College of Natural Sciences and Mathematics

UNIVERSITY OF
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25th Annual Student Research Poster Symposium

April 19, 2019
1:00 - 3:00 PM
Farris Center

Welcome from the Dean
College of Natural Sciences
and Mathematics

Welcome to the 25th Annual College of Natural Sciences and Mathematics Student Research Symposium. Today you will see some of the research that is being undertaken by students in the College. This year we have research from many fields - there are 72 posters involving 111 students mentored by 44 different faculty members. We encourage you to drop by the Farris Center to join us in celebrating the accomplishments of our students.

I look forward to seeing you there.

Cordially,

Stephen R. Addison

Stephen R. Addison, Dean
College of Natural Sciences and Mathematics

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Department of of Biology

Faculty Views on Evolution and Teaching Evolution at Several Arkansas Campuses

Student Author: Christie Birdsong
Faculty Mentor: Mark Bland

Evolution is widely regarded by scientists as one of the most important concepts in biology. According to Pews "US Religious Landscape Survey" conducted in 2014 Arkansas has one of the lowest rates of belief in Evolution in the country at only 20%. The reason for the disconnect between the scientific community and the general public is unclear and should be researched further at every level. There are multiple socioeconomic and academic factors at play that determine someone's preconceptions and predispositions toward evolution. Some common factors include the education system, religious backgrounds, and political affiliations. Our research assesses the views on evolution held by collegiate faculty at several Arkansas campuses. The area of collegiate education is understudied despite its importance in the formation of personal identity. To survey college faculty about their personal beliefs on evolution and teaching evolution we employed a combination of two different surveys that are considered reliable. One survey is the GAENE (Generalized Acceptance of Evolution Evaluation) which is a newer survey compared to MATE (Measure of Acceptance of the Theory of Evolution). They both ask questions which are answered on a scale of agreement from 'strongly agree' to 'strongly disagree'. Questions on GAENE cover the important of understanding evolution, while the MATE survey covers personal beliefs about evolution. Together they form a more comprehensive look at both a person's beliefs, but also their feelings about the importance of evolution as a theory. We conducted our research at CBC, a private Christian college, Hendrix, a private liberal arts school, and UCA, a larger public college.

A Tale of Two Sylamores: Understanding Relationships Among Landuse, Nutrients, and Aquatic Community Assemblages Across a Subsidy-Stress Gradient

Student Authors: D.M. Braund, A.J. Feltmann, G.B. Gavrielides, K.L. Lang, J.R. Main, A.K. Mogilevski, J.H. Mosbey, R.L. Relic, C.R. Rezac, B.K. Trejo
Faculty Mentors: Ginny Adams, Reid Adams

Agricultural land use is known to degrade aquatic systems with high inputs of nutrients, sediments, and pesticides. Increased nutrients can lead to increased algal growth and thus possible hypoxic conditions in slow moving water, while increased sediment loads have been shown to obstruct light and reduce substrate stability. These conditions negatively impact primary producers, macroinvertebrates, and fish. However, small-scale changes in land use can subsidize an aquatic ecosystem instead, where an increase in nutrients allows nutrient-limited biota to flourish, and minor increases in sedimentation may help support populations of collector-filterers. The stimulation in performance caused by small disturbances is part of the subsidy-stress gradient, where increasing perturbation subsidizes an ecosystem until a certain threshold is reached, at which a decline in performance and increased variability starts to occur. The North and South Sylamore watersheds in north Arkansas provide a useful template to investigate the subsidy-stress gradient in relation to land use. North Sylamore flows through the Ozark National Forest and has a heavily forested catchment, while South Sylamore flows through mostly private land, some of which is pasture (23%). Physicochemical, macroinvertebrate, and fish data were collected from multiple sites within each watershed to determine if South Sylamore is exhibiting a response to pasture/agriculture characteristic of a subsidy-stress gradient. Sites within South Sylamore had significantly higher nitrate levels and larger macroinvertebrate populations dominated by collector-filterers, suggesting South Sylamore may be subsidized by the surrounding pastoral lands. However, South Sylamore also had a significantly lower number of intolerant macroinvertebrate taxa, suggesting South Sylamore is experiencing stress as well. Habitat quality of South Sylamore could be improved by restoration of trees within the riparian zone. Monitoring aquatic systems for subsidy-stress responses can inform restoration/management decisions and guide intervention prior to watersheds and aquatic communities becoming overly stressed.

Mosquito Control by Invertebrate Predators in UCA Vernal Pools

Student Author: Caleb Bryan
Faculty Mentor: David E. Dussourd

UCA has five vernal pools behind the softball, soccer, and track complex adjacent to Stone Dam Creek. We tested if mosquito larvae are present in the pools and if macroinvertebrate predators provide adequate control. The five pools were sampled every other week from March 9 to May 10, 2018 to estimate macroinvertebrate diversity and abundance of mosquitoes and mosquito predators. Pools 1, 2a, and 2b had large numbers of alternative prey (mostly water fleas), sizable predator populations, and low numbers of mosquitoes. Mosquito numbers and diversity were higher and predator populations lower in pools 3 and 4. Unlike pools 1, 2a and 2b, pools 3 and 4 receive very little sunlight due to a dense understory of non-native privet together with an overstory of mostly hardwood trees; they also receive pesticide runoff from the adjacent soccer fields. To increase populations of alternative prey that maintain populations of mosquito predators, we recommend removal of the privet understory and reduction in the use of pesticides susceptible to runoff.

Effect of Sex on Osmoregulation of The Ohio Shrimp, *Macrobrachium Ohione*

Student Author: Drew Castleberry
Faculty Mentors: S. Reid Adams, Matthew E. Gifford

The osmotic adaption capabilities of Ohio shrimp, *Macrobrachium ohione*, collected approximately 892 river km upstream from the Mississippi River estuary, were studied. Similar to the widely studied *Macrobrachium rosenbergii* and *Macrobrachium acanthurus*, *M. ohione* larvae require a brackish environment to continue development to adulthood. The question of whether female *M. ohione* migrate from inland locations within the Mississippi River to downstream estuarine environments to facilitate larval development was explored via osmotic capabilities in this study. Females were compared to males to explore if adult female *M. ohione* migrate back downstream to brackish environments, then they should have a different osmoregulatory strategy relative to adult males that do not migrate. Shrimp were captured using wire mesh traps during the summer of 2018 and habituated to the laboratory environment for ~19 weeks. Shrimp were then acclimated over 12 days to three salinity treatments: 0 ppt, 10 ppt, and 20 ppt. Osmolality of shrimp hemolymph was measured with a water vapor osmometer. As a species, *M. ohione* exhibited hyperosmotic regulation at each of the three salinities. Males osmoregulated higher than females at 0 ppt and 20 ppt, while females osmoregulated higher at 10 ppt, similar in pattern to *M. acanthurus*. The osmoregulation strategy exhibited by female *M. ohione* reflects what might be expected, based on comparisons with other shrimp species, of individuals making a downstream migration to brackish environments.

Effect of Selection and Genetic Drift on Phenotypic Diversification in The Eastern Collared Lizard.

Student Author: Andrew J. Feltmann
Faculty Mentor: Matthew Gifford

Organisms display a wide diversity of traits that selection acts upon causing phenotypic change over time. When organisms disperse, however, the resulting small population can experience genetic drift due to decreased genetic diversity within the population. Reintroduction is one of the more common forms of population restoration in conservation management plans. The reintroduced populations face challenges that colonizing populations face (i.e. a reduced population number and possible inbreeding). These issues may lead to genetic drift which can majorly impact fitness in the population, potentially leading to population crash. We examined the effects of selection and drift on a metapopulation of Eastern Collared Lizards (*Crotaphytus collaris*) on Stegall and Thorny mountains in southern Missouri. We measured a suite of morphology and performance traits to assess levels of differentiation between mountains. Lizards on Thorny mountain were found to have longer fore limbs, higher bite forces, and had higher respiration rates. Stegall lizards had longer head lengths overall. This supports our prediction that the population on Thorny is experiencing novel selection pressures or genetic drift.

Predator Induced Phenotypic Plasticity in a Pond Breeding Amphibian

Student Author: Emily Field
Faculty Mentor: Matthew Gifford

Predator induced phenotypic plasticity is a common phenomenon throughout nature and is usually associated with an anti-predator response due to chemical interactions between predator and prey. This has been well studied among pond breeding amphibians in relation to morphology before and at metamorphosis. Such changes often manifest as changes in body size or tail structure. In this study we investigated the response of spotted salamander, *Ambystoma maculatum*, larvae to a predatory pond breeding salamander, the marbled salamander, *Ambystoma opacum*. The goal of this study was to test for differences in morphology in *A. maculatum* during egg incubation and as offspring post hatching after exposure to *A. opacum* during development. Due to high post hatching morality we were unable to examine post hatching phenotypes. However, we were able to examine the potential effects of the predatory salamander on hatchling body size and tail morphology.

Host Specificity Of *Burkholderia* Bacteria Symbiont: Measuring the Cost of a Novel Symbiont Infection in Other Social Amoeba Species and its Prevalence in Natural Populations

Student Authors: Haley Hensley, Sydney Ulmer
Faculty Mentor: Tamara S. Haselkorn

Microbial symbionts can have dramatic effects on their hosts' ecology and evolution. We use the social amoeba, *Dictyostelium discoideum* as a simplified model system to study eukaryote-bacterial symbioses because it is a single celled eukaryote that houses three naturally occurring bacterial symbionts in the *Burkholderia* genus. *D. discoideum* infected with these *Burkholderia* symbionts are able to carry food bacteria with them upon dispersal in a trait called farming. So far, these symbionts have only been characterized in *D. discoideum*, so it is not clear how host specific these infections are. We have previously determined that the *Burkholderia* can infect other closely-related amoeba species in the lab, however, the consequences of that infection are unknown. When pathogens infect a new host, theory predicts that they will have a greater fitness cost initially, particularly when that host is distantly-related to the original host. To test this, we artificially infected other species of amoeba (*D. purpureum* (closely-related) and *P. pallidum* (distantly-related) with three strains from two symbiont species, *B. agricolaris* and *B. hayleyella*, and measured the production of spores in these novel hosts with and without *Burkholderia*. We find that contrary to our predictions, the fitness cost is not higher in *P. pallidum*, and the costs vary more by symbiont strain. Furthermore, we used PCR to test the prevalence of *Burkholderia*, and other amoeba symbionts in five natural populations of five social amoeba species. We found a high prevalence of *B. agricolaris*, as well as other species of non-symbiont *Burkholderia*. Other characterized amoeba symbionts species, *Chlamydiae* and *Amoebophilis*, were found in only a couple of individuals. The findings suggest that *Burkholderia* is not host specific, and provide insight into the microbiome of the amoeba to allow it to become a better model organism for studying host-bacteria interactions.

Both Manuka and Non-Manuka Honey Types Inhibit Antibiotic Resistant Wound-Infecting Bacteria

Student Authors: Samantha R. Hewett, Shivange Satishbhai
Faculty Mentor: Kari Naylor

Postoperative infections are a major issue in US hospitals, accounting for roughly 20% of all hospital-acquired infections yearly. Wound-infecting bacteria in particular have a high rate of drug resistance (up to 65%), creating life-threatening complications. Manuka honey has been FDA-approved for wound treatment in the US after recent studies demonstrated its ability to inhibit a variety of bacterial species and facilitate wound healing. In this study, we demonstrated that there are several alternative (non-manuka) honey types, particularly raw Arkansas wildflower honeys, that comparably inhibit the growth of the resistant bacterial species specifically implicated in wound infections. Concentrations of 10%-30% honey completely inhibited the growth of the highly antibiotic resistant organisms that WHO declared in 2017 to be in critical need of new antibiotics. No statistical differences in MIC existed between manuka honey and Arkansas wildflower honey for any of the species tested. These results could transform wound care in the United States, where manuka honey can be expensive and difficult to obtain, and where antibiotic resistance remains a troubling concern for wound treatment.

Characterization of Smoke Particle Emissions from Rocket Stoves Versus Three-Stone Fires

Student Authors: Mackenzie Hoogshagen, Elizabeth Versluis
Faculty Mentor: Leah Horton

Citizens of third world countries around the globe are negatively impacted by environmental factors such as smoke inhalation. Our research is centered in the small village of Kanembwe, Rwanda. This people group is limited by a lack of resources and recurrent sickness.

The residents traditionally cook over open three-stone fires. When smoke is inhaled into the lungs, some of the particles can become imbedded into the soft tissue and cause damage. This can result in lower elasticity which ultimately causes lower pulmonary functioning and chronic obstructive pulmonary disease (COPD). Rocket stoves, improved cook stoves, were introduced to the village, and tested to measure if rocket stoves' impact on human health via reduction in inhaled smoke. We conducted trials in which smoke particles from both rocket stoves and three-stone fires were collected onto filters using a Siotus cascade impactor. We then examined particles by using scanning electron microscopy (SEM) to characterize the abundance of the particles with respect to their size distribution.

We hypothesized that rocket stove intervention would have a positive impact on human health by releasing fewer inhalable particles by being exposed to fewer particles, residents should experience less respiratory illnesses. Further, peak expiratory flow rate was measured among residents who utilize either three-stone fires or rocket stoves as their primary cooking method to quantify direct impact on user health.

Determination of Bat Species' Use of Artificial Bark Enhanced Habitat in Northern Arkansas

Student Author: Sarah Martin
Faculty Mentor: Vickie McDonald

Impending threats to regional bat populations from white-nose syndrome (WNS), climate change, and habitat loss has concerned federal and state wildlife agencies, as well as other natural resource entities. My project is to test whether Arkansas bats in general, and specifically whether endangered bats, such as the Indiana bat (Myotis sodalis), will utilize artificial bark applied to utility poles as an effort to mitigate habitat loss. In April 2018, we erected utility poles covered by the artificial bark at three sites in northern Arkansas, and one site in the Arkansas River Valley. Currently no Arkansas research exists on whether bats will use artificial bark (BrandenBark™) applied as sheets to large utility poles for potential colony nests or roosting. The BrandenBark™ artificial bark was created by Copperhead Environmental Consulting with the intent to help mitigate habitat loss for bark roosting bat species; thus far it has had limited pilot research. My research entails three methodological approaches. First is the erection of poles with the BrandenBark™ sheathing followed by year-round direct observations of bat occupancy. The second is to survey the vicinity for local bat species present using active and passive bat recordings. The third is to determine the species of the bats utilizing the BrandenBark™ poles via DNA analysis of bat feces collected bi-weekly at the base of the poles. The monitored artificial bark structures are the first to be installed in Arkansas, thereby making this presence/absence study the first of its kind in the area.

Variation in Habitat Use and Body Condition
of *Etheostoma Caeruleum* and *Etheostoma Fragi*
in The Strawberry River, Arkansas

Student Authors: Blake Mitchell, Jennifer Main
Faculty Mentors: Ginny Adams, Reid Adams

The Strawberry River is occupied by 19 fishes listed as Species of Greatest Conservation Need, including the endemic *Etheostoma fragi*. We explored potential differences in habitat use and body morphometrics between *E. fragi* and the more widespread *E. caeruleum* to better understand interactions between these two species. Totals of 453 *E. fragi* and 571 *E. caeruleum* were collected during 2017 and 2018 across 30 sites. Compared to historical data (1970-1980s), *E. fragi* was found at three additional sites and in higher abundance overall. Mean relative abundance *E. fragi* to *E. caeruleum* was significantly higher in pools (0.67 +0.08) compared to riffles (0.28 +0.06) and runs (0.20 +0.1) (P < 0.001). At 40% of sites where *E. fragi* was detected, they were found at 2X or greater abundance in pools compared to riffles, while *E. caeruleum* showed the opposite pattern. Both species showed similar condition (ANCOVA, p>0.05) within a species across habitat types (riffle, run, pool). Based on our data, future monitoring should include pool and run habitat to increase detection probability of *E. fragi*. Our data suggest *E. fragi* is stable or expanding within the system and interactions with *E. caeruleum* are probably influenced by habitat segregation.

Effect of 5α-Pregnan-3β-Ol-20-One 3β-Acetate Availability and
Steroidogenic Enzyme (HSD-3) on Dietary Restriction-Mediated Stress
Resistance in C. elegans

Student Authors: Brewer Owen, Kellee Miller, Chloé Chapman
Faculty Mentor: Mindy Farris

Dietary restriction (DR) can have a positive effect on longevity and stress resistance in C. elegans (Braeckman, 2006). While DR can be studied by bacterial deprivation (BD), it can also be obtained through a genetic DR model. A mutation in the eat-2 gene causes lifelong reduced pharyngeal pumping in C. elegans, reducing the amount of food it can consume despite bacterial availability (Kenyon, 2010). 3β-hydroxysteroid dehydrogenases HSD-2 and HSD-3 have been identified in C. elegans, orthologs to 3β-HSDs in vertebrates, enabling examination of hormone pathways involved in DR-mediated heat stress resistance (Kenyon, 2010). The hormone synthesized by HSD-2/HSD-3 is unknown but likely related to hormones produced by homologous enzymes. A double mutation in eat-2;hsd-3 removes eat-2-mediated stress resistance. Previous trials using Pregnenolone (PREG) showed PREG increased stress resistance in wild-type (N2) worms, but were unsuccessful at reverting eat-2;hsd-3 phenotype back to that of eat-2. PREG derivative and alternative hormone 5α-Pregnan-3β-ol-20-one 3β-acetate (ALLOPREG) was revealed and selected through gas chromatography-mass spectrometry (Broue, 2007). ALLOPREG was fed to eat-2, hsd-3, eat-2;hsd-3, and N2 worms to determine its ability to rescue the eat-2-mediated stress resistant phenotype. hsd-3 supplemented with ALLOPREG was hypothesized to have similar stress resistance to N2 control; furthermore, hsd-3 with ALLOPREG should have greater stress resistance than hsd-3 control. eat-2;hsd-3 with ALLOPREG was hypothesized to have greater stress resistance than eat-2;hsd;3 control, specifically similar to eat-2 control. Analysis revealed our results were inconclusive although there were notable trends: N2 worms fed ALLOPREG showed a slight increase in stress resistance as compared to controls. ALLOPREG also modestly increased eat-2;hsd-3 stress resistance when compared to eat-2;hsd-3 control, but not to the phenotypic extent of eat-2 control. It is possible that ALLOPREG is a precursor needed by HSD-2/HSD-3 to make its stress resistance-inducing hormone but a functional enzyme is required for synthesis.

Integration of Mixed Methods Into Community-Based Participatory Research (CBPR): A Methodological Approach and Health-Centered Case Study

Student Author: Mason Rostollan
Faculty Mentor: Leah Horton

The natural sciences have traditionally been dominated by postpositivist epistemology and quantitative research approaches; however, mixed methods research is gaining acceptance. This approach is particularly utilized in social sciences, medicine, education, linguistics, and similar fields. Mixed methods research blends both quantitative and qualitative methods to create a more thorough and contextualized study and we assert the natural science could benefit by blending qualitative components with otherwise quantitative studies.

Here we present a case study from Kanembwe, Rwanda, an impoverished village with limited access to healthcare. Our goal was to characterize environmental compartments that may lead to morbidity or mortality among the residents. To achieve this, we obtained quantitative data from health metrics and environmental conditions including lung function, smoke abundance, and water quality. We then employed semi-structured interviews to gain insight into participant attitudes toward interventions and perceptions of personal health. Without quantitative data, the findings are strictly based on participant interpretations of their surroundings; without qualitative data, the findings lack context and application.

Methods can be mixed at each level of research. In this case study, we mixed the methods in data collection, analysis, and reporting. This allows us to gain thick, rich data that can be directly translated into the context of our study site and provides opportunity for participants to directly see the effects of the study. Further, we were able to tailor our approach in a manner that accounts for social norms and cultural needs. This approach led to better intervention perception by the participants and more open communication, thus better feedback for future studies.

In conclusion, mixed methods research approaches have applications for the natural sciences through contextualizing studies and providing opportunities for blended approaches that yield more thorough and nuanced data and results, as exemplified by our study from Kanembwe, Rwanda.

Effects of Simulated Microgravity and Radiation on SERCA Expression in Arteries

Student Author: Claudy Sarpong
Faculty Mentor: Brent Hill

Microgravity is known to decrease the expression of the sarcoplasmic reticulum calcium ATPase (SERCA) in rats and mice; similar changes also happen in the skeletal muscle of humans. SERCA activity pumps cytosolic calcium into the SR, thus preventing a dramatic elevation in intracellular calcium in muscle cells. Our aim is to investigate the impact of radiation on SERCA expression in arteries from rats exposed to a microgravity environment (using hindlimb unloading). Adult male rats were housed and subjected to hindlimb unloading (to simulate microgravity) for a period of 30 days. At the beginning of 30 days, half the rats were irradiated with 1 gray of radiation. After 30 days, the aorta was dissection out and homogenized into a whole cell lysate. We used the Western Blot technique to compare SERCA to the loading control, beta-actin. Our preliminary/hypothesized results indicate that radiation exposure decreased SERCA expression. Our results may be extrapolated to understand how space radiation can impact the vascular system of astronauts. Support: Arkansas Space Grant Consortium & UCA Student Research Funds.

Energetic Cost of Girdling in a Notodontid Caterpillar, *Oedemasia Leptinoides*

Student Author: Brianna Trejo
Faculty Mentors: David Dussourd, Matthew Gifford

Some caterpillars use their mandibles to cut a ring around the petiole, rachis, or stem before feeding on the distal leaf blade. This girdling behavior has been observed in multiple notodontid species. In one study, final instar larvae of *Oedemasia leptinoides* spent up to 11% of their time girdling over a 12 hour observation period, whereas another notodontid, *Lochmaeus manteo*, did not girdle at all (Ganong et al., 2012). Girdling may improve leaf nutrition or reduce plant defensive responses. Using *O. leptinoides* and *L. manteo* as model notodontids, a combination of behavioral observations and respirometry data were used to produce overall energy allocation budgets for each species. Preliminary results indicate that the energetic cost of behaviors (feeding, walking, inactivity) was similar for the two caterpillar species, and that the cost of girdling in *O. leptinoides* was similar to the cost of feeding. *L. manteo* spent more time inactive. As a result, its overall energy expenditure was less, but it also grew more slowly than *O. leptinoides*, which spent more time feeding.

Butanone Association Learning in Wild-Type and Poly-Q *Caenorhabditis elegans*

Student Author: Whitney Wilkins, Priya Rana, Stefani Hall
Faculty Mentor: Mindy Farris

C.elegans change their behavior in a Pavlovian-like response to a conditioned stimulus (food) paired with an unconditioned stimulus (butanone). We compared wild-type (N2) and the Huntington disease (HD) model poly-glutamine (poly-Q) *C. elegans* for learning association and short-term memory experiments, reflecting early cognitive deficiencies. The poly-Q strain serves as a model for HD, as polyglutamine expansion in the neurons causes increased proteotoxicity with age and HD patients typically have a decrease in cognitive functioning before motor dysfunction occurs. Chemotaxis assays were conducted on media without food (OP50 E. coli) with ten percent butanone vs diluent control spotting over 0.4M sodium azide, following one-hour long exposure to ten percent butanone with OP50 *E. coli*. Larval and young adult populations were used for each assay. Results suggest that N2 animals are capable of butanone association after butanone inoculation, and poly-Q animals are less so by a Learning Index of 0.637. The ages in which assays were conducted were before typical neuronal degradation occurs in poly-Q animals, suggesting the mechanism(s) for learning are severely inhibited before full proteotoxicity of the neurons. Further experimentation has been conducted using glucose supplementation for analysis of learning rescue, with no significant rise in learning index of diseased populations. Experimentation has moved forward toward 10 µM rapamycin supplementation as previous literature suggests rapamycin reduces protein aggregation of cellular HD models by slight reduction in protein synthesis.

Using a Molecular-Genetic Approach to Investigate the Interactions Between Rice and Plant Growth-Promoting Bacteria, Azospirillum

Student Authors: Charles Wilson, Allee Haynes, Randall Rainwater, Grant Wiggins, Qinqing Yang, Connor Deen, Jacklyn Thomas
Faculty Mentor: Arijit Mukherjee

Major non-legume crops can form beneficial associations with nitrogen-fixing bacteria like Azospirillum brasilense. Our current understanding of the molecular aspects and signaling that occur between important crops like rice and these nitrogen-fixing bacteria is limited. In this study, we used an experimental system where the bacteria could colonize the plant roots and promote plant growth in wild type rice and symbiotic mutants (dmi3 and pollux) in rice. Our data suggest that plant growth promotion and root penetration is not dependent on these genes. We then used this colonization model to identify regulation of gene expression at two different time points during this interaction: at 1day post inoculation (dpi), we identified 1622 differentially expressed genes (DEGs) in rice roots and at 14dpi, we identified 1995 DEGs. We performed a comprehensive data mining to classify the DEGs into the categories of transcription factors (TFs), protein kinases (PKs), and transporters (TRs). Several of these DEGs encode proteins that are involved in the flavonoid biosynthetic pathway, defense and hormone signaling pathways. We also identified genes that are involved in nitrate and sugar transport and are also implicated to play a role in other plant-microbe interactions. Overall, findings from this study will serve as an excellent resource to characterize the host genetic pathway controlling the interactions between non-legumes and beneficial bacteria which can have long-term implications towards sustainably improving agriculture.

Department of Chemistry

Metal Complexes of a Heteroscorpionate with Unique Symmetries, Optical, and Magnetic Properties

Student Authors: Ali Abdulrahim, Madison Martin
Faculty Mentors: Patrick Desrochers, Makenzie Long

Scorpionates are effective facial chelates with predictable bonding patterns involving almost every metal ion on the periodic table. Heteroscorpionates (where one nitrogen-donor group is varied) exhibit unique asymmetry in the compounds produced. The ligand Tp'was created in our lab (Inorg. Chem. 2011, p. 1931) through simple triazole-for-pyrazole substitution. Here, with the first ever reported use of microwave heating, reaction time for this ligand has been drastically reduced. Tp' represents the monoanion scorpionate hydrobenzotriazolyl-bis(3,5-dimethylpyrazolyl) borate. The present work describes M(Tp')2 complexes (M=Mn, Fe, Co). The orange iron(II) form has been oxidized to the deep purple iron(III) form. The structure of the cis-Fe(Tp')2 was confirmed by single crystal XRD. These reactions demonstrate the utility of this scorpionate with a variety of first row transition metals. The Fe(Tp')2 and the Co(Tp')2 cases were separated into cis and trans isomers through column chromatography. All were characterized by B-11 NMR, Infrared, MALDI, and UV-Vis spectroscopy. The Fe(Tp')2 was unique in showing an intense MLCT in the visible region. This series allows variations in magnetic properties across the {Mn, Fe, Co, Ni} series to be investigated, including spin-crossover behavior in the iron(II) case and trends in B-11 paramagnetic NMR shifts. These experiments helped demonstrate that Tp' was a typical scorpionate. With our improved microwave synthesis method, we plan to use a similar ring substitution approach to anchor this scorpionate to cellulose, thereby increasing the utility of this ligand system.

Reaction of 2-ethynyl-1,3-benzothiazole

Student Author: Rachel Anderson
Faculty Mentor: Richard Tarkka

The electron deficient conjugated aromatic alkyne, 2-ethynyl-1,3-benzothiazole, was synthesized in three steps: 2-aminobenzothiazole was diazotized, then iodinated, yielding 2-iodobenzothiazole. Coupling with ethynyltrimethylsilane via a Shongashira reaction, followed by deprotection with an excess of KF, produced the target compound. Attempts to polymerize the compound, using conditions known to polymerize similar monomers, were unsuccessful, as indicated by proton NMR spectroscopy. When treated with 1,4 diazabicyclo-[2.2.2]octane (DABCO) as catalyst, in acetonitrile, the compound underwent a head-to-head dimerization, yielding the conjugated enyne, with the trans enyne being the major product. This outcome suggests that conjugated enynes may be easily accessible through a similar set of reaction conditions, obviating the need for a transition metal catalyst.

Thiyl Radicals: What Could be the Harm?

Student Author: Kyle Burgener
Faculty Mentor: Nolan Carter

Free radicals are key intermediates in the damage of biomolecules such as proteins and DNA. Radical-induced damage reactions are often initiated by reactive oxygen species such as hydroxyl radical. Thiols such as glutathione are believed to exert a protective antioxidant effect via donation of hydrogen atoms to radicals. This converts the radical to a stable molecule and halts the cascade of reactions involved with radical damage. However, a byproduct of this "repair" reaction is a sulfur (thiyl) radical. Since thiyl radicals are significantly less reactive than their oxygen counterparts, they have generally been considered benign. While it is true that sulfur radicals are much less reactive in processes such as hydrogen atom abstraction, they do readily react by pathways such as addition to carbon-carbon double bonds. This goal of this project is to examine the degree to which thiyl radicals may be involved in the damage of biological molecules such as DNA. To study this problem we are synthesizing a cysteine derivative which contains a photolabile disulfide functional group. This will enable the selective generation of thiyl radicals in the presence of nucleosides. Reaction products formed in this model system will provide insight into the possible role of thiyl radicals in DNA damage.

The Implementation of Edpuzzle Videos in a Freshman-Level Chemistry Classroom to Address Student Performance on Lewis Structures, VSEPR, VB Theory, and Polarity

Student Author: Morgan Burke
Faculty Mentor: Faith Yarberry

Lewis Structures, VSEPR theory, VB theory, and molecular polarity prove to be difficult concepts for students in freshman-level chemistry courses. Split- screen lecture videos on these topics have been developed with the overall goal to improve student success in the classroom and on the nationally standardized American Chemical Society (ACS) exam. Student success will be evaluated using their test scores on the end-of-course exam and the ACS exam after completion of an online lab dedicated to viewing the lectures through EdPuzzle.

EdPuzzle is a useful online tool because of its unique ability to embed questions into videos. In addition to the percent correct, it provides a variety of analytics that can be used to determine student use of the tool. This tool is not only useful for its analytics, but it also gives students the opportunity to identify concept errors and re-watch components that address those concepts.

For two years, videos on these topics have been implemented in the freshman-level chemistry classroom. The goal of the research is to determine if scoring above or below 60% on the EdPuzzle video quizzes wil help student performance on the End-of-course exam questions and ACS exam questions. Briefly, we find that scoring above 60% on EdPuzzle has a positive effect on ACS and End-of-course exam question scores for the test group, Fall 2018.

Tuning Efficiency and Product Formation in the Iron-Induced Decomposition of the Potent Greenhouse Gas SF$_6$ and its Analogs SF$_5$Cl and SF$_5$CF$_3$

Student Authors: Camille L. Foscue, Christopher L. Emmerling, Arthur L. Harris
Faculty Mentor: William S. Taylor

Gas phase reactions of SF$_6$, SF$_5$Cl, and SF$_5$CF$_3$ with Fe$^+$(^{6}D), FeX$^+$ ($^5\Delta$) (X= F, Cl, Br, I), and FeO$^+$ ($^6\Sigma$) were carried out in a selected ion drift cell apparatus at room temperature in 3.5 torr of helium. Rate coefficients and product branching fraction data were obtained for all reactions in order to evaluate reaction efficiencies and possible mechanisms. Reactions between SF$_6$ and ligated iron ions yielded multiple association products in all cases. Dependent on the ligand, various fluoride abstractions were also observed in small amounts, except with FeF$^+$ where SF$_5^+$ was the major product. For SF$_6$ reactions with bare iron ions only fluoride abstractions were observed. SF$_5$Cl reactions yielded various bimolecular products including SF$_2^+$, SF$_3^+$, SF$_4^+$, and SF$_5^+$, dependent on the reactant ion. SF$_3^+$ typically dominated product formation with SF$_5$Cl and association was not observed. SF$_5$CF$_3$ likewise exhibited various product channels dependent on the reactant ion, including SFx$^+$ (x=1-3) and CF$_3^+$ (from Fe$^+$ and FeO$^+$), and SOF$^+$ (exclusively from FeO$^+$). Both Fe$^+$ and FeO$^+$ reactions with SF$_5$CF$_3$ were found to be highly efficient. A ligand effect was observed in the efficiencies of reactions with SF$_6$ that correlates with the electronegativity of the substituent on the iron center. This ligand effect is not observed with SF$_5$Cl, suggesting that the strength of the activated bond is involved in the rate determining step for this neutral substrate. Where experimental thermochemistry was unavailable, reaction energetics were determined computationally using density functional methods. In cases where comparisons were possible, calculated reaction thermochemistry was generally in agreement experimental values.

Calibration Methods Using Microfluidic Paper-Based Analytical Devices

Student Authors: Nicole Gaile, Spencer Mallett
Faculty Mentor: Nathan A. Meredith

The development of microfluidic paper-based analytical devices (mPADs) as a low cost alternative to precision analytical instruments has typically relied on linear calibration curves to determine the concentration of an unknown analyte. However, calibration curves are not universally applicable for all samples or procedures, and alternate quantification methods must be used. Our goal was to demonstrate the use of standard addition and internal standard calibration methods on paper devices using the colorimetric reaction of nickel with dimethylglyoxime (dmg), which forms an intense pink product, as a model reaction. Standard addition is used when there is an interference in the sample matrix that causes the signal to deviate from the expected value. Ethylenediaminetetraacetic acid (EDTA) was used to create an interference with nickel to simulate a matrix effect for the standard addition experiment. An internal standard is required when sample loss is unavoidable during preparation or measurement. Paper devices experience inherent sample loss as the solution flows through channels reducing the accuracy and precision of the analysis. The reaction of zinc with zincon was investigated as a suitable internal standard for nickel determination.

Mathematics ACT Pre-Requisite Alteration for College Chemistry I and its Impact on the Student Cohort

Student Author: Aaron Gaul
Faculty Mentor: Faith Yarberry

Previous research illustrates a direct correlation between mathematics ACT exam scores and success in freshman-level chemistry courses. Currently, at UCA, a 21 mathematics ACT score is the pre-requisite for College Chemistry I with an alternative of a pre-requisite/co-requisite of College Algebra. Under the current requirements, there is still a 33.4% DFWI rate in College Chemistry I. It is therefore necessary to re-evaluate the prerequiste requirements for this course in order to increase student success. One possible option is to increase the Mathematics ACT score or, as an alternative pathway, make a course grade of C or better in College Algebra as a pre-requisite. Alterations considered to the Mathematics ACT requrement must be informed by data and be reasonable with respect to student impact on chemistry majors as well as majors for which College Chemistry I is a service course.

Biology majors are required to enroll in College Chemistry I through Organic Chemistry II for their Academic Map. This cohort of students is easily the largest group served by these chemistry classes. We, therefore, wanted to analyze the impact of potential pre-requisite changes on this group of students. College Chemistry I data, from Academic Years 2007-2017, collated with College Algebra data was evaluated. Potential changes of the current 21 to a 23, 24, or 25 Math ACT score were considered and cross-referenced by those that would not meet the alternative entry into the course to determine the impact. Our poster will demonstrate the impact that would be observed assuming these alterations to the pre-requisites for College Chemistry I.

Classification of Caddo Pottery Sherds Using SEM-EDS

Student Author: Lindsey Hazeslip
Faculty Mentors: Robert Mauldin, Duncan P. McKinnon

The purpose of this project is to classify temper from different types of Caddo pottery sherds and determine sub-categories that exist, if any. The pottery sherds are from the Bowman site (ca. A.D. 1100-1500) located on the Red River in southwestern Arkansas and were initially classified based on physical appearance using a light microscope. The sherds were initially divided into categories based on dominant temper: bone, clay, shell and grog. Early Caddo potters used only clay (or a lack of temper), whereas later production included the addition of bone, shell, or grog (ground, previously fired clay) in order to strengthen the pottery. The next step in the project used a scanning electron microscope with an energy dispersive x-ray spectrometer (SEM-EDS) to analyze the pottery sherds in an attempt to verify or modify previous light microscope temper classifications. The SEM-EDS helped determine which elements are present in addition to atom and weight percentages for each element detected. The pottery sherds are electrically non-conductive, so they were first sputter coated with gold. All of the samples contained carbon, oxygen, magnesium, aluminum, potassium, and silicon. SEM-EDS data indicated the bone-tempered pottery samples contained additional phosphorus and calcium, while the shell tempered samples contained only additional calcium (as compared to the clay pieces). Future work will involve the analysis of the clay and bone categories since the light microscope and the SEM-EDS suggested noncorresponding classification of these pieces.

The Effect of Retinoid Receptor Agonists on K562 Cellular Proliferation

Student Authors: William Higgins, Sidney Freyaldenhoven
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 RARs and RXRs in immune cell adhesion and proliferation have not been examined. In this study, the effect of all-trans-retinoic acid agonists on K562 cellular proliferation was examined. Interestingly, K562 cellular proliferation levels were decreased in a time- and concentration-dependent manner when cells were treated with the RARgamma agonist. In the presence of the RARalpha or RARbeta agonists, K562 cellular proliferation was comparable to the vehicle control. Our study is the first to demonstrate that specific retinoid agonists alter cellular proliferation in K562 cells.

Effect of Laboratory Videos on Student Performance in College Chemistry II

Student Authors: Erin Hollinger, Haylee Barnes
Faculty Mentor: Faith Yarberry

The flipped classroom teaching style has recently seen an upward trajectory of use across many colleges and universities in the classroom. Laboratories, by nature, are interactive for the students, but pre-laboratory material is still frequently presented using the typical lecture method. This experiment was designed to specifically test the impact of the flipped classroom approach toward the pre-laboratory lecture on the success rates of students in the College Chemistry II laboratory. Pre-laboratory videos, included in the online EdPuzzle program and embedded with interactive questions, were tested to determine the students' ability to retain information and perform laboratory techniques at a higher quality as determined by an overall increase in laboratory grade. The control group for the experiment were previous College Chemistry II classes that did not receive the videos, whereas the test group received the videos. The research presented will show the impact of the required EdPuzzle pre-laboratory videos on overall lab grade, compared to the previous years with no access to any pre-laboratory videos.

Squaramide-Based Anti-Parasitics: The Search for a New Treatment for Chagas Disease

Student Author: Hannah G. Howard
Faculty Mentor: Gregory R. Naumiec

Neglected tropical diseases are parasitic or bacterial diseases that are prevalent in lower income populations. Currently there are eighteen neglected tropical diseases worldwide, including Chagas disease, which is the focus of our research efforts. Chagas disease is most common in rural areas of Latin America, Mexico, Central America, and South America. In these areas many individuals live in poverty, therefore they are not aware that they are infected with the disease and do not seek treatment. Chagas disease is caused by a parasite called Trypanosoma cruzi, which is transmitted by the insect vector triatomine bug, commonly called the "kissing bug." These kissing bugs become infected after biting an infected animal or person. Chagas disease is spread when the T.cruzi vector bites and excretes feces onto the wound. Individuals with the disease may experience fever, swelling, cardiac complications, intestinal complications, and possibly death. The aim of this project is to use squaric acid and an assortment of amines to develop various drug candidates to treat Chagas disease. The synthetic path in this project involves the conversion of squaric acid to diethyl squarate, and this precursor is then further functionalized with different aniline derivatives. Squaric acid, along with the requisite amines, are relatively inexpensive and react well for this experiment. For example, the reactions have relatively fast reaction times, maintain moderate to high yields, and are easy to purify. The development of new drugs will allow for the proper diagnosis and treatment of Chagas disease, decreasing the number of individuals who contract the disease.

Investigation and Perturbation of PEP-19's Conformational Ensemble

Student Author: Josiah Johnson
Faculty Mentor: Tori Dunlap

PEP-19 is an intrinsically disordered protein (IDP) that binds to the calcium signal regulating protein calmodulin and enhances its calcium ion binding kinetics. Alterations in PEP-19 expression have been associated with calcium signaling disruption. In the brain, PEP-19 has been shown to be protective against glutamate induced cytotoxicity. Its levels are decreased in the brain in Huntington's disease, and its levels are increased in brain areas spared in Alzheimer's disease, suggesting that PEP-19 is protective against calcium overload. PEP-19 over expression in mice leads to premature neuronal differentiation and learning deficits. This is particularly interesting as the gene for PEP-19 is found on chromosome 21, likely linking the aberrations caused by PEP-19 over expression to the learning and memory deficits of Down Syndrome. When bound to calmodulin, ~20 residues at PEP-19's C-terminus become helical while the N-terminal half of the protein remains disordered. Consistent with the partial gain of helix when bound to calmodulin, PEP-19 belongs to a class of IDPs whose native conformational ensemble is predicted to change depending on the environment. We hypothesized that the conformational ensemble of PEP-19 can be influenced by its environment with the possible induction of secondary structure. We investigated this possibility by utilizing fluorescence resonance energy transfer (FRET) fluorimetry to determine PEP-19's N- to C-terminal distance as a proxy for compaction and circular dichroism (CD) spectroscopy to determine secondary structure content of PEP-19. These experiments were performed both in the absence and presence of crowding agents, denaturants, calcium ions, and alterations in ionic strength in order to ascertain the effects of environment on PEP-19's conformational ensemble. Additionally, we utilized analytical ultracentrifugation (AUC), size exclusion chromatography (SEC), and fluorescence anisotropy to investigate the interaction between calmodulin and PEP-19.

Aqueous Solvation of Alkaline Earth Metal Ions Using Combined Explicit and Continuum Solvent

Student Author: Madison E. Martin
Faculty Mentor: Makenzie Provorse Long

Aqueous solvation of alkaline earth metal ions plays an important role in biological and environmental processes. The water molecules most tightly bound to the cation constitute the first solvation shell. The size and flexibility of the first solvation shell affects the physical and chemical behavior of these ions. In general, the size and flexibility of the first solvation shell increases as the cation radius increases. However, the literature values for the number of water molecules within the first solvation shells of Ca^{2+}, Sr^{2+}, and Ba^{2+} can vary widely based on the method used. Physically, both short-range quantum mechanical interactions and long-range electrostatic interactions are expected to contribute to the aqueous solvation of alkaline earth metal ions. A promising computational approach that includes both of these interactions is to explicitly model the first solvation shell with quantum mechanics and treat the bulk solution as a dielectric continuum. There are many computational aspects that may affect the reliability of this combined solvent model. We use density functional theory to explicitly model the alkaline earth metal ion and its first solvation shell. This quantum mechanical system is then embedded in a continuum defined by the dielectric constant of bulk water. Several computational aspects are investigated: basis set size, effective core potential, empirical dispersion model, continuum solvent model, and the continuum cavity shape. Each alkaline earth metal ion is modeled with an increasing number of explicit water molecules and results are compared with experimental coordination numbers.

Synthesis of N-Benzoyl-2-Hydroxybenzamides for the Treatment of Malaria

Student Author: Allen Nguyen
Faculty Mentor: Gregory Naumiec

Malaria is a disease caused and transmitted by several species of Plasmodium parasites including P. vixax, P. ovale, P. malariae, P. knowlesi, and P. Falciparum. Malaria is one of many neglected tropical diseases due to its prevalence in developing nations located near the equator. It is estimated that half of the world's population is at risk of contracting malaria. Chloroquine, discovered in 1934, is one of the world's essential medicines for treating and preventing malaria; however, due to mass drug administration, strands have starting show resistance to chloroquine, especially in Africa, South America, and Southeast Asia. The second generation of drugs, mefloquine and lumefantrine, have harsh side effects, cannot be used during pregnancy, and are not used to treat severe cases of malaria. On top of resistance and ineffectiveness of second generation drugs, treatment and prevention efforts in these nations are costly. Recent efforts have uncovered a lead compound based on the structure of N-hydroxybenzamides that have shown effectiveness against the P. Falciparum parasite which is known to cause cerebral malaria. My research focuses on optimizing the synthesis of N-hydroxybenzamides as well as investigating any analogues that can increase the drug's effectiveness. The synthesis is broken into two major pathways based on the order of the reactions done: Suzuki coupling of alkyl and aryl substituents to halobenzoic acids followed by the coupling to salicylamide or coupling of halobenzoic acids to salicylamide followed by the Suzuki coupling of alkyl and aryl substituents. Currently ortho, meta, and para halobenzoic acids have protected in high yields are currently undergoing Suzuki coupling reactions. All products were analyzed with 1H and 13C NMR spectroscopy after purification by column chromatography with moderate to high yields.

A Comparison of Calibration Methods for the Graphite Furnace Atomic Absorption Spectroscopic Analysis of Lead in Drinking Water

Student Author: Martha Schanandore
Faculty Mentor: Robert Mauldin

The United States Environmental Protection Agency (EPA) claims there is no known level of lead exposure that is considered safe. Exposure to lead can cause severe side effects in pre-adolescents such as slowed growth, lower IQ, hyperactivity, seizures, and death. In adults, symptoms of lead consumption may cause cardiovascular effects, such as high blood pressure and hypertension, and decreased kidney function. Particularly, in pregnant women, lead is able to cross the placental barrier and affect the fetus, resulting in premature birth or reduced growth of the fetus. Although lead stems from many other environmental sources, the EPA predicts that 20% of a person's lead exposure is from drinking water. Lead in drinking water has been a frequent concern in many water sources. It has been found in several studies that the lead found in tap water stems from the lack of a chemical treatment that prevents the corrosion of the underground pipes. This corrosion occurs when other oxidants in the water react with lead in the pipes, allowing for lead to be oxidized into the water. The analysis of lead in drinking water, using a graphite furnace atomic absorption spectroscopy (GFAAS), is a useful way to demonstrate the difference in the calibration curve and standard addition methods. We designed a teaching lab to analyze the concentration of lead found in tap water when using these two calibration methods. The teaching lab will allow students to gain a better understanding of the ability of standard addition to account for the matrix effect. GFAAS data will be presented for the analysis of ppb levels of lead in Lake Brewer water, the local water source for Conway, AR, and tap water from Laney-Manion. Levels of lead well below the federal action limit (15 ppb Pb) were found in both water samples.

Synthesis and Characterization of Copper(II) Complexes Supported by Pyridylamide Ligands

Student Authors: Joseph Schneider, Metu Oslu
Faculty Mentor: Lei Yang

Mixed-valance copper clusters have been proposed as the intermediates during the catalytic reactions of natural copper-containing enzymes such as multicopper oxidase and nitrous oxide reductase. In our effort to make synthetic models of these mixed-valence copper clusters, we used a group of pyridylamide ligands as the platforms to support the copper centers with different oxidation states. Interesting multinuclear Cu(II) complexes, including a one-dimensional Cu(II) polymer, a hexanuclear Cu(II) metallomacrocycle complex and a trinuclear Cu(II) cluster, have been synthesized and characterized by X-ray crystallography, IR, UV-vis and EPR. Currently the study of these ligands with Cu(I) salts is under investigation.

Optimization of Microfluidic Paper-Based Analytical Devices to Detect Low Concentrations of Tetracycline in Agricultural Settings

Student Author: Erica Lane Smith
Faculty Mentor: Nathan A. Meredith

Tetracycline is commonly used in concentrated animal feeding operations, where overuse of antibiotics contributes to the issue of antimicrobial resistance, a significant problem affecting the overall human population today. Current testing for pharmaceuticals in agricultural runoff is time consuming, expensive, and requires experienced users to complete. This project investigates the development of a low-cost microfluidic paper analytical device for the rapid detection of tetracycline based on its native fluorescence and the fluorescence of the europium-tetracycline complex. The limit of detection for each method was $4.1*10-6$ M and $2.8*10-7$ M, respectively. The europium-tetracycline complex was found to be approximately 3 times more sensitive than the native fluorescence, and it has a limit of detection approximately 14.6 times lower. Ongoing work is focused on interferences and testing real world water samples.

Natural Products to Combat Leishmaniasis: Chalcone-Based Anti-Parasitics

Student Author: Kaitlyn Solley
Faculty Mentor: Gregory Naumiec

Leishmaniasis is a parasitic infection that is classified as a neglected tropical disease (NTD). A neglected tropical disease is an illness that impacts the health and well-being of more than one billion people annually in poor and underdeveloped countries. Peoples of the tropic and subtropic regions of Central and South America, Asia, the Middle East, North Africa, and Southern European regions of the world are most at risk. Leishmaniasis, caused by the Leshmania parasite, is one such NTD that is spread to humans through the bite of a sand fly. The most common forms contracted by humans are the cutaneous and visceral form which cause skin sores as well as swelling of the liver and spleen affecting the blood and ultimately leading to death. Conventional treatments often have little to no effect due to increasing drug resistances and second line drugs are highly toxic. Chalcones, natural products with anti-parasitic properties, are the precursor to several biological compounds that can be readily synthesized via an aldol condensation reaction of a benzaldehyde with an acetophenone. After a 24 hour reaction period in an ice bath, the product solution is extracted with DCM to obtain a purified product in moderate to high yields. All products have been characterized by 1H and 13C NMR spectroscopy. These compound derivatives have been shown to have medicinal properties against leishmaniasis and are potentially more potent and less toxic than current treatments. The purpose of our research is to build a drug library of chalcone derivatives with varying sidechains that would then be tested for their anit-leishmanial ability.

Squaramide-Based Anti-Parasitic Drugs Toward the Discovery of Novel Treatments for American Trypanosomiasis

Student Author: Emily N. H. Tran
Faculty Mentor: Gregory R. Naumiec

American trypanosomiasis, or Chagas disease, is a neglected tropical disease caused by the parasite Trypanosoma cruzi. This illness is known to affect over one sixth of the world's population, most prevalently in Central and South America. The two current treatments for Chagas disease utilize the drugs Nifurtimox and Benznidazole, potent anti-parasitic medications that eliminate T. cruzi. Though effective drugs, their side effects are extremely harsh. Some of these effects include difficulty eating, passing stool, and cardiac complications which could result in sudden death. Our research project focuses on the production of a library of drug candidates that are inexpensive yet innocuous to treat Chagas disease. Squaramide-based drug derivatives synthesized from 3,4-dihydroxycyclobut-3-ene-1,2-dione (squaric acid) have shown to have anti-parasitic properties against T. cruzi. Our target compounds are synthesized in three short synthethic steps. Squaric acid is first converted to the squaric ester diethyl squarate via condensation with ethanol. Diethyl squarate is subsequently converted to the targeted squaramides when reacted with a variety of amines. This class of compounds have demonstrated low toxicity in humans and high affinity for the T. cruzi parasite. Through a series of condensation reactions, potential drugs are being created from alkyl and aryl amines. The availability of these compounds will enhance the chances of discovering a novel and safer remedy for Chagas disease. Currently, significant progress has been made in the synthesis of a diverse drug library. Future research involves testing the potency of these drug candidates and synthesizing a new generation of drug derivatives.

The Synthesis of a Fluorophore for the In Vivo Diagnosis of Neglected Tropical Diseases

Student Authors: Emily Trinh, Colton Andrews
Faculty Mentor: Gregory Naumiec

Due to inadequate water sanitation and poor hygiene, NTDs are becoming a world-wide crisis affecting more than 1 billion people in developing countries. The symptoms of NTDs are asymptomatic or similar to other diseases which creates an issue in misdiagnosis. The current diagnostic techniques for NTDs are lab blood tests that are not widely accessible due to limited infrastructure, cost, difficulty in tracking patients, and lack of fieldwork. Therefore, there is a critical need for a quick, accurate, and cost-efficient method for diagnosing and monitoring the level of infections.

The goal of this research is to develop a cost-efficient and accurate method of diagnosing NTDs by fluorescent emissions. Near-infrared (NIR) spectroscopy is a non-destructive and qualitative imaging technique that works within the NIR region. When a fluorophore is tethered to a substrate capable of binding to NTD microscopic organisms, the interactions of the substrate with the disease can be observed on a molecular level. Based on these observations, current drug therapies could be improved to counteract the constant evolution of drug resistance in NTDs.

The Eu(III)-doped fluorophores display intense peaks in the NIR region when absorbing UV light (365 nm). This provides evidence for the photoluminescence properties of Eu(III) and its capability for biological fluorescent labeling. Since both compounds are based on commercially MRI contrast agents, the toxicity of the ligands is negligible. The second fluorophore designed is based on the naturally-occurring fluorophore chlorin, a compound found in chlorophyll, which is responsible for photosynthesis via absorption of light. Chlorin displays a strong fluorescent emission in the NIR region. Due to its permeability and low toxicity, both fluorophores are an ideal candidate to tether to substrates for the in vivo diagnosis and treatment monitoring of NTDs.

Synthesis of Espintanol-Based Natural Products
for the Treatment of Leishmaniasis

Student Author: Kayla Vinh
Faculty Mentor: Gregory Naumiec

Neglected tropical diseases (NTDs) are a group of parasitic and bacterial infections that affect developing nations near the equator. Many of these countries struggle to fight NTDs because they are hard to detect, easily communicable, and costly. One NTD of particular interest is leishmaniasis, which is caused by protozoan parasites carried by sandflies. Currently, more than twenty strains of leishmania species that cause disease in humans have been identified. 1.6 million new cases of leishmaniasis occur every year, and 350 million people are at risk for infection in Africa, Asia, and the Americas. Common treatments, such as pentavalent antimonial compounds, have harsh side effects and are not immune to resistance, thus the development of new drugs is crucial to fighting leishmaniasis where drug resistance is becoming a large concern. A class of cyclic, unsaturated hydrocarbon compounds, called terpenes, has shown strong anti-leishmanial capabilities across several strains. Our target molecule, espintanol, is a natural product found in the bark of the Bolivian spruce tree, Oxandra espintana, can be easily functionalized at 5 positions on the aromatic ring. Our research focuses on the optimization on the synthesis of terpenes as well as developing more analogs to determine their effectiveness on the parasite. We are currently one synthetic step away from the completing espintanol. All products have been purified by using column chromatography and fully characterized by 1H and 13C NMR spectroscopy. Once complete, espintanol will then be functionalized with different substituents to create a library of potential anti-parasitics targeting leishmaniasis. Our proposed development of novel treatments helps combat the problem of drug resistance among the strains of leishmaniasis.

Department
of
Computer Science

An Iterative Approach for Partition-Based Optimization Model for Generative Anatomy Modeling Language

Student Authors: Doga Demirel, Berk Cetinsaya
Faculty Mentors: Tansel Halic, Sinan Kockara, Dirk Reiners, Shahryar Ahmadi

Background: This work presents an approach that increases the iteration amount for Partition-based Optimization Model for Generative Anatomy Modeling Language (POM-GAML) to decrease the normalized error percentage for the constraint sets of 500 and 1000. We assume that the joint communities with more constraint density could be good candidates for model partition. We carried out Clauset Newman Moore, k-means, and Density-Based Spatial Clustering of Applications with Noise clustering/community detection algorithms before partitioning our constraints.

Results: For the fifth iteration for the constraint set 500, the normalized error varied from 0.024 to 0.019. For the fifth iteration for the constraint set 1000, the normalized error varied from 0.017 to 0.014. In the first iteration the average error difference between constraint set of 500 and 1000 was 0.014 while in the fifth iteration this number decreased to 0.006. For the constraint set of 500 the biggest decrease was for Density-Based Spatial Clustering of Applications with Noise (61.64%), while for the constraint set of 1000 the biggest decrease was for k-means5(59.5%). Overall, between iteration-1 to iteration-5 the average decrease in normalized error was 56.55% for the constraint set of 500 and 55.92% for the constraint set of 1000.

Conclusion: We have increased the iteration size for POM-GAML. Previously, iteration amount was kept at one to lower the computation time from exponential to linear. Our results showed that as the iteration size increased normalized error decreased. We have carried out POM-GAML with three different clustering/community detection algorithms (Clauset Newman Moore, k-means, and Density-Based Spatial Clustering of Applications with Noise). Overall, the average decrease in normalized error for POM-GAML using the cluster/community detection algorithms for constraint set 500 was 56.55% and for constraint set 1000 was 55.92%. This research is supported by the Arkansas INBRE program, with an award# P20 GM103429 from the National Institutes of Health/the National Institute of General Medical Sciences (NIGMS).

Fluid Flow for Virtual Arthroscopic Skill Trainer

Student Authors: Aditya Dendukuri, Mustafa Tunc
Faculty Mentors: Tansel Halic, Sinan Kockara, Shahryar Ahmadi, Sreekanth Venkata

Background: Arthroscopy is a minimally invasive surgical procedure for diagnosis and treatment of a joint. Arthroscopic Rotator Cuff (ARC) is a surgical treatment for group of muscles and tendons that connect the upper arm to the shoulder blade. Our objective is to build a virtual simulation platform aiming arthroscopic skills training for ARC in collaboration with UAMS. We use various modalities including highly realistic real-time visualization, interactive physics simulation and haptic (touch) devices (robotic devices that can deliver force feedback). The ultimate goal is to develop a high fidelity platform to train physicians with quantitative performance feedback. One critical aspect of the simulation is to model the arthroscopy irrigation solutions and heat flow for electrocautery procedures. Irrigation solutions are mainly used for safety and efficacy during the procedure. Electrocautery is used to clean and remove the tissue and prepare the footprint before the placement of anchors at the humeral head.

Results: A numerical approach is essential for modeling liquid and heat flow as the medium of fluid flow changes continuously as the simulation progresses. Therefore, we are utilized a numerical computational technique called Smoothed Particle Hydrodynamics (SPH) to model both heat transfer and liquid simulation. Our formulation virtual simulates complete liquid motion of the irrigation solution and the mechanism of conduction and convection of heat flow within the shoulder cavity in real time.

Conclusion: We present the preliminary results of our unified SPH approach to simulate electrocautery process and liquid flow in the context of ARC surgery. We achieved 45hz for 5000 particles for fluid and heat transfer simulation. We also computed the L2 norm error compared with its analytical solution. The error is noted within 0.397 and 0.428 with 1000 and 5000 particles respectively. This research is supported by the Arkansas INBRE program, with an award# P20 GM103429 from the National Institutes of Health/the National Institute of General Medical Sciences (NIGMS).

Predicting Wine Quality Using Sentiment Analysis

Student Author: Zeqing Dong
Faculty Mentor: Bernard Chen

Wine has been popular with the public for centuries. In the market, there are a variety of wines to choose from. However, few studies have applied sentiment analysis to wine reviews to benefit consumers. In this paper, we collect all wine reviews about the Bordeaux wines that are listed in the 1855 Bordeaux Wine Official Classification from WineSpector.com. We used one-hot encoding to convert words into vectors through Computation Wine Wheel. Naive Bayes classifier, multilayer perceptron classifier, and support vector machine classifier are applied to predict the qualities (90+/ 90-) of 1359 wines. 5 fold cross-validation is used to evaluate the predictive performance of our models, especially the performance of the training models for new data, which can reduce over-fitting to some extent. Accuracy, precision, and recall are our measures to describe the performance of our models since our dataset is imbalanced. So far, we achieved 87.08% on accuracy, 88.93% on precision, and 91.59% on recall with Naive Bayes classifier. 89.74% on accuracy, 90.80% on precision, and 93.74% on recall with MLP classifier. Also, with the benefit of using the Navie Bayes, which is a white-box classification algorithm, we are able to see the keywords from the reviews in the category of 90+ class. We can also look at the weights of each variable that MLP assigned to better explain our models. However, SVM is not explainable since it is a black-box classifier. More white-box classification algorithms should be applied in the wine field to benefit consumers as well as producers since it is explainable.

Validation Study Data Analysis for Minimally Invasive Surgery Simulators

Student Authors: Jake Farmer, Mustafa Tunc, Doga Demirel, Seth Baer
Faculty Mentors: Tansel Halic, Sinan Kockara, Shahryar Ahmadi, Kevin Sexton, Sreekanth Venkata, Seema Maruti Shedage, Daniel Ahmadi

Background: In minimally invasive surgery, there are several challenges for training novice surgeons, such as unintuitive hand-eye coordination, limited field-of-view, constraints instrument and endoscope movement. Typical methods for training include cadavers, mannequins, and apprenticeship, all of which are costly and limited in use. Virtual Reality (VR) surgical simulators are promising to offer a novel, risk-free, and cost-effective way to train surgeons. They allow for ease of setup, repeatability of tasks in a quick and efficient manner, and in some cases, automatic feedback that does not require expert intervention, thus saving time and money with qualitative and quantitative performance measurement. In this study, we analyzed preliminary study for two of our minimally invasive virtual simulators designated for the training and assessment for arthroscopic and laparoscopic procedures.

Results: We were discriminating performance between experts and novices based on data recorded for movement features, such as path length, average acceleration, and total time to complete the simulator tasks. These features were derived from the movement data of the Phantom Omni haptic devices, and then normalized using Z-Score, Min-Max, and Absolute Value normalization methods. Extracted features from surgeons' movements were later used for clustering and classification of surgeons' skill levels. The features used in the clustering algorithms were decided based on Welch's TTest, which assumes unequal variances among two groups (e.g. novice and expert), and the features with the lowest scoring p-values were selected to represent the two populations.

Conclusion: Using classification algorithms such as K-Nearest Neighbors, Support Vector Machines, and Logistic Regression we have achieved up to a 100% accuracy rate in identifying novices and up to an 83% accuracy rate identifying experts. Clustering algorithms such as K-Means and Mean Shift have also been applied over the dataset, with varying degrees of success, with up to 88% accuracy over both groups. This research is supported by the Arkansas INBRE program, with an award# P20 GM103429 from the National Institutes of Health/the National Institute of General Medical Sciences (NIGMS).

A Machine Learning Approach for Monitoring a Cyber-Physical Systems for Tactile Perception

Student Author: Avinash Garud

Faculty Mentors: Ahmad Patooghy, Olcay Kursun

Cyber-physical systems (CPSs) are becoming dominant technology in different aspects of our daily life. The applicatons of CPSs range from critical infrastructure such as a power grid and transportation system to health and biomedical environments. Most of CPSs meet the following criteria: processing large amounts of data; continuously offering real-time services; having operator-in-the-loop because of human judgment and an accountability requirement for safety critical systems. However, system reliability, i.e., the ability of performing intended function/service under a given set of environmental and operational conditions, is a fundamental requirement of CPSs. This study aims to improve system reliability of data collecting cyber-physical system using machine learning. In this study, we use machine learning algorithms for online testing of a typical cyber-physical system. The CPS tactile perception system to be monitored (online) is developed at Intelligent Embedded Systems laboratory in the Department of Computer Science at UCA. In this study, we first do a reliability investigation to find the set of relevant model of faults that may affect correct functionality of the mentioned cyber physical system. Previous researches in this field have shown that similar devices are highly susceptible to various models of electromechanical faults. Especially the sensor parts are too sensitive and show time-varying behavior. Then, we design and build an efficient machine learning based algorithm to monitor the behavior of the system using a camera capturing images in the course of operation of the system. We study the impacts of different faults on the captured images and train the machine learning algorithms to detect these faults as unexpected/faulty states and conditions of the system.

Classification Working Set Approach for Unsupervised Learning of Deep Learning Features

Student Author: Nicholas Scoles

Faculty Mentor: Olcay Kursun

Deep Learning (DL) has recently led to great success in artificial intelligence and attracted further attention due to the fact that the features extracted in the early cortical layers have properties similar to those of real neurons in the primary visual cortex. Understanding cortical mechanisms of sensory information processing is important for improving DL systems as well as for developing more realistic simulations of cortical systems. Using insights about how the cortex processes sensory stimuli (at least in its early areas), in the literature, it has been shown that an unsupervised learning approach based on transfer learning and contextual guidance can extract features that closely match the structural and functional properties of the primary visual cortex. These contextually-guided pluripotent features well represent textures and offer higher classification accuracy than deep learning methods such as AlexNet on the texture classification problem. Although this unsupervised DL feature-extraction approach yields better features using fewer object classes in the training set, for deep supervised networks more object classes are needed to learn these early features due to the problem known as gradient-vanishing. Our work shows that the number of classes available in the training set is an important factor that affect the quality of the learnt features for supervised deep networks. Finally, we propose a number of mechanisms that can improve deep learning using hybrids of unsupervised and supervised approaches.

Department of Geography

A Statistical and Geographical Analysis of Hispanic Voting Patterns in the 2016 Election.

Student Author: Hunter Crockett
Faculty Mentor: Stephen O'Connell

The 2016 election seemed to initially favor Democratic candidate Hillary Clinton. One of the potential explanations for why she would win was that she was thought to have a large majority of the Hispanic vote, and in 2012, Barack Obama won the Hispanic vote in key swing states. Clinton was able to secure the Hispanic vote but had a lower percentage of Hispanic votes than Barack Obama did in 2012. This study investigates the voting patterns of the 2016 election to determine if the Hispanic vote substantially affected Hillary Clinton's results. The three key swing states of Colorado, Nevada, and Florida were examined to determine the effect Hispanic voting had on overall outcomes. These states were chosen because all of them have sizeable Hispanic populations, and Hispanic voters, and in recent election cycles, tended to vote Democrat. The statistical analysis compares county-level percentage of Hispanic voting-age population to the percentage of 2016 Democratic votes cast using linear regression. Additionally, the Hispanic population was divided into four groups: Mexican, Cuban, Puerto Rican, and Other. This was done in order to determine whether Hispanic populations should be viewed as a homogenous voting group. The results of this analysis explain the Hispanic voting patterns in 2016 and examine whether Hispanic populations reflected a homogenous voting group in the election.

Fire History of an Unlogged Shortleaf Pine Forest in the Ouachita Mountains, Arkansas

Student Authors: Lillian McDaniel, Cathleen McNutt, Alexander Russell
Faculty Mentor: William Flatley

Shortleaf pine-bluestem ecosystems are a fire adapted vegetation community in the Ouachita Mountains that has declined drastically since fire suppression started in the 1930s. Managers recently began carrying out prescribed burning treatments with the goal of using fire to restore this important habitat. However, little is known about the historical fire regime in the Ouachita Mountains and managers lack site-specific information to guide prescribed burns. Our objective was to characterize the historical fire regime, specifically frequency and seasonality; and to understand how the fire regime changed through the following land use periods: pre-EuroAmerican settlement (pre-1830), post-EuroAmerican settlement (1830-1930), and fire protection (post-1930). We sampled in the Lake Winona Research Natural Area, an unlogged shortleaf pine forest in the eastern Ouachita Mountains of Arkansas. We collected, processed, and crossdated 41 fire-scarred cross sections in order to identify historical fire years. Our samples spanned the years 1561 to 2018 and fires were identified during both the pre- and post-EuroAmerican settlement periods. Fires were most frequent during the post-EuroAmerican settlement period. The majority of fires occurred during the dormant season indicating that they burned in the late fall, winter, or early spring and suggesting that ignitions may have been anthropogenic in origin. There have been no fires recorded at the site during the recent 90-year fire protection period. This project provides site-specific data to help guide the re-introduction of fire to the Ouachita Mountain landscape and help perpetuate shortleaf pine-bluestem ecosystems.

Department
of
Mathematics

A Tax System Based on the Scale Advantages of Wealth

Student Author: Stefano Battisto
Faculty Mentor: Fred Hickling

In the study of economics, the criteria of a effective tax plan are that it must be equitable, simple, and fund the government. Yet, any observation of the current U.S. tax code shows it is none of these. Famed economist Milton Friedman argued that a flat tax meets all three criteria, but most see a problem with the equity of such a tax (a 10% tax on someone making $15,000 year is a lot more of a burden than a 10% tax on someone making $100,000 a year). There is a scale advantage associated to increased wealth (doubling the amount to spend allows for the purchase of more than double the amount of a product). A generalization of a flat tax that takes into consideration this scale advantage can be built into the tax code. A tax code based on only taxing this scale advantage provides us with a blueprint for a simpler, more equitable tax code that can fully fund the government, and potential additional social programs, based on how constants are chosen in the tax equation described below.

NYCHVS in the Asa Data Challenge Expo:
An Attempt to Assess the Housing Quality and Price

Student Authors: Siata Coulibaly, Younouss Ouata
Faculty Mentor: Sharif Mahmood

Housing quality has improved dramatically since 1970 in New York; however, some sectors of the housing stock continue to face poor conditions and some specific maintenance deficiencies continue to show higher prevalence. The purposes of the study are to create a housing quality index for the New York City Housing and Vacancy Survey (NYCHVS) data that enables an overall view of the housing conditions faced by residents and how the prevalence of these issues has shifted over time, predict how the NYC rental market will look like in 8 years, and find what causes NYC two-third population to rent their houses in opposed to the overall US trend. Various statistical learning methods are implemented to assess the usefulness and accuracy of the results. To better judge the rental and purchase price of housing in New York City, a housing index is proposed that is sensitive to every single housing condition, higher rents in NYC market, and trend due to some geographical attributes.

Buffered Fourier Spectral Method

Student Author: Monica Davanzo
Faculty Mentor: Yinlin Dong

Standard Fourier spectral method is efficient for solving problems with periodic boundary conditions, but oscillations occur for problems with non-periodic boundary conditions. This can be corrected using a buffered Fourier spectral method. For non-periodic functions, a buffering polynomial will be added to the right end boundary, making it smooth and periodic on the boundaries, before applying FFT. Then the buffering zone can be removed to compute maximum error and order of accuracy. Using this method, the derivatives of non-periodic functions can be approximated and the solutions of select ordinary differential equations can be calculated and the error reduced from 10-5to 10-11.

Biplots for Visualizing Complex Data with Multidimensional Scaling (MDS) and Multivariate Regression Analysis

Student Author: Nathaniel Gregg
Faculty Mentor: Yeil Kwon

Analysts often rely on their eyes to spot problems with a model and to find exploitable patterns in data. When data are represented as points in high dimensional spaces, one can use what's known as a biplot to visualize a multivariate regression or display the data in fewer dimensions. Since introduced by Gabriel in the 1970s, biplots have been applied to various areas by interpreting data as a matrix and displaying a geometric interpretation of a matrix decomposition that results in a generalization of a scatter plot for multidimensional data. In this research, we explore two methods - regression biplots and multidimensional scaling biplots - and illustrate their potential for exploratory data analysis by applying them to letter recognition data and economic indicator data.

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Divergent Thinking or Problem Posing: Creativity at its Best

Student Author: Demitrius Moore
Faculty Mentor: James Fetterly

Historically, a long-standing connection exists between creativity and problem posing. One way to understand creativity is through divergent thinking. It has been noted in the past that one of the most efficient and effective ways to foster creativity is to be exposed to creativity. This study desires to understand if mathematical exposures and experiences with problem posing and/or divergent thinking affect mathematical creativity in the classroom. By using a sample population of Algebra students, this study seeks to answer which treatment will enhance mathematical creativity, if any. For this study, three treatment groups are considered. The first treatment exposes students to mathematical problem posing activities, the second treatment explores divergent thinking in mathematics, and the third combines both experiences of problem posing and divergent thinking. Over a six-week period, three problem-posing treatments will be administered every other week and, on alternate weeks, three divergent thinking treatment will administered, where the duration of each treatment is one 50-minute class. The collection of pre- and post-test data will test for significant differences in mathematical creativity, beliefs, and knowledge among the three groups to discover which treatment is effective.

Impact of Historical Mathematical Problems on Student Metaperspectives of Mathematics

Student Author: Scarlett Nestlehut
Faculty Mentor: Todd Abel

Jankvist (2009, 2011) distinguishes between mathematical in-issues and meta-issues. In contrast with in-issues, meta-issues are concerned with mathematics as a whole (Jankvist, 2009, 2011), including the nature of mathematics as a discipline and the social and cultural-situatedness of mathematical work (Bishop, 1988, 2002; D'Ambrosio, 1985). Student conceptions of these meta-issues are termed metaperspectives, and are important in shaping how they interact with and understand mathematics.
Work of the past few decades has established a number of potential benefits for integrating the history of mathematics into mathematics curriculum (Clark, 2012; Clark, Kjeldsen, Schorcht, Tzanakis, & Wang, 2016; Fauvel, 1991; Swetz, 1995). This project considers undergraduate metaperspectives as students engage with historical problems grounded in primary sources (Barnett, Lodeer, & Pengelley, 2014), investigating the research question: How do students' meta-perspectives change as they engage with historical mathematical problems?
Twelve undergraduate STEM majors enrolled in a history of mathematics course completed a series of journal entries reflecting on meta-issues in mathematics and their own experiences encountering historical mathematics. Initial journals included prompts such as "Describe a mathematician", and "Is mathematics invented or discovered?" As the semester progressed, prompts addressed reactions to class work more specifically. All journals were completed online. In addition, five students were interviewed two times each. One interview asked students to expound on passages from their journals, while a follow-up interview at the conclusion of the course prompted reflection on their views of the meta-issues described above. Themes within these journal entries emerged using open coding (Charmaz, 2014).
Results indicate that students initially viewed mathematics as "discovered" - existing independently of any human knowledge of it. Furthermore, an archetypal mathematician was described as an "old, white Greek man". Initial meta-perspectives indicated widespread exposure to a modified Eurocentric perspective on mathematics history (Joseph, 2011), with some awareness of historical mathematical work in Asia. As the semester progressed, students began to describe mathematics as arising from practical needs within a culture and recognize differences in mathematical communication. The proposed poster highlights themes in student metaperspective shifts, particularly new cultural awareness and appreciation of the way mathematics is embedded in cultures that produce it. The results indicate that historical problems prompted students to reflect on mathematical meta-issues and develop new metaperspectives while not entirely dismissing their existing ones.

Assessing Sensitivity and Robustness Index of Propensity Score Estimation for Causal Inference

Student Author: Abdel-Aziz Soumahoro

Faculty Mentor: Sharif Mahmood

In observational studies, propensity score that is defined as the probability of receiving the treatments given covariates, are unknown and need to be estimated from propensity score model with observed covariates. The behaviors of sensitivity and robustness of propensity score estimation to the impact of unobserved covariates have not been fully understood. In this study, we propose a new technique to assess the sensitivity and robustness of propensity score in estimating the impact of unobserved covariates on an individual level outcome. The sensitivity is defined as the difference between the propensity score that is estimated from propensity model using all observed covariates to a potential propensity score that would be estimated from propensity model using both observed and unobserved covariates. The robustness is defined as a range of probability of sensitivity compared to a pre-defined threshold that is estimated through kernel density techniques. Finally, implementation of this method is demonstrated with the National Survey on Drug Use and Health (NSDUH) data, 2015.

Department of Physics & Astronomy

The Future Of Weather Balloons

Student Authors: Elma Abdullah, Madison Hardcastle
Faculty Mentor: Debra Burris

Twice a day, every day of the year, weather balloons are released simultaneously from almost 900 locations worldwide.[1] A weather balloon is a radiosonde used to collect meteorological measurements attached to a latex or neoprene balloon by a string. The balloons provide data for meteorologists to use in various ways from forecasting to research. However, of the 75,000 weather balloons, only 20% of radiosondes launched are returned to the National Weather Service.[1] The rest of the balloons litter the environment. The purpose of this research is to determine ways to improve the eco-friendliness of the weather balloon.

[1]US Department of Commerce & NOAA. (2015, September 23). Weather Balloons. Retrieved from https://www.weather.gov/bmx/kidscorner_weatherballoons.

A Real Time Automated Microclimate Ecosystem

Student Author: Kayce Conville
Faculty Mentor: William Slaton

The goal of the project is to create an automated microclimate which recreates any given ecosystem in real time. The ecosystem is controlled with a Rasberry Pi and the program is written in Python. The user is able to give the program a given weather station ID associated with Weather Underground, which the program then pulls the HTML code from the website providing the program with the real time weather information for that particular station. The program than processes the data and pulls the information wanted, like current temperature, solar radiation, hourly precipitation, and daily precipitation. The focus of the project as of now is mimicing solar radiation. The environment will be equipped with a semiconductor photodiode sensor which will give off a voltage proportional to the amount of energy given off by the light source. To create the scale of voltage versus light, data is collected with the photodiode sensor in the vicinity of a weather station which reports solar radiation. The data from the weather station and the data from the sensor can then be analyzed to create this scale. With this information, the program will then be able to take in the live data from the weather station and adjust a light source to give off the correct amount of energy, matching the real time conditions. By creating a real time automated microclimate ecosystem, it can allow the user to recreate an environment and observe the subject that is being studied in its natural habitat from anywhere in the world.

Development of Wildfires and Debunking Their Myths

Student Authors: Monica Davanzo, Luke Ogle
Faculty Mentor: Debra Burris

Weather can potentially play a prominent role in the start and spread of fires. Dry weather, droughts, and higher temperatures are prerequisites for wildfires. Higher winds provide oxygen to the fires which act as fuel. Lightning strikes can ignite foliage, or strong winds can uproot power lines which can ignite vegetation and surrounding buildings. Recent wildfires in the California area have bred some unusual conspiracy theories such as the government testing directed energy weapons (DEWs) on civilians despite scientific evidence that proves otherwise. Weather patterns and scientific inquiry will be used to explain the potential ignition and intensity of wildfires. The Oklahoma Mesonet will also be utilized to provide an example of how daily fire hazard conditions can be used to predict where wildfires are most likely to occur. Mesonet is network of environmental monitoring stations that are designed to measure the environment at the size and duration of mesoscale weather events. The Oklahoma Mesonet consists of 121 automated stations capable of collecting large volumes of useful data for this research.

Pointing Isn't Rude: A Proof-Of-Concept HAB Payload Stabilizer

Student Author: R. D. Jeffery
Faculty Mentor: William Slaton

High-Altitude Balloons (HABs) are excellent platforms for research projects in physics, meteorology, engineering, and other related fields because of their low cost in comparison with other platforms that offer similar capabilities. One of the major drawbacks of HAB platforms, however, is their instability; lack of any fixed attachment point makes it practically impossible to use directional instruments in any controlled manner. While several HAB payload stabilization methods have already been developed, they all have limitations that leave something to be desired. For example, gyroscopes necessarily take up a large portion of the payload mass, leaving little room for instruments within the legal weight limits; servo motors promise low-cost, high-precision control, but it is difficult to design adequate control algorithms to compensate for the lack of stable attachment points; passive systems can be very cheap and relatively effective, but still lack precise attitude control capabilities. A method that does not appear to have been tried, however, is the use of cold-gas thrusters. This thesis details the design and construction of a proof-of-concept, cold-gas thruster, stabilization device and thoughts about the potential value of further development.

Storm Analysis Using Lightning Mapping Array

Student Author: Austin Jones
Faculty Mentor: Debra Burris

The Lightning Mapping Array (LMA) is used to create three-dimensional models of lightning in order to better understand the structure of storms. This projects looks at the data taken from a storm over Northern Texas on December 26, 2018. Of particular interest is specifying a lightning strike to a meteorological tower outside Lubbock, TX. Using the xmla program it is possible to analyze data gathered at the storm and look at lightning strikes around the area of the tower to determine which strike formed in such a way that it might have connected to the tower. Furthermore, finding the lightning strike requires analyzing the charge distribution of the storm to find generally how strikes caused by the storm behave.

Economic Impact of Mesonet on Agricultural Production

Student Authors: Hayes McNeely, Samantha Mask
Faculty Mentor: Debra Burris

In the rapidly evolving world of agriculture, every year there are new technological advances that help to maximize profits and minimize losses. In particular the advancement of weather forecasting in the mid twentieth century to present day has allowed the modern farmer to be able to better plan for the next growing season. The Mesonet, a network of 121 weather stations, was developed by the University of Oklahoma and Oklahoma State Univeristy. It primarily measures temperature, rainfall, windspeed, solar radiation, pressure, and relative humidity every five minutes. Additionally it measures soil moisture every thirty minutes and soil temperature every fifteen minutes. This data is publically available through a web based platform. The subject of this research is to determine in what ways the Mesonet benefits farmers economically. The research was collected through a variety of interviews with farmers and ag extension agencies across the state. Research shows the implementation of Mesonet data dramtically increases farmers economic savings and helps minimize potential losses/expenditures.

Petit Jean Cave Art and its Astronomical Significance

Student Author: Luke Ogle

Faculty Mentor: Debra Burris

Cave paintings have a very important part in Native American culture. Many of their religious leaders looked to the skies for guidance. There was one cave painting at Petit Jean that proved to be particularly interesting. The painting appears to a comet like object traveling through the sky with some objects in the background. My hypothesis is that the Object traveling through the sky in the painting is Halley's Comet, which would match up with previous records from the Chinese Astronomers. The other surrounding objects we believe to be the stars of Orion, Taurus, and Gemini. We believe this to be of some great cultural significance to the Mississippian people. But it may be possible that what they were observing was a rare phenomenon that very little people have witnessed called a supernova. We will explore all the possibilities and how Astronomy played a central role among the Mississippian people.

An Investigation of Thermoelectric Element Power Generation and Heat Pumping Ability

Student Author: Isaac Raphael

Faculty Mentor: William Slaton

The purpose of this research project was two fold: to first quantify the cooling ability of three different CPU cooling units and then to characterize the power generation and heat pumping ability of a Peltier device in the context of a model CPU and CPU cooling unit. A Peltier device is a thermoelectric device that can work in two ways. Firstly, it can act as a power supply when the two sides of the device are at different temperatures. Secondly, the device can work as a heating/cooling device where one side of the device gets cold and the other side gets hot when an input voltage is applied to the leads. Along with that, the goal of the research project was to automate the data collection processes. This was accomplished with prototyped circuits on a breadboard that were controlled by a Raspberry Pi 3. Python was the language used for the automation programs. Python's Matplotlib plotting library as well as Matlab were used for data analysis. Studying the cooling ability of the CPU cooling units resulted in Temperature vs. Time plots that showed how the well the cooling units could stabilize temperature when an aluminum block (model CPU) was heated over a range of power levels. Then, using the ability to develop staple temperature differences between the metal block and cooling unit and placing a Peltier device in between the two allowed I-V curves of the Peltier device to be be produced. Applying varying input voltages to the device while having the device in between the cooling unit and metal block lead to a new set of Temperature vs. Time plots that were then compared to the heat pumping ability of the conventional cooling units.

Protostellar Outflows in L1448

Student Author: Jordan Rhoades
Faculty Mentor: Dr. John Tobin

Protostars are formed from molecular clouds and are at the forefront of star formation. Outflows within the L1448 region in the Perseus molecular cloud were observed using the Sub-Millimeter Telescope. We used the data from the protostars' spectra to determine the mass, momentum, and energy of the protostars systems. This allows us to see the effects on the molecular cloud and the protostar systems at a larger scale

Development of an Acoustic Field Scanner

Student Author: Nick Scoles
Faculty Mentor: Carl Frederickson

A system has been designed to scan a microphone over a 30x30 cm plane to image an acoustic wavefield. The system uses two PI stepper motors to provide motion in both x and y directions. A quarter inch microphone is mounted on the stepper motor setup to scan an acoustic wavefield. The servomotors and data acquisition/analysis are controlled using python. This system is used to visualize acoustic wavefields projected from a defined acoustic source.

The Optimal Locations for Sweet Corn and Soybeans to be Grown in Oklahoma Based on Historic Rainfall Patterns

Student Authors: Erica Smith, Marissa Watson
Faculty Mentor: Debra Burris

Different types of crops require different amounts of soil moisture for optimal growth. Because sweet corn is a shallow-rooted plant, it is water thirsty. On the other hand, soybeans typically do not need large rainfall amounts because they are deep-rooted. There is enough moisture stored in the soil to achieve high yields of the soybean crop. Based on these facts, we propose that sweet corn should be planted in areas that have historically received high amounts of rainfall, and soybeans should be planted in areas with lower amounts of rainfall in Oklahoma. The purpose of this project is to answer the question, "What are the optimal locations for two types of crops, sweet corn and soybeans, commonly grown in Oklahoma based on rainfall?" and also to analyze how well Oklahoma farmers are currently utilizing weather patterns to grow their crops. We will execute this research by using data from the Oklahoma Mesonet. The Oklahoma Mesonet is a network developed by The University of Oklahoma designed to measure the environment at the size and duration of mesoscale weather events.

Feasibility Study of Spherical Phased Array Radar

Student Authors: Jordan Sturdivant, Andy Crafford
Faculty Mentor: Debra Burris

Phased array radar is a system of antennas that can be electronically controlled to point a plane wave at a specific location. This allows for the radar to scan an area much more quickly than a traditional radar. These systems are often configured with the elements in a flat plane, limiting the field of view of the array. This study aims to judge the feasibility of configuring the elements in a spherical orientation to increase the field of view of the array. This would increase the usability of phased array radar in meteorological applications.

Relative Strength of Rat Bones

Student Author: Daniel Toomer
Faculty Mentor: Rahul Mehta

For this research project, I was supplied with 4 different groups of rat leg bones. A control group, a group that was Hind Leg Suspended (HLS), a group the was irratdiated (IR), and a group of both HLS and IR. I was tasked with cleaning these bones, cutting them, and then bending them using a homemade cantilever bending set up in order to determine the effects on the relative strengths these different techniques had on the bones. The HLS is used to signify the affects of a zero gravity environment, while the IR is used to signify the affects of space radiation. These are applied to the rats in order to learn more about the affects that spacelike conditions have on the relative leg bone strength.

Once the bones were cleaned, they were cut at the knee joint to analyze both the affects on the femur and the tibia independently. A small square mirror was then glued to one side of the bone in order to reflect a laser in the bending mechanism. The bending mechanism had a clamp where the bone would be placed and secured. Then a string would be tied around the bone and run through a series of two pulleys with mass at the end of the string. This caused a force on the bone in order to bend it. A laser was shot at the mirror so that it would reflect on the back wall where measurements would be taken as extra mass was added on increasing the force on the bone. This data allowed for the determination of the relative bone strength, or the (stress/strain). The stress is calculated by the (force/area) and the strain is calculated by the (bend/length).

Native American Astronomy

Student Author: Garrett Tyndall
Faculty Mentor: Debra Burris

When bringing up the topic of early astronomy people like Copernicus and Galileo are the first to be brought up. However, humans have been observing the movements of the stars and other celestial bodies thousands of years before their time. Astronomy also seems to be a topic that until colonization was confined to the old world, but this is not true. Civilizations in the new world also studied the heavens and tracked their movements. It seems that where ever humans have lived they have always looked up at the stars. The subject of this research was studying a site near Conway, Arkansas that was possibly constructed by Native American's. This site has interesting features that line up with certain astronomical events. It is unclear who exactly made the site and work was done to try and narrow down likely candidates. The reason for looking at something like this is to give us some understanding of what peoples before us were like and how they thought. It can in some ways give us a better understanding of ourselves now and for the future.

Use of Drones in Weather

Student Authors: Sonja Wagner, Matthew Kalkbrenner
Faculty Mentor: Debra Burris

Drones have the possibility of being used to collect meteorological data and more accurate forecasts. Drones will be able to collect data in locations that have in the past been too hard to collect data in or in areas that are not easily accessible. Drones also allow for more risk to be taken during severe weather by allowing people to send the drones directly into the storm. The data that can be collected from this would allow for a better understanding of these storms and help make predictions on future storms more accurate. In addition to taking data in risky environments, the Oklahoma Mesonet is working on adding drones to their weather stations to help build a 3D model of their mesonet system. With this new influx of data we can have questions answered that we have long had unanswered.

Weather's Effect on Sporting Events

Student Authors: Chris Walker, Raleigh Wood
Faculty Mentor: Debra Burris

Weather has affected our lives, in numerous ways. Outdoor sporting events is such a way in which weather can effect our lives. In order to protect our athletes, the NCAA and other professoinal associations have taken measures so that the players, the coaches and everyone envoled remains safe. The most dangerous threat to athletes who participate in summer sports are categorized as External Heat Related Illnesses (EHRI). This term characterizes any condition that effects an athlete during conditions of high temperature and or humidity. Of these inclode, heat stroke, muscle cramps, heat exhaustion, heat rash, etc. In recent years the NCAA, and the NFL has restricted the amount of practice hours during the summer months to avoid any serious injury or any fatalities. The NFL and NCAA are also passing rules that prevent athletes from practicing if the temperature and or humdity is too high. Another threat that weather has on sporting events is thunderstorms. Since thunderstorms mostly occur during the fall, and spring seasons this effects every outdoor sports. According to the Natonal Oceanic Atmospheric Associatioin (NOAA) 62 percent of all lighting related fatalities occur during sporting events. Because of this there are regulations that state if lighting strikes within a 10 mile radius of a locaction, then the event is postponed for thirty minutes. Weather can effect, the athletes, coaches and everyone present during a sporting event. So in order to make sure that everyone remains safe, we should continue researching so that we can understand weather patterns.

Investigating Relationship Between Stress Applied to Leg Bones of Rat and its Mechanical Strength

Student Author: Yelaman Zhenis
Faculty Mentor: Rahul Mehta

The purpose of this research is to investigate elasticity of the rat bone utilizing cantilever beam bending setup. The bone is fixed at one end and a string attached at the other end with a pulley allowing for applying a stress using a hanging weight. A mirror glued to the free end allows measurement of bending of the bone as force is applied along the major axis of the cross section of the bone. The position change of a Laser beam incident on the mirror as stress is applied is recorded . To consider the elliptical shape of the bone's cross section the bending procedure is repeated after the bone is rotated by 90 degrees and stress is applied along the minor axis of the cross section. The amount of bending as a function of applied weight is used to ascertain the relationship between stress and strain and determine the elastic modulus of the bone.

Interdisciplinary Research

Phytoremediation in *Helianthus annuus*: Seedling Establishment Inhibition and Translocation of Cadmium in a Simulated Bioswale System

Student Author: Ashley R. Barto
Faculty Mentors: Robert Mauldin, KC Larson

Bioswales are a type of green infrastructure many cities are utilizing to mitigate the environmental impact of urbanization. Specifically, bioswales are a means to mitigate urban pollutants from washing into waterways, and they are designed to use phytoremediation to sequester those pollutants. While research shows bioswales effectively sequester heavy metals associated with urban impervious surfaces like parking lots, there is also evidence that removing heavy metals from aquatic ecosystems recycles those contaminants into terrestrial ecosystems via herbivory and nectary production. However, the impact of cadmium, a prevalent contaminant in urban stormwater, on the seedling establishment and growth of *Helianthus annuus*, a known hyperaccumulator, is unclear. This research assessed the vegetative health of seedlings in an assay of cadmium-spiked environments, and it employed graphite furnace atomic absorption spectroscopy to identify the cadmium content in shoots and roots of sunflowers in a simulated bioswale system. Seedlings dosed with cadmium established and grew leaves at the same rate as those not exposed to cadmium, but plant weight was reduced in cadmium environments. After six weeks, plants exposed to 550 ppm cadmium accumulated about 300 mg Cd/kg dry plant, and most cadmium remained in the roots of the plants.

Investigating Antimicrobial Activity of Honey Using NMR Fingerprinting

Student Authors: John Dodson, Ridge Bryant, Alex Rieth
Faculty Mentors: Richard Tarkka, Samantha Hewett, Kari Naylor

Honey is well known to have antimicrobial properties. In particular, Manuka honey is approved by the FDA as a wound dressing. Experiments by our collaborators demonstrate that other varieties of honey, including Arkansas wildflower honey, are also effective at preventing growth of antibiotic-resistant microbes: some minimum inhibitory concentrations (MIC values) were found to be comparable to those of Manuka. In an effort to try to correlate the chemical properties of honey samples to their antimicrobial properties, the honey samples were analyzed for ^{1}H NMR fingerprint, osmolarity, pH, and color. Antimicrobial properties correlated poorly with pH, color, and osmolarity. Statistical analysis by principal component analysis (PCA) of NMR data suggests significant correlation between a honey's chemical composition and its floral source. More advanced statistical analysis techniques are currently being employed to establish the correlation between antimicrobial properties of honey samples and their chemical properties.

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