College of Natural Sciences and Mathematics

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Titles

BIOLOGY

Genotypic comparison of *Escherichia coli* isolated from food animals
Greg Asbury, Chris Winfrey, Kristin Mayhan, and Amber West
Faculty Mentor: Steven Foley

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Equating time across species
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Quantification of NHE and V-ATPase mRNA levels in MCF-7 tumor cells
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Endothelin-1 constriction is unaffected by short-term exposure to estrogen in fresh and organ cultured coronary arteries from aged female pigs
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Early life history and effect of flow on two cave-inhabiting salamanders, *Typhlotriton spelaeus* and *Eurycea lucifuga*, in Arkansas.
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CHEMISTRY

SEIRA II: Studies of p-nitrobenzoic acid and o-, m-, and p-nitroaniline
Jacob Boucher, Bridget Bridges, Krystal Posey, Merritt Smith, Kaitlyn Stambaugh, Mark Viegas, and Chen Wang
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Phosphate collapse around cationic protein residues is correlated with DNA bending in DNA/protein complexes
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SEIRA I: UV/VIS and AFM characterization of silver films as substrates for Surface-Enhanced Infrared Absorption (SEIRA)
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Investigating the interaction between Mg^{2+} and the crystal dehydrating agent 2-methy-2,4-pentanediol (MPD) and its role in DNA bending.
Courtney Huff and Tori O'Bannon
Faculty Mentor: Lori Isom

Peptide mimics as nanosensors
Garen Holman and Blake Robinson
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Analysis of doubly-charged transition metal ions: reactions of M^{2+} with chlorofluorocarbons
Cullen C. Matthews
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Detection and characterization of DNA distortion induced by cation-pi interactions
Mikaela Stewart
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FTIR and GC/MS characterization of acidic sites on Al^{V} catalysts
Chen Wang, Mark Viegas, Krystal Posey, Merritt Smith, Kaitlyn Stambaugh, Bridget Bridges, and Jacob Boucher
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David Lindquist, Rajesh Sharma, and Malay Mazumder
University of Arkansas, Little Rock (UALR)

COMPUTER SCIENCE

The design and implementation of a web-based content management system for an academic department
Brian M. Allen
Faculty Mentor: Chenyi Hu

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Chad Miller
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Enhancing Boyer-Moore pattern matching algorithm with character pairs
Paul Opala
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Parametric symmetries of ordinary differential equations
Yousuf Abbasi
Faculty Mentor: Danny Arrigo

General compatibility of the 2+1 diffusion equation
Luke Brown
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Symmetry analysis of the variable-coefficient beam equation
Joel Harris
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Positive solutions of quadratic equations with a parameter
Ethan Hereth and Jason Norton
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Non-classical symmetries of the one-dimensional diffusion equation with a non-linear source term
Jason Torrence
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Scanning electron microscope studies of bone sample: Influence of microgravity in adult male mice
Ashley Brown
Faculty Mentor: Rahul Mehta

Be star H-alpha line profile variability
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Applied chaos: Finding the needle in the haystack
Travis Hoggard, Katharina Ochterbeck, and Katie M. Reynolds
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Chris McNeill
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ABSTRACTS

BIOLOGY

Genotypic comparison of *Escherichia coli* isolated from food animals

Greg Asbury, Chris Winfrey, Kristin Mayhan, and Amber West
Faculty Mentor: Steven Foley

Escherichia coli can cause food-borne illnesses and serve as indicator organisms for fecal contamination in watersheds, therefore it is important to be able to determine the source of the organisms and understanding of how the organism disseminates in the food supply and in the environment. The objective of this study was to evaluate whether detection of specific virulence factors and/or plasmid DNA profiles from *E. coli* isolated from different animal species would provide a discriminatory method to distinguish the origin of *E. coli* isolated from different food animal sources. Two hundred *E. coli* isolates from cattle, swine, and chickens were screened using PCR for the presence of genes for K88 and K99 capsules, serum survival (*iss*), hemagglutinin (*tsh*), shiga-like toxin, (*sltII*), and cytotoxic necrotizing factor (*cnfI*). Additionally, plasmid DNA from these strains was isolated and visualized following separation using pulsed field gel electrophoresis. The PCR and electrophoresis results were entered into the BioNumerics program for genotypic analysis. The results indicated that certain genes had an increased prevalence in isolates from one species over the others. *iss* was most commonly associated with chicken isolates, while the K99 gene most commonly found in bovine isolates. With the other genes tested, there did not appear to be a single species that predominated. Plasmid analysis indicated that certain profiles were most commonly associated with one source over the other. The results suggest that there may be some host specific differences in the presence of particular plasmid profiles and virulence genes detected among certain isolates from different food-animal species that may provide a tool to help understand conditions that lead to water pollution and food-borne illness.

Acidification induced exocytic response in MCF-7 cells and correlating apoptosis

Cody C. Cook
Faculty Mentor: Steven Runge

Apoptosis, programmed cell death, is an essential mechanism for the development and maintenance of multi-cellular organisms. We are interested in the unique ability of tumor cells to thrive in acidic environments that induce apoptosis in normal cells. The interior of a solid tumor does not have sufficient vascularization for the removal of metabolic waste; as a result, tumors possess a pH lower than normal body fluid. To account for

cellular survival we hypothesize that under acidic stress, tumor cells will utilize an exocytic pathway to integrate pH regulatory proteins into the cellular membrane to help stabilize intracellular pH levels. Our hypothesis is based on previous identification of numerous proteins that are regulated via protein trafficking; including some involved in pH regulation.

Our present study evaluates how extracellular acidification affects the rate of exocytosis in human breast cancer cells using the fluorescent fluid phase maker fluroescein dextran (FD). Our hypothesis is that extracellular acidification will increase the exocytic rate in MCF-7 cells. If acidification stimulates vesicular trafficking, cells loaded with FD prior to the acid insult will release FD into the surrounding media. If the exocytic activity increases with the level of acid challenge, the cells may be attempting to prevent apoptosis. If increases in acidification do not correlate with an increase in the exocytic pathway, the study indicates that another method besides vesicular trafficking is utilized to enable tumor viability under low pH conditions.

Evaluation of antimicrobial resistance in veterinary *Escherichia coli* isolates from Arkansas

Amanda Harrell, Steven Rogers, and Ryan Singer
Faculty Mentor: Steven Foley

Escherichia coli is the causative agent in a number of food-borne illnesses and urinary tract infections. Transmission of *E. coli* to humans can occurs as a result of contact with animals or animal products contaminated with pathogenic *E. coli*. An increasing concern with pathogens, such as *E. coli,* is the development of resistance to antimicrobial agents that can be used to treat infections. The objective of this study was to detect the level of antimicrobial resistance among veterinary *E. coli* isolates from Arkansas and begin to examine the potential for spread of antimicrobial resistance. Ninety-seven *E. coli* isolates from dogs (50), birds (11), cats (9), horses (9), cattle (7), and exotic/other mammals (11) were subjected to antimicrobial susceptibility testing and plasmid analysis. Antimicrobial susceptibility testing was carried for 15 agents using the methods prescribed by the National Antimicrobial Resistance Monitoring System (NARMS) with the Sensititre™ autoinoculator. Additionally, plasmid DNA from these strains was isolated and visualized following separation using pulsed field gel electrophoresis. The susceptibility testing results and plasmid electrophoresis results were analyzed using the BioNumerics program. The results indicated that there were 59 different antimicrobial resistance profiles among the isolates and resistance were fairly widespread among isolates, with 22 isolates being resistant to greater than 5 drugs. Eighteen of the isolates tested were susceptible to all of the agents tested. Additionally, there were 63 different plasmid profiles detected among the isolates, indicating that there is a high level of genetic diversity among the isolates. The results indicate that companion and other animals can harbor antimicrobial resistant pathogens that could be a potential source of multidrug resistant human infections, therefore good hygienic practices be exercised when interacting with other animals to limit pathogen spread.

Apoptotic-induction in MCF-7 cells by [dppeNi^{II}CYSEt^{+}] Cl^{-}

Laura Huffman and Kyle Basham
Faculty Mentors: Patrick Desrochers and Steven Runge

Recently there have been research efforts targeted at developing drugs that will treat platinum resistant tumors. One facet of these efforts has been aimed at the cytotoxic activity of dppe-phosphorous ligand compounds. The compound [dppeNi^{II}CYSEt^{+}] Cl^{-}, developed in Dr. Patrick Desrochers' laboratory, has cytotoxic activity in the human breast cancer cell line, MCF-7. Dose response experiments revealed the lowest effective concentration for inducing cell death to be 1.0 μM. Using Annexin-V-FITC staining kits, levels of apoptosis will be detected in the MCF-7 cells exposed to the nickel compound. During apoptosis, phosphatidylserine is translocated from the inner leaflet of the plasma membrane to the outer leaflet. Annexin-V-FITC has a strong Ca^{+}-dependent affinity for phosphatidylserine and fluoresces green upon binding. Propidium iodide is used to detect necrosis. During necrosis, membrane integrity is lost, allowing this compound to enter the cell. Propidium iodide fluoresces red upon binding to the nuclear material of the cell. Apoptotic-induction in MCF-7 cells by [dppeNi^{II}CYSEt^{+}] Cl^{-} could give possible insight into a new class of metal-containing chemotherapeutic drugs that would offer alternatives for treating tumors that are resistant to current therapeutic modalities.

Temporal patterns of development in field-sampled ammocoetes of the southern brook lamprey (*Ichthyomyzon gagei*) in Cadron Creek, Arkansas

Casey Kennedy
Faculty Mentor: Reid Adams

Lampreys are one of the few extant representatives of a primitive group of vertebrates, the jawless fishes. Marine and freshwater forms exist, and lamprey species are either parasitic or nonparasitic based on feeding strategies of adults. Both feeding forms have an extended larval period where they spend 3-7 years as ammocoetes burrowed into the sediments of streams and rivers. After development into an adult, adults of parasitic species may live for up to 2 years, attaching themselves to other fishes using their suctorial mouth to extract body fluids from their hosts. In contrast, adults of the nonparasitic species, known as the brook lampreys, do not feed as adults; following transformation, they live for 5-6 months, reproduce, then die. The southern brook lamprey, a nonparasitic species, is one of four lampreys occurring in Arkansas. Ammocoetes of this species reportedly begin metamorphosis into an adult during early fall in preparation for spawning during late spring/early summer. General changes in morphology that occur during development (e.g., increased eye size, reduction of digestive structures, and increase in gonadal mass) are known, but these morphological changes have rarely been quantified over time, particularly in southern populations. I collected southern brook lampreys in Cadron Creek every 4-5 weeks from September

2004 through March 2005 with a backpack electrofisher. Specimens were fixed in 10% formalin, dissected in the lab, and a number of morphological/anatomical parameters were measured. Weight of the digestive tract, gonad, visceral fat, and total wet body were measured with an Ohaus analytical balance. Total body length and eye diameter were measured with digital calipers. Both metamorphosing (ammocoetes that will reproduce during the subsequent spring season) and nonmetamorphosing (ammocoetes that will not reproduce this year) individuals were present in each sample. During the initial sampling interval in September, mass of visceral fat and of the gonad relative to total body weight were similar among all ammocoetes, but there was already a 4-fold difference in digestive tract mass between metamorphs and nonmetamorphs. However, beginning in November and continuing through February, visceral fat mass was lower and gonadal mass higher in metamorphs relative to nonmetamorphs. Eye diameter was greater in metamorphs throughout the study period; development of a larger eye is probably an adaptation to aid in predator avoidance and mate recognition when emerging from burrows. The digestive tract of metamorphs decreases to a nonfunctional remnant between September and November and remains a miniscule structure. During at least a 4-month time period with no exogenous source of energy, metamorphosing lampreys appear to rely heavily on stored fat (and probably the metabolism of some muscle tissue) to meet daily energetic requirements and to develop gametes. I plan to continue documenting morphological changes until spawning occurs in late spring/early summer and hopefully collect data on aspects of their reproductive biology.

Equating time across species

Brandon Kersh, Julie Staudinger, and Jessica Harrison
Faculty Mentor: Barbara Clancy

In this study, we use a bioinformatic approach to address a fundamental research question: How can developmental studies in experimental animals be equated to humans in an accessible and user-friendly format? Bioinformatics uses large databases to answer biological questions, uniting biology with disciplines such as computer science, mathematics, and statistics. We have created a Structured Query Language (SQL) database site that allows brain development to be converted across various mammalian species, including humans, using JavaScript to allow immediate feedback. The site is based on a statistical model initially formulated to describe brain evolution and adapted to translate time across species (Finlay & Darlington, 1995 Sci. 268:1578-1584; Clancy, et al., 2001 Neurosci. 105:7-17). This database-driven website also provides users with predicted dates of neural events when empirical data are unavailable. Our goal is for this site to be of value to researchers and clinicians across many disciplines. We will incorporate additional data from current and new species on a regular basis, ultimately allowing precise timing for medical procedures such as anesthesia intervals, diagnostic inquiries, and intervention strategies in humans. We have recently added data in which neural development in guinea pigs (a precocial mammalian species) and chickens (an altricial non-mammalian species) are compared. We find that guinea pigs fit the current model, although chickens do not.

A single neuron causes foot contractions that lead to turning in the marine slug *Tritonia diomedea*.

Josh Morrison
Faculty Mentor: James Murray

Tritonia diomedea crawls forward propelled by cilia; turning is effected by contractions of the foot. During crawling the lateral edges of the foot (foot margin) contact the substrate, and motor neurons that lift the foot margin (up to 50% of the edge) dorsally effect turning toward the ipsilateral side. Although many pedal ganglion neurons control the foot muscles, one identified neuron, Pedal neuron 3 (Pd3) has a wide area of innervation and a strong effect on the lateral musculature in the middle of the anterior-posterior axis. Injection of current (0.1-6 nA) into this presumptive motor neuron elicited firing at 1-15 Hz and caused lifting of the foot margin away from the substrate (at 0.5-4 mm/s) in a way that resembles the lifting that was observed during normal turning. The movement starts 1 s after stimulation, and peaks in 2-3 s. Movement is reduced from 3 s until the end of the stimulus even though the firing does not accommodate, and relaxation takes over 60 s.

Other neurons that do not meet the description of Pe3 also produce contractions of the foot that may lead to turning, but we have not yet monitored their activity with fine wires during crawling. Some of these neurons produce shortening of the foot margin that does not involve lifting the foot. This alternative mechanism of turning is also observed in freely-crawling slugs. *Support Contributed By: State Undergraduate Research Fellowship , University of Central Arkansas, National Science Foundation*

Nesting ecology of alligator snapping turtles (*Macrochelys temminckii)*

Courtney Nippert
Faculty Mentor: Stephen Dinkelacker

Alligator snapping turtles (*Macrochelys temminckii*) were an economically important species during the late-1900s and as a result, their populations experienced over-harvesting by commercial trappers. In 1994, Arkansas passed legislation that prohibited the collection of alligator snapping turtles within the state. Currently, very little is known about the reproduction of this species in natural environments. Therefore, I intend to document the nesting ecology of alligator snapping turtles in central Arkansas. During May and June, previously captured females will be relocated via radio telemetry early in the evening and observed until they begin their nesting forays. Females will be followed to the nest site where the date, time and location of her foray, time of oviposition, number of roads crossed, distance traveled, and weather will be noted. Data collected at the nest site will include nest depth and width, clutch size and mass, incubation temperatures, and date of hatchling emergence. I expect to find that alligator snapping turtles nest in the

early evening and build flask-shaped nests, into which they will deposit between 9-61 eggs. Data gained from this research will begin to elucidate vital life history characteristics of a species that is underrepresented in the literature.

Are the adverse effects of neonatal pain retained into adulthood?

Shannon Palmer, Brian Bowden, Amanda Plummer, Sonja Isbell, Heather Delahunt, James Hyde, and Jason Talburt
Faculty Mentors: Barbara Clancy and K.S. Anand (ACHRI)

The repetitive pain related to preterm birth is associated with high occurrences of cognitive and behavioral defects at maturity in humans. This suggests that the cortex may be disrupted because it is the principal brain region involved in complex processing. Moreover, during the precise period when most preterm children are born, the cortex is involved in massive organizational strategies. We hypothesized that repetitive pain in a rat model would be evidenced through behavioral testing conducted at both early and late adulthood. We further hypothesized that an anesthetic administered prior to pain would provide protective effects. Our data indicate an altered response to pain is retained throughout adulthood. Data from tests for spatial memory and anxiety are currently being analyzed. We expect our results will strengthen contemporary opinions that a paradigm shift in the current clinical approaches to pain and anesthetic in human infants is imperative.

Identification of antimicrobial resistance genes on plasmids of multi-drug resistant strains of *Salmonella* Newport isolates from food animals

Bobbie S. Rhodes
Faculty Mentor: Steven Foley

Each year in the United States, the Centers for Disease Control and Prevention estimate that approximately 1.4 million people are infected by the pathogen *Salmonella enterica*. One of the most commonly implicated serotypes of *Salmonella* in human infections is *Salmonella* Newport. Antimicrobial resistance in *S.* Newport is an emerging problem. Certain strains of *S.* Newport exhibit resistance to killing by multiple antibiotics, with some resistant to greater than 10 agents. It has been proposed that the use of antimicrobials in food animals selects for resistant strains. The main objective of this project is to identify antibiotic resistance genes on plasmids of multi-drug resistant strains of *S.* Newport isolates from food animals. A total of 40 *S.* Newport isolates from chicken (10), swine (11), turkey (8) and cattle (11) were examined to detect the number and size of the plasmids in each isolate following separation using pulse field gel electrophoresis. Additionally polymerase chain reactions (PCR) for five different genes (bla_{CMY}, *tetA/R, aad,* bla_{AMP}, *tem),* were used to identify and to detect the presence of antimicrobial resistance genes present in the plasmids. Our results indicate that 31 of the 40 *S.* Newport isolates had the bla_{CMY} gene (codes for resistance to drugs such as penicillin), 18

of the 40 isolates contained the *tet* gene (codes for resistance to tetracycline), 11 of the 40 isolates contained the bla_{AMP} gene (codes for resistance to ampicillin), 20 of the 40 isolates had the *tem* gene (codes for resistance to broad-spectrum beta lactams such as ceftriaxone) and 2 of the 40 isolates exhibited the *aad* gene (codes for resistance to streptomycin). Fifty-eight percent (29) of the *S.* Newport isolates contained multiple antibiotic resistance genes located on their plasmids. Our study suggests that the identification and characterization of antimicrobial resistance genes located on plasmids provides needed information to understand the multi-drug resistant strains of *S.* Newport isolates from food animals.

Quantification of NHE and V-ATPase mRNA levels in MCF-7 tumor cells

Kyla R. Shelton, Andres Chang, and Candice Ray
Faculty Mentor: Steven Runge

Apoptosis is an orderly mechanism of cellular death used in multi-cellular organisms to remove cells that are exhausted, damaged, or abnormal. *In vivo* tumor cells thrive in hypoxic microenvironments with a more acidic extracellular pH (pH_e) than found in normal tissue. The low pH_e is due to the build up of metabolic waste as a result of poor vascularization; and the accumulation of H^+ within the cell can induce apoptosis. In order to survive such a microenvironment and avoid apoptosis, tumor cells may up-regulate pH regulatory proteins to extrude H^+ and maintain physiological pH_i (~7.3) that is necessary for normal cellular functions. Two of the pH regulatory proteins investigated here are the sodium/hydrogen exchangers (NHE) and the vacuolar proton adenosinetriphosphatases (V-ATPase). This project will investigate whether transcription levels of NHE and V-ATPase change in a human breast cancer cell line (MCF-7) incubated at different pH levels under normoxic and hypoxic conditions. The RNA Invader Assay (Third Wave Technologies) is a highly sensitive assay that allows direct, quantitative detection of RNA without target amplification or reverse transcription that is required for quantitative real time RT-PCR and is less expensive than RT-PCR methods.

Endothelin-1 constriction is unaffected by short-term exposure to estrogen in fresh and organ cultured coronary arteries from aged female pigs

Saigiridhar Tummala
Faculty Mentor: Brent Hill

The objective was to determine if estrogen could attenuate the constrictive effects of endothelin-1 (ET-1) in coronary arteries from aged pigs. Right coronary arteries were obtained from female Yorkshire pigs (~3-4 yrs. old) and immediately used (fresh) or organ cultured for 3 days. Arteries were sectioned into 3 mm rings (endothelium removed) and suspended in organ baths. Each bath contained a different concentration of estrogen (10^{-9} to 10^{-5} M). After incubating the rings in their respective estrogen concentration for 50 min., a concentration-response relationship was generated to ET-1 (10^{-9} to $3x10^{-7}$ M) and the isometric tension measured. While exposed to the vehicle

control for estrogen, organ culture induced a 2-fold increase in tension to $3x10^{-7}$ M ET-1 compared to fresh arteries (113.68 ± 6.47 % and 52.11 ± 4.53 % of the paired 80 mM K^+ contraction, respectively). The effective concentration to reach a 50% response (EC_{50}) was not different between fresh and organ cultured arteries ($1.86\pm0.77x10^{-8}$ M and $1.75\pm0.82x10^{-8}$ M, respectively). Rings incubated in each respective estrogen concentration did not show any change in the maximum contraction or EC_{50} value to ET-1 in fresh or organ cultured arteries. Our results indicate that short-term exposure to estrogen did not attenuate the constrictive response to ET-1 in fresh and organ cultured coronary arteries from aged female pigs. Support: UCA Research Council.

Early life history and effect of flow on two cave-inhabiting salamanders, *Typhlotriton spelaeus* and *Eurycea lucifuga*, in Arkansas.

Kerry Wilkins
Faculty Mentor: Ginny Adams and Reid Adams

Despite numerous studies on the biology of cave vertebrates, very little is known about the general life history parameters of cave-inhabiting salamanders in the United States. To address this knowledge gap, we examined the abundance and life history of grotto salamanders (*Typhlotriton spelaeus*) and cave salamanders (*Eurycea lucifuga*) in the cave environment and the effect of flow on larval salamanders. Three trips were made to caves along the Buffalo River between July and December 2004. A total of 35 larval and adult salamanders were observed along with nine eggs. In July, many of the grotto salamanders observed were in the process of metamorphosing from the aquatic larval to terrestrial adult stage. Subsequent trips in November and December revealed only adult terrestrial salamanders. Number of adult salamanders declined sharply from July to November, with continued low numbers in December. Salamander eggs were discovered in rimstone pools in the back of Fitton Spring Cave in November. It is likely these belong to cave salamanders given the similar size and placement to reports in the literature. If verified, this is the earliest reported date for cave salamander reproduction in Arkansas. Nine eggs were sighted in a total of four rimstone pools. Egg diameter ranged from 2.6-2.8 mm and all were laid singly. Pool dimensions were recorded and water quality was monitored in November and December. In December, only four of the nine eggs remained and these were in various stages of hatching. The five eggs from the largest pool were missing and raccoon tracks were observed in the silt-covered pool. In addition to field studies, we are currently preparing to compare the ability of larval grotto and cave salamanders to maintain station in low, medium and high flows in a laboratory flume. This will provide pertinent information on the ability of these species to resist downstream displacement during spring flooding events in the cave environment.

CHEMISTRY

SEIRA II: Studies of p-nitrobenzoic acid and o-, m-, and p-nitroaniline

Jacob Boucher, Bridget Bridges, Krystal Posey, Merritt Smith, Kaitlyn Stambaugh, Mark Viegas, and Chen Wang
Faculty Mentor: Don Perry

P-nitrobenzoic acid (PNBA) was used as a standard for surface-enhanced infrared absorption (SEIRA) studies in order to compare the current work to experiments in the literature. Submonolayer coverages of PNBA were adsorbed on CaF_2 windows coated with silver films varying in thickness from one to twelve nm. The highest quality SEIRA spectra were obtained with seven nm thick silver films. NO_2 stretching modes of PNBA on seven nm thick silver films were symmetric and enhanced by approximately a factor of fifty when compared to thick PNBA layers adsorbed on clean CaF_2 windows. SEIRA studies were also performed with o-, m-, and p-nitroaniline. All m-nitroaniline infrared absorption bands were strongly enhanced when m-nitroaniline was adsorbed on seven nm thick silver films. O- and p-nitroaniline infrared peaks exhibited no SEIRA enhancement.

Phosphate collapse around cationic protein residues is correlated with DNA bending in DNA/protein complexes

Mason Breed
Faculty Mentor: Lori Isom

In this project, the theory that cation interactions with DNA phosphate groups result in partial charge neutralization, thereby inducing DNA bending and minor groove narrowing is tested. X-ray crystal structures of protein/DNA complexes offer an advantageous system for investigating the influence of cations on DNA structure because unlike monovalent ions, the position of cationic side chains such as lysine and arginine are unambiguous and so their location with respect to DNA phosphate oxygens can be calculated. We selected high-resolution DNA/protein crystal structures and screened for the induction of phosphate crowding by the association of cationic protein residues and then, the relationship between phosphate crowding, cation density and the magnitude and direction of DNA bending was investigated. Preliminary analysis of 53 structures has led to interesting results suggesting that phosphate crowding is, indeed, related to cation density in interesting ways. A positive correlation value (0.43 ± 0.10) was calculated for DNA/protein complexes containing DNA that bends toward the bound protein while a negative value (0.17 ± 0.12) is observed for complexes with DNA bending away from protein. As expected, complexes containing unbent DNA have correlation close to zero (0.08 ± 0.04). Although only a subset of the selected structures fitting the criteria have been analyzed thus far, the trend is observed is intriguing and supports a correlation between phosphate collapse and DNA bending.

SEIRA I: UV/VIS and AFM characterization of silver films as substrates for

Surface-Enhanced Infrared Absorption (SEIRA)

Bridget Bridges, Jacob Boucher, Krystal Posey, Merritt Smith, Kaitlyn Stambaugh, Mark Viegas, and Chen Wang
Faculty Mentor: Don Perry

A vacuum apparatus has been constructed for the evaporation of silver films for use in surface-enhanced infrared absorption (SEIRA) studies. Silver atoms are evaporated from a silver wire wrapped around a double-stranded tungsten filament. Film thickness is monitored with a quartz-crystal microbalance (QCM) placed in a geometrically equivalent position to the substrate (an infrared transparent CaF_2 crystal). At an optimal silver thickness of seven nm, atomic force microscopy (AFM) shows tightly packed ellipsoidal silver islands with an average length and height of sixty and five nm, respectively. Ultraviolet/visible spectroscopy (UV/VIS) spectra reveal an absorption band with a maximum at approximately 450 nm that broadens and shifts towards the infrared with increasing silver coverage.

Detecting cysteine and homocysteine with nickel

Duong, D., Winkler, S. A., Hong, B., Brown, J. R., Holman, G., and Richardson, C. B.
Faculty Mentors: Patrick Desrochers and Richard Tarkka

Cysteine is in the active sites of numerous metalloproteins, and its metal affinity can also contribute to the poisonous nature of these elements. This laboratory has described factors controlling the geometry adopted by cysteine and nickel. Selective nickel-cysteine interactions will be described, now with a cysteine peptide anchored to plastic polystyrene gel support. The discrimination of nickel(II) between cysteine, homocysteine, and methionine is observed. Spectroscopic measurements show that properly complexed nickel(II) binds plastic-supported cysteine in trigonal bipyramidal and square planar geometries identical to solution phase analogues. Newly reported here are diamagnetic water soluble square planar complexes [dppeNi^{II}CysX]Cl. CysX represents cysteine, cysteine ethyl ester, cysteamine, and selenocysteamine. These results will extend observations for nickel-cysteine small molecules to larger protein systems. The cysteine/homocysteine discrimination and accompanying color change with nickel binding are also being investigated as a selective detection method for these amino acids in complex mixtures.

Investigating the interaction between Mg^{2+} and the crystal dehydrating agent 2-methy-2,4-pentanediol (MPD) and its role in DNA bending.

Courtney Huff and Tori O'Bannon
Faculty Mentor: Lori Isom

The mechanism of DNA bending has long been debated and conflicting results from various solution and x-ray crystallographic methods exists. Solution methods have been used in the past to demonstrate the effect of MPD on DNA bending. These reports suggested that MPD, which is added to all crystals during growth, removes bends from DNA. This project focuses on explaining the mechanism by which MPD affects DNA bending and specifically investigates whether MPD chelates Mg^{2+} ions. If DNA bending is induced by cation binding then chelation of Mg^{2+} by MPD could sequester the ions away from the DNA thereby decreasing its curvature. To test this hypothesis, competition experiments between MPD and the indicator Eriochrome Black T (EBT) for Mg^{2+} ions have been used to test for the MPD Mg^{2+} chelation. Samples containing EBT/ Mg^{2+} with varying amounts of MPD were prepared and analyzed using UV spectroscopy. An absorbance wavelength maximum shift corresponding to the color transition from pink to blue indicates competitive removal by MPD of Mg^{2+} from EBT. This transition has been detected and quantitated by monitoring absorbance values at various MPD concentrations at two wavelengths: 550 nm (pink, EBT/Mg^{2+}) and 650 nm (blue, MPD/Mg^{2+}). A clear transition occurs at approximately 25% MPD concentration for mM solutions of $MgCl_2$. No such transition occurs for other alcohols that are incapable of chelation. Therefore, we can conclude that MPD chelates Mg^{2+} and currently, further experiments are being performed to quantify the strength of the interaction.

Peptide mimics as nanosensors

Garen Holman and Blake Robinson
Faculty Mentor: Richard Tarkka

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

Analysis of doubly-charged transition metal ions: Reactions of M^{2+} with chlorofluorocarbons

Cullen C. Matthews
Faculty Mentor: William Taylor

Examinations of the gas phase chemistry between metal ions and chlorofluorocarbons can provide fundamental information regarding mechanisms relating to catalytically-significant processes such as bond activation. Activation of C-F bonds in chlorofluorocarbons has significant implications relating to remediation of these species

in the environment. Our earlier work on the reactions of singly charged transition metal ions with chlorofluorocarbons has revealed that C-Cl bonds are readily activated by singly-charged gas phase metal ions, while activation of C-F bonds is not induced by M^+. It has recently come to our attention that the energetics present in our instrument are sufficient to produce and observe the chemistry of doubly-charged transition metal ions, M^{2+}. While common in solution, the chemistry of doubly-charged gas phase metal ions has received much less attention due to energetic difficulties in their production. Here, we describe the reactions of M^{2+} with the family of chlorofluorocarbons used in our prior studies in which *direct* activation of C-F bonds is observed. C-F activation products observed here appear to be formed via mechanisms similar to those proposed for other, similar reacting systems involving M^{2+}. In addition, we have measured reduced zero-field mobilities for these ions which, to our knowledge have not been previously reported.

Detection and characterization of DNA distortion induced by cation-pi interactions

Mikaela Stewart
Faculty Mentor: Lori Isom

Cation-pi interactions are a type of cation-induced DNA distortion that pulls bases out of the helical stack and into the major groove where a bound Mg^{2+} ion or waters of its bound hydration shell interact with the exposed aromatic face of the unstacked base. Many high resolution DNA structures have been deposited in the PDB since the initial publication describing DNA cation-pi interactions in 2DNA and 2 RNA structures (Isom, et al., Biochemistry, 1998). A survey of the Nucleic Acid Database (NDB) produced 10 structures with resolution 1.6 A or higher that contain groove-bound cations but no significant chemical modifications or bound ligands. Each structure's coordinates were analyzed using Visual Basic for Application programs written to calculate the distance (d) and angle (T) between the base centroids and the bound cation. Interactions having distances less than or equal to 5.0 A and angles less than or equal to 50 degrees were considered cation-pi interactions. Using this procedure, cation-pi interactions were detected in 9 of the 10 high-resolution structures analyzed, including the surprising discovery of cation-pi interactions between DNA bases and monovalent thallium ions (PDB 1JGR). These interactions were found to induce DNA distortion including base unstacking in many of the structures. Based on these data, we conclude that cation-pi interactions are common between cations and DNA bases and that these interactions do, indeed, induce DNA distortion.

FTIR and GC/MS characterization of acidic sites on Al^V catalysts

Chen Wang, Mark Viegas, Krystal Posey, Merritt Smith, Kaitlyn Stambaugh, Bridget Bridges, and Jacob Boucher
Faculty Mentor: Don Perry
David Lindquist, Rajesh Sharma, and Malay Mazumder

University of Arkansas, Little Rock (UALR)

Transitional phase aluminas are valued as adsorbents and catalysts due to a stable porous microstructure and their amphoteric properties. The lab of Dr. David Lindquist at UALR has created a patented method for the preparation of a very active Au catalyst for carbon monoxide oxidation using an Al_2O_3 having abundant surface defects. The activity, found to be substantially higher than that of a World Gold Council reference catalyst (Type A 1.5 wt% Au/TiO_2) may be attributed to surface hydroxyl functions important to the mechanism of catalysis. The pure Al_2O_3 contains many pentacoordinate (Al^V) environments as determined by ^{27}Al MASNMR, and is expected to exhibit remarkable Lewis acid properties.

In these studies the chemical surface properties of the Al_2O_3 will be quantified by: (1) vacuum chamber Fourier transform infrared (FTIR) spectroscopy using Lewis base molecular probes in order to determine the strength and type of surface acid species (work at UCA), (2) isomerization studies of α-pinene via gas-chromatograph mass spectrometry (GC/MS) in order to determine the relative numbers of Brønsted versus Lewis acid and base sites (work at UALR), and (3) FTIR studies of dehydroxylation/rehydroxylation of the Al_2O_3 surface using H_2O and D_2O (work at (UCA). There are numerous hydroxyl sites on alumina (at least six that are well documented on γ-Al_2O_3) as identified by FTIR bands in the range 3500-3900 cm^{-1}. Catalytic properties are associated with Lewis acid sites formed by dehydroxylation of alumina above 400 °C. In later work, noble metal Al_2O_3 supported catalysts will be prepared by methods of coprecipitation, incipient wetness, and micelle encapsulation. Activity of these catalysts for pollution control reactions will be assessed by gas-chromatography and FTIR.

COMPUTER SCIENCE

The design and implementation of a web-based content management system for an academic department

Brian M. Allen
Faculty Mentor: Chenyi Hu

In this project, we study the design, customization, and implementation of web-based Content Management System (CMS). The purpose of a CMS is to gather information into a centralized location and provide a means to organize it so that it is as readily accessible as possible with flexibility and security measurements. The generic design principles include objective specification, content identification, classification and organization, software tool selection, interface design, security measurements, system maintenance, and customization. The implementation of a CMS should facilitate and

enhance the process of creation, editing, management, and publishing of original content within an organization,

As a case study, we have applied the above principles to design and implement as initial framework of the web-based content management system for the Department of Computer Science at UCA. The framework provides searchable, retrievable, and updatable access to hare and to manage digitized documents of the department. Software tools used include PHP, MySQL, vBulletin, and Apache web-server. Different user privileges have been defined and created to ensure privacy, confidentiality, and security.

Localization problem in distributed robotic systems

Chad Miller
Faculty Mentor: Han-Chieh Wei

During the past twenty years the field of robotics has been concerned increasingly with mobile robots, equipped with on-board computers and a variety of sensors. As the computing power has grown, the robots expected to become more intelligent and autonomous. To reach this goal, a robot needs to have the following basic capabilities: mapping, path finding, localization, and object recognition. Among all these functionalities, localization problem is the most fundamental problem to provide a mobile robot with autonomous capabilities. Mobile robot localization is the problem of estimating a robot's location and orientation relative to its environment. In order for a mobile robot to perform any task, it is important for the robot to know its location and be able to determine the results of its actions. Localization is also a key problem in mobile robotics, since it plays an important role in various successful mobile robot systems.

Basically, the location and orientation of a robot is derived through the environment maps, odometric information, and sensor readings. One of the most successful algorithms developed for the localization problem is the Monte Carlo Localization (MCL) algorithm. MCL uses a belief system based upon weighted samples and will accurately show the position under a Bayesian formulation. In this project, we implement a modified version of this algorithm in our wireless distributed robotic system. The robot can locate itself in a previous-known static environment. This project also serves as an initial platform for the study of localization in a dynamic environment with moving objects and obstacles (e.g., human and other robots).

Enhancing Boyer-Moore pattern matching algorithm with character pairs

Paul Opala
Faculty Mentor: Chenyi Hu

In distributed computing environment, processing flat text files is more cost efficient than that of other files. Therefore, text processing algorithms play very important roles in computational cost reduction nowadays. Among text processing problems, exact pattern matching finds the occurrence (s) of a given sequence of characters, called pattern, within a text. People believe the most effective algorithm currently available in practice for exact pattern matching is the Boyer-Moore algorithm developed in 1977.

In this research, by discovering the properties of character pairs in pattern, we have developed two modifications that further enhance the performance of Boyer-Moore algorithm noticeably. One of them is to skip an entire block of characters without character-wise comparison if the block does not satisfy the condition of a selected pair. And, the other is to check only a half of the text for locating a possible pair in a text. By embedding the two modifications into classical Boyer-Moore algorithm, we have achieved over 10% performance improvement in our experiments.

MATHEMATICS

Parametric symmetries of ordinary differential equations

Yousuf Abbasi
Faculty Mentor: Danny Arrigo

The method of symmetry analysis of ordinary differential equations (ODEs) was first introduced by Sophus Lie in 1881 as a method to unify the seemingly unrelated techniques in solving ODEs. It is well known that if a nonlinear second order ODE admits an 8-parameter Lie group of symmetries, it can be transformed into a linear second order ODE. If the ODE fails to admit an 8-parameter family of symmetries, it is still sometimes possible to linearize the equation. We will show that by the parameterization of both independent and dependent variables, it is possible through symmetry analysis to obtain an equation for the independent variable such that an 8-parameter family of symmetries is admitted, thereby indicating linearization.

General compatibility of the 2+1 diffusion equation

Luke Brown
Faculty Mentor: Danny Arrigo

We consider the compatibility between first order partial differential equations and nonlinear reaction-diffusion equations in 2+1 and 3+1 dimensions. In 2+1 dimensions, we give conditions on the reaction term such that the compatible equation is quasilinear. We further show that in 3+1 dimensions, compatible equations are quasilinear regardless of the nature of the reaction term.

Symmetry analysis of the variable-coefficient beam equation

Joel Harris
Faculty Mentor: Danny Arrigo

The one-dimensional beam equation models flexural waves in beams and thin rods. It is typically assumed that the beam is homogenous and has a constant cross-sectional area. These assumptions lead to a fourth order partial differential equation with constant coefficients that can be solved by standard methods. Without these assumptions, the coefficients become functions of the variable representing the axis of the beam. The goal of this research was to find forms of these functions that would allow the reduction of the original partial differential equation to an ordinary differential equation by means of a method called symmetry analysis, the ultimate goal of which was to find exact solutions of these more general forms of the beam equation.

Positive solutions of quadratic equations with a parameter.

Ethan Hereth and Jason Norton
*Faculty Mentors***:** *Ramesh Garimella and Haiyan Wang*

A discussion of positive solutions to some quadratic equations which involve a threshold parameter that changes the structure of the equations. In particular we show the equation $x = \lambda\ (Ax^2 + Bx + c)$, where $A,B,C > 0$ and _ is a parameter, will have two positive solutions when $\lambda < \frac{1}{B + 2\sqrt{AC}}$. As a matter of fact, one solution goes to ∞ and the other goes to 0 as _ goes to 0.

Non-classical symmetries of the one-dimensional diffusion equation with a non-linear source term.

Jason Torrence
Faculty Mentor: Danny Arrigo

Recently it has been shown that the compatibility between evolution equations and first order quasi-linear partial differential equations (PDEs) lead to their non-classical symmetries. Here, we consider the compatibility between the one-dimensional diffusion

equation with a nonlinear source term and a general class of nonlinear first order PDEs. Enforcing compatibility leads to a constraint in the form of another 2nd order nonlinear PDE. We will show that this constraint equation admits a first integral and further that it is reducible to solving an Abel equation of the second degree. Several examples are considered.

PHYSICS AND ASTRONOMY

Scanning electron microscope studies of bone sample: Influence of microgravity in adult male mice

Ashley Brown
Faculty Mentor: Rahul Mehta

Microgravity environment is known to induce changes in the ratio of elements present in bone. However, exact changes and their mechanisms are not known. In this study, we have used a NASA validated hind limb suspension by tail model to induce weightlessness in mice, and examined any changes in the bone. Swiss-Webster mice were hind limb suspended by tail for 21 days. During this period, body weight, food and water intake of these animals were monitored. At term, the animals were sacrificed using approved anesthesia and protocols. Various samples including bone and tissue were collected. Skull samples were extracted and washed with 0.9% saline solution, rinsed with distilled water, dried with acetone, sputter coated with gold, and maintained in desiccators. The ASPEX 2000 SEM was used to take pictures and elemental analyses with both the backscatter and secondary electron modes. In the elemental analysis, the K-, L- and M-shell x-rays produced from the sample in the ion-atom collisions were measured and analyzed for sub-shell and total shell intensities. The sample region and the spot size were varied to normalize measurements. Pictures were taken at magnifications ranging from 250X to 7500X and with an electron beam ranging from 12 to 20 keV. Preliminary investigation with elemental analysis indicates different atomic percent of oxygen, calcium and phosphorus around suture joints for two sample groups. These results collectively suggest that microgravity indeed influences elemental profiles and needs to be further investigated in detail. Acknowledgement: The authors would like to acknowledge Ben Waggoner[1], Department of Biology, for assistance with the SEM work. (Sponsored by funds from Arkansas Space Grant Consortium.

Be star H-alpha line profile variability

Bart Dunlap
Faculty Mentor: Scott Austin

The monitoring of the spectroscopic variability of Be stars is crucial for testing Be star models. Motivated by this, a Be star monitoring project was developed for undergraduate

student research involvement. We have been obtaining 0.8 Angstrom/pixel resolution H-alpha line profiles for several bright Be stars since 2003 June. These spectra were acquired using the UCA Fiber Fed Spectrograph used at the UCA Observatory and the Nubbin Ridge Observatory in Royal, AR. H-alpha line profiles, velocities, and variability are shown for Delta Sco, Chi Oph, Eta PsA, 48 Lib, and Upsilon Sgr (HD181615). Funding has been provided by the UCA University Research Council and the Arkansas Space Grant Consortium.

Applied chaos: Finding the needle in the haystack

Travis Hoggard, Katharina Ochterbeck, and Katie M. Reynolds
Faculty Mentors: Rahul Mehta and Stephen Addison

Nonlinear differential equations can be expressed by circuits, with the various circuit elements representing the different terms of the equations. We are building circuits to model certain differential equations that exhibit chaotic behavior. These equations are necessarily non-linear. This non-linearity is realized in the circuit by a variable resister. By adjusting this resistor, we can drive the circuit in and out of chaotic oscillations. One application we are studying is the use of this chaotic behavior for signal encryption and decryption.

Ultrasonic vibrometer design and testing

Chris McNeill
Faculty Mentor: Carl Frederickson

An ultrasonic vibrometry device was constructed and tested as part of this project. This device uses two ultrasonic transducers to measure the vertical motion of a surface. One transducer acts as the source of a 50 kHz incident acoustic signal that is reflected from the moving surface and received by the second transducer. The surface motion is induced using a base shaker forced to oscillate at between 50 Hz and 200 Hz. The motion of the surface will produce a Doppler shift in the reflected frequency effectively creating a frequency modulated signal at the receiver. Current work has focused on the design and testing of this device. This talk will present results of these efforts and plans for future work.