control samples.

*Acknowledgement: This work is supported by funds from Arkansas Space Grant Consortium (ASGC).

Preliminary Data of an Automated Von Frey Filament Test

Brian Halldorson
Faculty Mentor: Azida Walker

The von Frey filament technique for measuring the pain withdrawal threshold in diabetic rats has been a standard practice for many years. Typically the test is administered with a handheld von Frey filament and a transducer to measure a test subject's withdrawal threshold. Establishing the correct withdrawal threshold has been difficult as there is no universally accepted method. The withdrawal threshold is defined, as the smallest amount of stimulus needed to illicit a response from a test subject. The automation of this experiment would reduce the human error by establishing a routine delivery of stimuli over many trials.

This technique is computer controlled using a VISUAL BASIC code, which communicates to the stepper motor. A force transducer is attached via a plexiglass carriage; the design and mechanical operation of this will be presented.

Initial experiments were performed on a soft foam core to simulate the animal model. The data presented here obtained from a WINDAQ data acquisition system show the changes in the force as the filament operates using "step" instructions, until the foam core is punctured with the force not exceeding 0.75N. Future applications and improvements to this technique will be discussed.

Regions of Constant Magnetic Field Inside a Helmholtz Apparatus

Patrick Kells and Nathan Walsh
Faculty Mentor: Stephen R. Addison

In this experiment a Hall effect probe was used to determine the magnetic field strength and uniformity inside a Helmholtz coil apparatus. A current was applied to the Helmholtz coils via two DC power supplies, which produced a magnetic field in the region between the coils. The current was varied and magnetic field measurements were taken inside the Helmholtz coils. By varying the current in the coils, the regions of constant field (to within some deviation) were determined to be a function of the current and the radius of the coils. The results from this experiment would benefit applications where a region of small or constant magnetic field is needed.

Materials Analysis Using X-Ray Fluorescence (XRF) Spectrometry

Michael C. Kitchens and Brian Halldorson
Faculty Mentors: Rahul Mehta and Stephen R. Addison

X-Ray Fluorescence (XRF) Spectrometry is conservative analytical technique utilized by multiple industries in which a fast, accurate means of elemental analysis is crucial. The sample of interest is exposed to high-energy ionizing radiation, called primary radiation, in order to cause the ejection of inner shell electrons. The orbital is then filled by another electron resulting in a photon emission of characteristic energy. The energy of the emitted photons is measured using a Silicon-Lithium (Si(Li)) detector. The energies of the photons are used to determine the specific type of atom from which they were emitted. ^{109}Cd was the source used to irradiate the samples as well as calibrate the system. Samples of single, as well as multiple elemental compositions were studied.

Error Analysis in Stellar Abundance Models used for n-Capture Abundance Determinations

Jeremy Lusk
Faculty Mentors: Debra L. Burris

The origin of light neutron capture elements is an unsolved problem of nuclear astrophysics. No study has been able to provide a satisfactory mechanism for the production of elements such as zirconium (Zr) yttrium (Y) and strontium (Sr) in the early galaxy. In a previous paper (Burris et al 2009), the abundances of these elements was studied using high-resolution spectra to reduce uncertainty. We now analyze possible sources of error in the computational models used to simulate the stellar atmospheres under observation - models that are used in the calculation of elemental abundances. By adjusting the model parameters such as effective temperature, microturbulent velocity, surface gravity, and metallicity the relative sensitivity of our calculations to errors in these values can be determined.

BalloonSat and LabPro

Kim Mason
Faculty Mentor: William V. Slaton

BalloonSat is a NASA and Arkansas Space Grant Consortium backed program that allows students to build payloads to send to high altitudes. These payloads can contain any combination of devices including temperature sensors, pressure sensors, GPS systems, digital cameras and even video cameras. With the LoggerPro system students can get a hands-on experience with taking data, and not only can students retrieve data from the balloon launches, but the data is physically very accurate. From the data gathered so far a few of the thermodynamic properties of our atmosphere have been observed such as the change in pressure and temperature with altitude.

Since the Troposphere is considered to contain mostly idea gases, use of the idea gas law, heat capacities, and the knowledge that our atmosphere is approximately adiabatic gives a dry adiabatic lapse rate similar to our temperature verses altitude results. For our pressure verses altitude results we assumed that temperature is independent of altitude and that our atmosphere was an ideal gas to compare our results to the barometric equation. In the future other sensors will be sent up to gather more data with the Loggerpro system. Payload information and flight data will be presented.

Bessel's Flames of Glory

Shane McNew
Faculty Mentor: William V. Slaton

The Ruben's Tube is a popular physics demonstration that dramatically illustrates one-dimensional standing waves. The demo consists of a long tube closed on one end and the other driven with speaker. The tube is filled with natural gas that exits through small evenly spaced holes along the top of the tube. The gas exiting the holes is lit and the heights and color of the flames are an indication of the speaker-driven standing wave that appears in the tube. Regions where the standing wave acoustic velocity is large are illustrated by tall yellow flames, whereas regions with low acoustic velocity have short bright blue flames. This variation in flame height is due to the Bernoulli effect. This research project explored the theoretical and experimental design, construction and testing of two-dimensional flame pans: square and circular. The square geometry should support standing waves similar to the Ruben's tube in both directions and so the flame patterns will be lines of yellow flames in a grid pattern. The circular geometry should support standing waves that have a radial and polar dependence with corresponding flame patterns. Theoretical predictions of the resonance modes in the two-dimensional flame pans will be compared to photographs of the flame pans in operation.

Electro-dynamic Loudspeaker Parameter Measurements

Eric Sellers
Faculty Mentor: William V. Slaton

The electro-dynamic parameters of loudspeakers are a set of defining characteristics that show how a speaker will perform under a variety of settings and placements. The parameters are best used as quality control for a production facility and possibly for future placement of the speaker. A loudspeaker can be model as a driven damped mass-spring system with an appropriate ordinary differential equation. However, to find out the exact spring constant, moving mass, damping factors, and other properties of the system we would have to destroy the speaker. Since destroying the speaker isn't an option, we need a non-destructive way to find out the basic properties of the speaker; therefore, we can run other tests to obtain the parameters that we need. These parameters were found for a 3 inch and 10 inch speaker. The set of parameters for each speaker were found using different methods so that all the parameters could be found.

Wave-Particle Duality

Luis R. Suazo
Faculty Mentor: Stephen R. Addison

The nature of light is subject to great debate. It seems to behave as collection of discrete quanta in some instances although it exhibits the wavelike characteristics of interference and diffraction in other. We recreated Young's double slit interference experiment, which originally showed that light interfered and diffracted, behaviors attributed to waves. We then isolated single light quanta – or photons - verifying that light transfers energy and momentum as discrete particles and not waves. Finally, we performed Young's double slit interference experiment using single photons, and found that even at that fundamental level, we can still see interference and diffraction. Therefore we verified that light, at its most fundamental level, is both a particle and a wave.

Variational symmetries and local conservation laws in general relativity

Olabode Sule
Faculty Mentor: Balraj Menon

The variational symmetries and local conservation laws admitted by stationary, axisymmetric spacetimes are investigated. The vacuum Einstein equations for stationary, axisymmetric spacetimes are derived from a variational principle by adopting the projection formalism devised by Robert Geroch in his investigation of such spacetimes. The variational symmetries (symmetries of the action functional) are obtained by applying Lie's symmetry group methods and the local conservation laws associated with these variational symmetries are derived by invoking Noether's theorems that relate variational symmetries to local conservation laws.

Determination of thickness of Copper, Iron, Silver, and Titanium using Rutherford Scattering

Chris Willette and Joshua Lieblong
Faculty Mentors: Stephen R. Addison and Rahul Mehta

The Rutherford scattering experiment educated us on atomic structure in modern physics. During this experiment, we used a 1.50 MeV singly-ionized Helium beam to strike the Copper, Iron, Silver, and Titanium targets. The detector was placed at an angle of 150° from the incident beam. The kinematical scattering factor was used to determine the value of the scattered energy from a known elemental mass. A gold standard was used to calibrate the detector with the Maestro software using a scattered energy of 1.391 MeV. The Maestro software generated spectra of counts versus energy for each of the targets. The theoretical cross section and the experimental cross section of the Rutherford scattering were compared to calculate the thickness. The

theoretical cross sections were calculated for each target, which depends on the atomic numbers of the source & targets, and on the scattering angle. The experimental thicknesses of the targets were then calculated. The thickness of the gold target was found to be 14×10^{17} $\mu g/cm^2$.

Acknowledgements: Dr. Jerome L. Duggan, Lucas Phinney, Mangal Dhoubadel, Venkata Kummari, and Dr. Khalid Hossian of Ion Beam Modification and Analysis Lab (IBMAL) at the University of North Texas, Denton, TX.

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