UCA College of Natural Sciences and Mathematics

21st Annual Student Research Symposium

HPER Gymnasium

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Department of Biology

Isolation by Drainage: Connectivity of Salamander Populations Occupying Headwater Streams

Amber Anderson
Faculty mentor: Don Shepard

Dispersal of individuals and their genes is fundamental to evolution, population demography, and community assembly. Geographical and environmental heterogeneity can have profound effects on the genetic structure of a species across its range. In stream-associated species, population connectivity is often determined by stream network structure and drainage divides can act as barriers to gene flow among populations in different basins. A reduction of gene flow among populations in different drainage basins is predicted to increase genetic divergence among populations and may ultimately lead to speciation if there is a long-term lack of gene flow. Many salamanders are restricted to microhabitats associated with aquatic systems and this is thought to explain the high levels of genetic structure frequently observed across small spatial scales. My research examines how microevolutionary processes in headwater stream populations of salamanders generate genetic structure and drive divergence between populations in different drainage basins. The Caddo Mountains in southwestern Arkansas are headwaters for the Cossatot and Little Missouri rivers. In this region, these headwaters are separated by a

Reproductive Biology of a Catadromous Striped Mullet in the Lower Arkansas River

Kristin Caserta
Faculty Mentors: Ginny and Reid Adams

We are studying a population of striped mullet (*Mugil cephalus*) approximately 940 km from the Gulf of Mexico in the Lower Arkansas River, hypothesized to exhibit catadromous behavior, spawning in the Gulf from December to February. Our objective is to study reproductive biology (gonadal development) of fsh while in the lower Arkansas system to further understand the life history strategy of this population. Fish were collected in the main channel downstream of Wilbur D. Mills Dam (Dam #2) and at a nearby oxbow, Morgan Point Bendway Lake, where fsh are semi-isolated and impeded from migrating to spawn. Fish were collected in October and December 2014, and length, weight, age, gonadosomatic index (GSI), and gonadal stage were determined. Sex ratio was highly skewed towards females. In the oxbow lake mullet, mean female GSI (n= 40) increased from 8.8% to 21.9%, and male (n= 6) GSI increased from 8.1% to 24.3%. Female (n=27) and male (n= 3) GSI in the channel mullet were similar to the oxbow lake mullet in October, but remained low in December. Oxbow lake mullet appear to be following a gonadal development pattern similar to marine residents, while channel mullet reflect outmigration by spawners and/or capture of fsh that will not spawn this cycle.

Knockdown of Telomerase in Human Cancer Cell Lines Using shRNAs

Ethan M Clement
Faculty Mentor: Calin Marian

Cellular senescence denotes the biological aging of the cell due in part to the shortening of telomeres. In somatic cells, during normal chromosomal replication, the lagging DNA strand is not continuously replicated like the leading strand. This phenomenon, known as the end replication problem, leads to gradual telomere shortening after each cell division. In some normal actively proliferating tissues (such as skin, gut lining, hair follicle, etc.) as well as majority of cancer cells the end replication problem is solved by telomerase, a specialized enzyme that has the capacity to add telomere repeats to the end of chromosomes. Telomerase has two components, the RNA template (hTR) and the reverse transcriptase (hTERT). The re-activation of telomerase has been widely regarded as playing a vital role in the immortality of cancerous cells. Recently, telomerase inhibitor drugs have been shown to induce critical telomere shortening in various cancer types. Our major interest is to investigate the impact of these critically short telomeres on cancer cell functions, specifcally on self-renewal pathways mediated by OCT4 and NANOG transcription factors. In order to avoid potential drug off-target effects we will generate critically short telomeres by knocking down telomerase activity in three prostate cancer cell lines using shRNAs that target the hTERT subunit of telomerase.

Phenotypic and Genetic Integration of the Cranium of Diamondback Watersnakes (*Nerodia rhombifer*)

Ian T. Clifton
Faculty Mentor: Matthew E. Gifford

The Effect of Science Fair Participation on Studentsô End of Course Biology Exam Scores

Hailey Ellison
Faculty Mentor: Mark W. Bland

Whatôs Your Life History Strategy?: Response of Orangethroat Darters (*Etheostoma spectabile*) to Natural Gas Development on the Fayetteville Shale Gas Play

Extent and Trends of Lead Poisoning in Raptors Of Arkansas

Deana Hughes
Faculty Mentor: Victoria McDonald

Avian lead toxicity from bullet fragments has been documented in waterfowl since the 1950s and more recently in birds of prey, or raptors, which acquire lead contamination from their prey and scavenged food. My project will assess the extent, trends, and sub-lethal levels of lead in Arkansas raptors. Currently in Arkansas, bald eagles (Haliaeetus leucocephalus) are the only raptors tested for lead. Testing all species of raptors for lead poisoning would give better insight into the extent and geographical scope of lead exposure to birds in Arkansas. Arkansas has wildlife rehabilitation facilities throughout the state. Several of them have offered to have all birds admitted tested for lead. Historical data indicating lead levels in bald eagles are also available. Analyzing the toxicity of chemicals in top predators and scavengers is a good indicator of overall ecosystem health, because any declines in these populations will have ripple effects down all the trophic levels in the community. My specifc research questions are as follows: What is the extent of lead poisoning in Arkansas and is there a certain geographical region of the state that shows higher lead toxicity? Is there a seasonality toxicity levels based on hunting season/ winter? Are gender, bird age-classes, and different species of raptors differentially impacted by lead levels in the environment? We expect to see statewide exposure to lead, however, we predict higher toxicity in areas near human hunting camps. We also predict more cases of lead-exposed birds in the winter months when live prey is scarce for the raptors, and when recreational hunting by humans is more prevalent. To date, I have obtained partial data on three bald eagles tested since January 2015. My research results from analyzed blood samples will begin to come in during summer 2015. The results will be used to help wildlife decision-makers educate the public regarding lead poisoning in birds.

Regulation of the Sarcoplasmic Reticulum Calcium ATPase pump (SERCA) by 17-ɓ estradiol in mice

Quinton Kaufman
Faculty Mentor: Brent Hill

In today’s society cardiovascular diseases remain one of the leading causes of death in the United States and it is expected that 40 % of the Population will be effected by some form of cardio vascular disease by the year 2030. In females, menopause decreases gonadal estrogen levels circulating in the bloodstream. Many calcium regulating proteins are influenced by estrogen, thus this decrease in circulating estrogen causes an increased risk for heart disease in females. One of the proteins regulated by estrogen is the SERCA

Using Sanger Sequencing to Resolve Targeted Complex Regions for Flowering Plant Chloroplast Genomes

Brittanie Kling
Faculty Mentor: Richard D. Noyes

In flowering plants, the chloroplast genome is circular and has about 150 kb of DNA. A chloroplast genome consists of four regions: a large single copy region (LSC), small single copy region (SSC), and two inverted repeats (IRa and IRb) that separate the LSC and SSC. Next generation sequencing (using Miseq technology) of entire chloroplast genomes is now possible, which uses massive parallel sequencing and assembly of short reads (150 or 300 bp) into the genome. However, short read assembly may not be effective at sequencing complex intergenic regions within genomes. In our chloroplast genome sequences for goldenrod (*Solidago)* and aster (*Symphyotrichum)*, we determined that the 4 junctions (regions #1-#4) and 10 other complex regions (#5-#14) required validation. To validate these regions, we used PCR amplification and Sanger sequencing to provide an independent and robust sequence of the regions. The resulting forward and reverse sequences were assembled into contigs and compared with the Miseq genome sequence. In general, Sanger sequences agreed with our Miseq assemblies; however, a few corrections needed to be made. For *Solidago*, comparisons showed that 13 out of 14 regions had no discrepancies, and region #11 required one 48 base pair insertion into our original Miseq assembly. For *Symphyotrichum*, 6 out of 14 regions required corrections, including two ~200 bp insertions, three

Effects of Population Dynamics and Hormones on Titillation Behaviors of Melanistic and Non-Melanistic Freshwater Turtle, *Trachemys scripta*

Lori H. Monday
Faculty Mentor: William B. Cash

Titillation has been described as an excitatory courtship behavior consisting of a series of stereotyped movements whereby a male turtle will extend his forelimbs parallel to the head of a female and vibrate his foreclaws near or against her eyes. This classic description of titillation has led to research assumptions that it is strictly a ritualistic courtship display especially in the *Trachemys scripta*, red-eared slider turtle. If titillation is a strict courtship behavior, it should occur most often during mating season, when reproductive hormones peak, between two sexually mature individuals of the opposite sex and of the same species. However, there is no empirical evidence to support this assumption, while there are published data that contradict it. There is an ontogenetic shift in titillation behavior and melanism in red-eared sliders that may be a response to similar challenges with different strategies depending on various social and environmental contexts.

There are positive correlations between melanism and body size, aggression, and testosterone, while there is a negative correlation between melanism and titillation. This leads to a causal relationship between melanism (a byproduct of hormone variation) and courtship strategy. The physiological responses will be quantified by measuring corticosterone and testosterone concentrations prior to and after behavioral trials. In order to elucidate the true function of titillation, we must evaluate the response of turtles receiving the signals in differing population structures. I will quantify the duration and frequency of titillation behavior to investigate the importance and function of the behavior in courtship and successful reproduction of red-eared slider turtles.

A Safe and Thrifty Approach to Silver Staining Ciliates

Taylor Newman and Taylor Tarbutton
Faculty Mentor: Ben Waggoner

Ciliates belong to a phylum of invertebrates known as Alveolata, aptly named for the flattened vesicles—alveoli—located just under the plasma membrane. As their name implies, ciliates are completely covered with rows of cilia, which are anchored to the cell via basal bodies. Oddly enough, upon flushing the organisms with silver, the basal bodies and silverline system absorb the metal, allowing visibility of anatomical structures that may otherwise be invisible under a light microscope. The patterns of the ciliature are species-specific, and, thus, the silver impregnation procedure allows for precise identification of different species of ciliates. The species-specific results of this protocol allow students to make meaningful observations about unique characteristics of various ciliates. Our goal was to modify an existing silver staining protocol (which called for the use of hazardous chemicals, such as picric acid) to make it safer and more cost- and resource-efficient for secondary and post-secondary laboratory settings. This was accomplished by replacing dangerous chemicals with commercial photographic developer. Our procedure could easily be implemented into any classroom and is valuable to high school campuses that may not have access to state-of-the-art technology.

Characterization of Gym Microbes

Duy Nguyen
Faculty Mentor: Benjamin Rowley

Methicillin-resistant *Staphylococcus aureas* (MRSA) has been identified as an emerging threat to the general population. Multidrug resistant strains of the bacterium have been isolated from healthy adults. Risk factors for health care-associated MRSA (HA-MRSA) infections included extended hospitalization along with undergoing invasive procedures. Cases involving community-associated MRSA (CA-MRSA) occur in healthy people unexposed to a hospital setting. Skin abrasions can allow CA-MRSA distribution to happen more readily, with individuals in athletic settings at a higher risk. A gymnasium is an area with many individuals sharing machines and during peak hours cleaning of the machines after every user is not feasible. CA-MRSA, along with other bacterial pathogens, can infect individuals in a situation like this and without preventive measures in place, the risk of an outbreak increases. Therefore, proper assessment of current equipment cleaning methods implemented in a gym should be tested for effectiveness against representative bacterium from four general groups (Gram positive and negative coccus and bacillus). The goal of this study is to determine to what degree current cleaning methods are efficient, specifically cleaning solution and physical cleaning methods effects on general bacterial types isolated from the gym.

Estrogen Induces Coronary Arterial Dilation via Downregulation of Voltage-gated Ca^{2+} Channels

Edouard Niyonsaba[1], Mohamed Idrissa Moussa[1], Robin J. Dalton[1]
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Gender studies have suggested that the female sex protects against abnormal vascular tone. Our lab has shown that estrogen (E2) can downregulate voltage-gated L-type Ca^{2+} channels (VGCCs) to prevent excessive vasoconstriction. The aim of this study is to determine the mechanisms associated with this E2-induced downregulation. The right coronary artery was obtained from hearts of female pigs. The right coronary artery was sectioned into longitudinal strips (Western blots, real-time PCR) or rings (isometric tension) and incubated for 24 hrs in 1nM E2 or EtOH (E2 solvent). The role of the endothelium was evaluated by removing the endothelium of the artery with a toothpick before the 24 hr incubation period. E2 decreased the expression of pore-forming α_{1c} subunit of the VGCC by 35%, but did not affect the mRNA encoding of the α_{1c} subunit. This decrease was not affected by the presence of endothelium. Isometric contractions were also measured to the VGCC agonist, FPL64176, in endothelial intact and denuded rings. Although E2 decreased the FPL41176 contraction by 50%, the presence of endothelium had not effect. To determine the role of estrogen receptors (ER), the arterial strips were incubated with either an E2 α/β antagonist (ICI 182,780), or a G-protein-coupled ER antagonist (G-15). Using western blots, only ICI 182, 780 prevented the E2-induced decrease in the α_{1c} subunit expression. Overall, our result suggest that E2 posttranscriptionally downregulates VGCCs via the activation of ER α/β;2006ion.

Exploring the Use of Isotropic Fractionation in the Nine-Banded Armadillo

John Patterson, Bethany Verkamp, Lindsey
Faculty Mentor: Jeff Padberg

In order to gain insight into the constraints upon and factors affecting mammalian brain organization, one must look at many mammalian lineages. To date, however, much of the focus has been on two mammalian superclades—Euarchontoglires (e.g., primates, rodents) and Laurasiatheria (e.g., felines). We propose to examine the brain of the nine-banded armadillo, a member of superclade Xenarthra, using state-of-the-art neuroanatomical

In Vivo Regulation of ß1, 2, 3, & 4 Subunits of Ca_L Channels in Response to Ovariectomy and Estrogen Replacement Therapy in Mice

Krystal Pham
Faculty Mentor: Brent Hill

17β-estradiol (E2), the primary female sex hormone, functions as a vasodilator and plays a signi f cant role in maintaining vascular tone via voltage-gated L-type calcium channel (Ca_L) regulation. The intracellular component of Ca_L, the beta subunit ($Ca_v\beta$) is essential in maintaining the gating properties of these calcium channels through regulation of various cell signaling molecules (G proteins, kinases, GTPases, etc.). In postmenopausal women, E2 levels decline and susceptibility to cardiovascular disease (CVD) increases. Furthermore, recent studies demonstrate various detrimental effects in $Ca_v\beta$ knockout models towards cardiovascular health in postmenopausal women. Therefore, the purpose of our study is to understand the mechanisms of Ca_L, speci f cally the beta-subunit isoforms 1-4, in maintaining healthy arterial blood pressure. Mice will be menopause-induced via ovariectomy, sacri f ced 4-weeks post-surgery, and aortas will be excised and analyzed. This study intends to measure protein level and mRNA expression of each beta subunit in mice aortas via western blot and qRT-PCR analysis, respectively. Additionally, we plan to examine the restorative effects of hormone replacement therapy to β subunit regulation in ovariectomized mice.

Prey Preference and Prey Handling in Two Populations of *Nerodia rhombifer*

Samantha Pike
Faculty Mentor: Matthew Gifford

Behavior plays a major role in the adaptation of populations to unique environments. My objective is to uncover the similarities and differences in prey preference and prey handling behaviors between two distinct populations of the Diamondback water snake, *Nerodia rhombifer.* In a population of water snakes near Lonoke, Arkansas, diet is very generalized, with frogs making up a substantial portion of ingested prey. The Lonoke site has a high abundance of both frogs and bait f sh. In a second population in Keo, Arkansas, the diet appears to be predominantly f sh, which mirrors the dominant prey type at the study site. Prey preference of a snake can be determined by counting the number of tongue f icks the snake directs toward a prey scent that is presented on a

Toward Capabilities-Based Environmental Leadership: A Case Study in Kanembwe, Rwanda

Brandon R. Rogers
Faculty Mentor: Leah Horton

This project aimed to develop an understanding of how residents in Kanembwe, Rwanda perceive their current reality with respect to capability opportunities and failures, explore the role the environment plays in influencing individual capabilities, and investigate whether an alternative cooking method, in the form of rocket stoves, took less time/energy than traditional 3-stone fires. The quantitative experiments taking place at the University of Central Arkansas revolve around the time/energy efficiency of site-built rocket stoves compared to that of traditional 3-stone fires. By using the rocket stoves built on campus, we will conduct two tests—the Water Boiling Test (WBT) and the Standard Cooking Test (SCT)—using the 3-stone fire and the rocket stove. We will then collect such quantitative data as time required to boil water, mass of wood consumed to achieve boiling, cooking time for beans and potatoes, and mass of wood consumed during cooking. The knowledge obtained during these experiments will serve as a preliminary source of information regarding the efficiency and necessity of the methodology that will be used for field-testing in Kanembwe, Rwanda.

Change in Land Use and Fish Assemblages in Sylamore Creek Over a Thirty-Nine Year Period

Heather A. Saco
Faculty Mentor: Ginny Adams

Long-term studies evaluating land use and fish community structure are often lacking but necessary to further the understanding of anthropogenic influence on local fish assemblages. Land use is known to influence the health of aquatic ecosystems, and alterations may result in negative impacts including increased sedimentation, nutrient enrichment and loss of habitat. Sylamore Creek is a tributary of the White River in Stone County, Arkansas. During June 2014, we sampled fishes at10 sites within the Sylamore Creek watershed. Sites, dates and sampling methodology were consistent with a historical data set collected during 1975. Fish assemblages will be compared with historical data using Morisita-Horn similarity indices and non-metric multidimensional scaling. Fish metrics (species richness, percent tolerant, percent intolerant, etc.) will be analyzed in relation to change in land use type. Land use change will be determined using current GIS technology as well as remote sensing for historical data. Results from this comparative study will be a valuable contribution to the long-term evaluation of fish community structure in Sylamore Creek. Further comparative investigations of additional Arkansas upland stream systems will follow.

Exploring Biomedical Issues Using A Time Translation Model

Atikatou Amadou Sadou, Anthony Cardillo, Sarah England, Ha Ram Kim
Faculty Mentor: Barbara Clancy

Basic Science Literacy in Arkansas

Patrick Ward
Faculty Mentor: Mark W. Bland

DEPARTMENT OF CHEMISTRY

Radiocarbon Dating of Rock Paintings at Eagle Cave, TX

Trinidy Allen
Faculty Mentor: Karen Steelman

Measurement of Aerosol Optical Properties Using Pulsed Laser Cavity Ring-Down Spectroscopy (Crds).

Logan Bevill, Julio Castillo, and Jay Pittman
Faculty Mentor: Kristin Dooley

Synthesis and Characterization of Iron Heteroscorpionates

Katherine Demaree
Faculty Mentor: Patrick Desrochers

The heteroscoropionate Tp’ was developed in our lab following a simple pyrazole-for-triazole substitution strategy. Tp’ represents the scorpionate chelate hydrobenzotriazolyl-bis(3,5-dimethylpyrazolyl)borate, a monoanion. Scorpionates are aggressive tridentate chelates with broad applications encompassing nearly every metal ion on the periodic table. Heteroscorpionates (where one of the three nitrogen donor groups is

The Effect of Retinoid Receptor Agonists on K562 Cellular Adhesion, Proliferation, and Ŭ5ƃ1 Integrin Cell Surface Expression

Raynin Phomakay
Faculty Mentor: Melissa Kelley

Establishment and maintenance of proper immunity requires a precise balance between cellular adhesion and proliferation. A disruption in either event culminates in a variety of pathologies encompassing immunosuppression, auto immunity, and cancer. Retinoids, profoundly affect immune function by mediating cellular adhesion and proliferation in certain leukocytes. Retinoids, by binding to retinoid receptors (RARs or RXRs), modify the expression of a variety of signaling proteins involved in immune cell proliferation and adhesion including, integrins. Integrins are a family of transmembrane heterodimeric receptors consisting of non-covalently linked α and β subunits that are considered to be the principle receptors involved in attachment to the extracellular matrix and provide adhesive interactions that control cellular proliferation. Currently, the contributions by retinoids in immune cell adhesion and proliferation have been independently examined; however, in retinoid responsive immune cell lines there appears to be a potential synergism between cellular adhesion and proliferation, which may be mediated through integrins, specifically the α5β1 subset. In this study, the effect of all-*trans*-retinoic acid agonists on K562 cellular adhesion, proliferation, and α5β1 integrin cell surface expression was investigated. RARgamma agonist exposure increased K562 cellular adhesion to RGD containing extracellular matrix proteins fibronectin and FN-120. Cell surface expression of both the α5 and β1 integrin subunits was increased in the presence of a RARgamma agonist; however, RARgamma agonists decrease K562 cellular proliferation. In the presence of the RARbeta agonist, K562 cellular proliferation was increase, while α5β1 cell surface expression was decreased. The RARalpha agonist was comparable to the control in K562 cellular adhesion, proliferation, and α5β1 integrin cell surface expression. Our study is the first to demonstrate that specific RAR agonists alter cellular adhesion, proliferation, and intergrin cell surface expression.

State-Speciýc Reactions of $Cu^+(^1S,^3D)$ with SF_6 and SF_5Cl: Thermochemical Control Over Product Formation

Xavier S. Redmon, Benjamin A. Scheuter
Faculty Mentor: William S. Taylor

Reactions of the gases SF_6 and SF_5Cl with the ^1S ground state and ^3D excited states of Cu^+ were carried out in order to examine parameters influencing S-X (X=F,Cl) bond activation. Experiments were conducted using a selected ion drift cell apparatus. Both Cu^+ states were prepared in a glow discharge utilizing Ne as the working gas. Ion mobility spectrometry (IMS) revealed state-specific product formation for both gases. $Cu^+(^1S)$ reacts with both SF_6 and SF_5

Gas-Phase Reactions of Cu^+ (^1S, ^3D) with CF_3CH_2Cl, $CF_3CH_2CH_2Cl$, and $CF_3CH_2CH_2Br$: Proximity Effects in Substrates with Competitive Reactive Sites

Benjamin Scheuter, Xavier Redmon

Department of Computer Science

The Robotic Maze Runner

Kwadi Higgins, Paul Morrison, Justin Duff, Kendall Mason
Faculty Mentor: Yu Sun

In every aspect of our lives, we are required to react to stimuli within our environments. Navigating is essential to this process. In order to represent the process of having to react to different stimuli within an unknown environment, in this project we have researched using an EZ-Robot to navigate a maze. Within this maze, the robot will encounter several symbols and it will need to react accordingly to those symbols. Detecting each symbol, performing the correct reactions to those symbols, and navigating the maze is the end goal for this

Label Noise Correction Methods

Bryce Nicholson
Faculty Mentor: Victor S. Sheng

A main concern in data preprocessing is ensuring that the data in question is clean. In real-world applications, label noise is an unavoidable phenomenon. The important task of correcting label noise is addressed infrequently

Analysis of Stock Market prices

James Robert Stamps
Faculty Mentor: Chenyi Hu

Due to the huge interest in stock market prices, statistical analysis of stock market data has and will always be researched. The Dow Jones is used as a measurement of the strength of the United States economy and in this research I will perform a statistical analysis and scientific computing methods of two quarters of the components of the Dow Jones. I find the general trends of prices and how stocks affect each other.

Semi-Active Learning

James Robert Stamps, David Fink
Faculty Mentor: Victor S. Sheng

Often active learning is used to increase the accuracy of low confidence instances for other algorithms such as semi-supervised learning algorithms. The goal here is to use active learning as the base algorithm and apply other algorithms to lower the cost of “querying the oracle.” Two of the ways in which we will lower the cost of active learning; one is to make better selections in which instance to query, and the other is to lower the number of instances needed to create a good model. To begin a few things are needed a data set of labeled and unlabeled instances, a model to evaluate with, and a bases for selecting unlabeled instances to label.

Semi-supervised Multi-label Learning

James Robert Stamps
Faculty Mentor: Victor S. Sheng

Semi-supervised learning is a commonly used learning method that has proven itself quite useful for single label data. It produces high quality models, while being extremely cost efficient. This efficiently makes semi-supervised

Department of Geography

Predictive Habitat Modeling for Ivory Billed Woodpeckers in Arkansas and Louisiana

Russell T. Rogers
Faculty Mentor: Mary Sue Passe-Smith

The Ivory Billed Woodpecker once ranged over the majority of the Southeastern United States, where it would dwell primarily in the swampy bottomland hardwood forests that had a large canopy of old growth trees. Since the 1800s logging and agriculture has reduced the bird's habitat from 24 million acres down to only 4.4 million acres of scattered forests. With the great majority of the forests being replaced by farmland there was a large increase

Department of Mathematics

Symmetries of the Gross-Pitaevskii Equation

Kyle Barker
Faculty Mentor: Danny Arrigo

We consider the classical and nonclassical symmetries of the Gross-Pitaevskii equation (GPE). We will show that the nonclassical symmetries are more general than the classical symmetries. We further consider first order compatibility and the GPE and show a class of compatible equations exists that are not obtainable by the symmetry method.

Effects of Interactive Images on Student Understanding in Calculus

Katie Burden, Cyrus Koch, Sarah Zimmerman
Faculty Mentor: Jason Martin

Conceiving of and relating pertinent measurable attributes of objects or phenomena is known as quantitative reasoning. This reasoning can be used to continually refine and generalize a student's personal mathematical model so that the associated mathematical concepts may be applied across varied contexts. Reasoning quantitatively while modeling mathematical concepts is especially important with calculus concepts as these concepts are frequently applied to a wide range of contexts across the spectrum of STEM fields.

Project CLEAR Calculus is a research-based effort to develop calculus curriculum that is conceptually accessible to students while simultaneously increasing the coherence, rigor, and applicability of the content learned. First year results indicate substantial gains in students' conceptual understanding but there is room for improvement. Recent studies indicate that interactive images may support additional gains in conceptual understanding.

To capitalize on recent advances of technology, virtual manipulatives (computer based interactive representations) and animations were constructed to support Project CLEAR Calculus. In this study we asked the questions, "What effects do interactive images have on student understanding?" and, "How do students conceive of and relate quantities differently with graphical and contextual representations?"

During clinical interviews, individual students were shown contextual and graphical representations with differing levels of interactivity, including static images, animations, and virtual manipulatives. They were asked a series of questions to gauge whether a more interactive representation aided their understanding of the concept and their ability to reason quantitatively. Students' interactions with the images were recorded and analyzed with a focus on determining when the students began reasoning quantitatively.

Early results indicate that students first attended to general shapes and patterns and that the transition from static to animated representations tended to correlate with a recognition of changing quantities.

Mathematical Modeling of a Smoking System

Alma Malibekova, Diana Morales
Faculty Mentor: Long Le

Our research focuses on mathematical modeling of smoking in a population. The study focuses on four different groups that consist of a potential, exposed, smoking, and quitter individuals. A set of differential equations is derived for the system whose equilibrium points are found and analyzed for their stability. Our results determine whether the system will eventually reach stability and whether smoking will become nonexistent or more prevalent within the system.

Department of Physics and Astronomy

Identiýcation of AGB Variable Stars in the KELT Survey

***Robert A. Arnold*[1]**

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[2]

Metacognition and Epistemic Games in IPLS Group Problem Solving

Charles Bertram
Faculty Mentor: Andrew Mason

In order to improve how physics is being taught in introductory physics for life sciences (IPLS) courses, an effort is being made to understand how non-physics majors learn physics from a problem solving perspective. A metacognitive exercise in problem solving was given to an IPLS class at UCA over the course of the Spring 2014 and Fall 2014 semesters. This exercise was presented to the class at the beginning of the lab period and the students were allowed an allotted period of time to work in groups to solve a context rich problem relevant to that day's lab activity. The exercise featured scaffolding in the form of a rubric that students could use to note where they struggled in a group problem solving effort. One of the concerns was that students who are not physics majors do not necessarily have the same epistemic framework as physics majors would for the classroom. As such, we examine written artifacts from the students' reflection activities and audio-visual data recorded from the various groups working on the activity for evidence of different epistemic games. We also describe a comparison of written artifacts to pre-post data from the FCI and CLASS surveys.

Sound Absorption and Resonance of Venturi Resonator Systems

John P. Ferrier, Jr
Faculty Mentor(s): William V. Slaton

Venturi resonators allow for sound absorption in wind pipes while introducing minimal flow damping to the system. Utilizing this technology, it is possible to create sound abatement technologies for use in larger scale applications without utilizing volume outside of the pipe. To test this, a 3D printer was used to create Venturi resonators, and microcontroller systems were developed for data acquisition, in order to test for flow excitation and absorption to verify the acoustical theory.

Pearcey Function Modeling of the Transverse Cusp Caustic

Nicholas Frederickson
Faculty Mentor: Carl Frederickson

The transverse cusp caustic is an acoustical phenomenon in which sound rays form a focal envelope after being reflected off a curved surface. The amplitude of the waveform is highest along the edge of this envelope, lower on the inside of the envelope, and nearly nonexistent outside of the envelope. The diffraction pattern associated with the transverse cusp caustic is given by the Pearcey function. Inside the cusp caustic there are three specular reflection points on the curved surface. At the caustic two of these points merge. Outside the caustic there is only one specular reflection. In propagating from the surface to an observation point inside the caustic, some of the specular ray paths will touch the caustic surface. The shapes of these pulses will be changed during this encounter.

To look for these ray paths, a reflective surface of the necessary shape was created using a MakerBot 3D printer. Sound bursts from a 50 kHz source were directed at the surface and the reflected wave front is measured at certain points inside and outside of the expected caustic. Measurements of the shapes of the reflected signals show the expected shape changes. In order to test Pearcey function modeling of the transverse cusp caustic diffraction pattern, MATLAB code was written to evaluate the function based on the source, reflective surface, and observation positions. Quasi-static signals will be used to develop a picture of the acoustic wavefield that will then compared to the model generated by the Pearcey function.

Construction of a Sub-Sonic Wind Tunnel

Samuel A. Johnson
Faculty Mentor: Carl Frederickson

The sub-sonic wind tunnel is a staple piece of equipment for all forms of aerospace engineering. Even with computers allowing increasingly accurate models, wind tunnels are still needed to verify predictive models and also visualize fuid fow about a specifc design. An operational wind tunnel will provide another tool to allow experimentation conducive to engineering felds. The tunnel was designed with three parameters in mind: cost, wind speed, and laminar airfow. A tunnel with variable wind speeds and laminar airfow is a good emulator of objects moving through the atmosphere. At the highest of three speeds the tunnel is expected to have winds approach 100 mph. So long as the airfow at this speed is both laminar and continuous, the proposed tunnel will allow for the study of basic fuid fow principles (like air drag) and design of parts for cars, aircraft, and spacecraft.

Impedance Tube Measurements of Acoustic Properties of Porous Materials

Forrest McDougal
Faculty Mentor: Carl Frederickson

An impedance tube has been used to make measurements of the acoustic impedance of porous samples. Micron-scale sized glass beads were tested for their characteristic impedance. Software was developed to make the data acquisition process more robust. Unidentifed issues with previous measurements were discovered due to the new process. The measurements taken were compared to previous measurements and calculated values. The end goal is to develop a system that can be used with 3D printed porous materials to test porous material acoustic propagation models.

The Killing Equation and Isometriesof the Metric

Brandon Miller
Faculty Mentor: Balraj Menon

Though it is often not mentioned, physics is done on manifolds—usually $\mathbf{R}^3$, but also in Minkowski spacetime in $\mathbf{R}^4$, the state spaces in thermodynamics, and the confguration spaces in mechanics, and even more exotic manifolds in M-Theory. Often these manifolds have a tensor feld defned on them: The metric tensor, which gives the notion of distance on the manifold. One can ask the question “what are the transformations that are allowed by this metric such that the metric (the measure of distance) does not change?” and this is equivalent to fnding the vector felds that generate these transformations, known as Killing vector Fields, and these are solutions to Killing’s Equation. These vector felds and their associated transformations are closely related to conservation laws on the manifold. Conservation laws are very important in physics, and conserved quantities (such as energy, momentum, charge, etc.) are useful in describing many physical situations. Killing’s Equation was solved to

A Study of Concrete and Determining Elastic Moduli of Materials Using Resonance

Gerard Munyazikwiye
Faculty Mentor: William Slaton

The objective of this multidisciplinary study was to determine elastic moduli of materials; especially concrete, using a resonance technique. Therefore, a separate study of concrete was initially done to learn necessary skills that are required for one to work with concrete. In order to determine elastic moduli of rods; their mass, length and density were obtained experimentally. The torsional, longitudinal, and transverse resonance modes for the rods were recorded by a multichannel analyzer which swipes the current through coils that were wrapped around on both ends of the bar. Both ends of the bars were placed in a magnetic field that was created by two PASCO magnets in which the two bar ends were placed. Hence, an electromagnetic force caused the bar to vibrate with different frequencies from which a resonance frequency can be obtained. These resonance frequencies are related to the elastic properties of the materials; Young's moduli and Shear moduli. Therefore, by measuring these quantities the strength of the material were determined. Preliminary tests as proof of principle were conducted with aluminum, brass, wood and plastic rods and the results supported the claim. Data and experimental techniques for determining the elastic moduli for concrete using this procedure will be presented but more work need to be done for the final conclusion to be made.

Effects of Microgravity and Radiation on Elastic Modulus of Rat Femurs Using 3-Point Bending*

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The aim of this study was to determine the changes in elasticity and lattice structure in leg bone of rats which were: 1) under Hind-Limb Suspension (HLS) by tail for 2 weeks and 2) were exposed to radiation of 10 Grays in

Atomic Force Microscopy to Quantify Adhesive Force between Silicon Tip and Silicon Surface in the Presence of Graphene

Brandon Rogers, Lucus Ratz, and Forrest McDougal
Faculty Mentors: Radwan Al Faouri and Dr. Azida Walker

Determining Black Hole Mass of Active Galactic Nuclei Using FWHM of the Hϐ Emission Line and Luminosity Relations

Hunter Ward, Stephen Clark, Lucus Ratz
Faculty Mentor(s): Debra Burris, Balraj Menon

Our research is a joint project with Dr. J. Kennefick and others at the University of Arkansas. There they hope to determine a correlation between the spiral galaxy pitch angle and the mass of the super massive black hole (SMBH). Our goal is to provide independent mass determination of these black holes in order to conclude if correlations exist. We will do this by looking at the emission lines from the Active Galactic Nuclei (AGN) which contains the Balmer Hβ emission lines. From these Hβ lines, the velocity of the gas can be determined. The luminosity of the black hole can be determined by applying the extinction correction to the spectral files. The extinction correction accounts for the amount of light that our own galaxy absorbs, giving the true luminosity of

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