College of Natural Sciences And Mathematics

UNIVERSITY OF CENTRAL ARKANSAS™

28th Annual Student Research Poster Symposium

April 22, 2022
1:00 – 3:00 PM
Prince Center

Welcome from the Dean

College of Natural Sciences And Mathematics

Welcome to the 28th 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 57 posters involving 84 students, mentored by 31 different faculty members. We encourage you to drop by the Prince 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 Science and Mathematics

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Department of Biology

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Ensemble perception of semantic information extracted from perceptually defined sets

Student Author(s): Emily Andrews, Caroline Dacus, Kassandra Lee
Faculty Mentor(s): Amrita Puri

Research has shown that we can not only attend visually to specific details about individual items, but also rapidly analyze groups of items simultaneously. Ensemble perception has been observed for basic features like size, and for more complex stimuli, such as facial emotions. Ensemble coding may occur at a semantic level; in our recent studies participants accurately reported whether the average value of sets of digits was less-than or greater-than 5 without an increase in reaction times, suggesting they processed digit arrays as ensembles. We asked whether ensemble representations based on semantic information are generated automatically or require attention to specific items by testing whether the average value of digit subsets can be extracted without attention to a specific subset. Volunteers completed a set of tasks identifying the average value of either a subset of digits (distinguished by color) or of an entire 5- or 10-digit display. For the subset condition, participants were prompted by a pre- or post-cue to indicate whether the average was less-than or greater-than five for the digit subset of a specific color.
Accuracy for the 5- and 10-item conditions was higher compared to the pre-/post-cue tasks. However, there was no difference between either the 5- or 10-item, or the pre- and post-cue conditions. This similar accuracy across the pre- and post-cued conditions suggests that we can generate ensemble representations based on semantic information and that these representations are extracted automatically. Additional experiments will examine eye movement patterns associated with the pre- and post-cued conditions.

BPA and C. elegans reproduction

Student Author(s): Matthew Baltz
Faculty Mentor(s): Dr. Mindy Farris

BPA is a ubiquitous secondary plastic that can easily leech into the environment and impact invertebrates. However, its complete impact on reproduction is not yet known. *C. elegans* is a model organism that would be among the first organisms adversely impacted by BPA exposure via the wild type (N2) strain. Therefore, the goal of this research was to determine whether BPA impacted *C. elegans* reproduction via the number of offspring in the wild type and the oxidative stress-sensitive mutant *skn-1* (Skn-1, a homolog to Nrf-2 in mammals). Agar plates were prepared and spotted with either OP50 *E. coli* or OP50 *E. coli* + BPA a day after they were poured. N2 worms and *skn-1* worms were transferred daily, and the offspring were counted. There was no significant difference the number of offspring between the treatments (1,420 worms with BPA and 1,323 with OP50 alone). There were fewer offspring in the N2 BPA compared to the OP50, and there were more *skn-1* offspring on the BPA plates compared to OP50 (970 vs. 1,545 for N2 and 1,423 vs. 1,234 for *skn-1*) The results indicate that BPA has little effect on C. elegans egg-lay phenotypes. The experiment should be expanded to epigenetic experiments to examine effects of BPA exposure during development on subsequent generations. Overall, the study highlights one important way that BPA can impact wildlife, and by extension, humans.

Comparing Public and Private High School Biology Teachers' Acceptance and Teaching of Evolutionary Theory in Arkansas

Student Author: Britteny Berumen
Faculty Mentor: Mark Bland

Evolution is a central and unifying concept in the sciences, especially biology. The significance and status of evolutionary science should be reflected in science classrooms, yet evolution instruction in high schools have been shown to be unsatisfactory. Multiple factors likely have contributed to the current state of evolutionary education, such as teachers' understanding, views, and acceptance of evolutionary theory. Research studies to assess the status of evolution education in public high schools have been conducted; however, private schools are understudied. We sought to assess public and private Arkansas high school biology teachers' acceptance of evolutionary theory and their levels of acceptance of 4 other widely accepted scientific theories. We also assessed the state of evolution education in public and private high schools overall, as well as how evolution is treated with respect to other biology topics. Arkansas high school biology teachers were invited to complete a survey designed to assess their acceptance and teaching of evolution. Results suggest that biology teachers in public and private high schools have a lower acceptance rate of evolutionary theory compared with the other four scientific theories, and that private high school biology teachers have a lower rate of acceptance of evolutionary theory than public high school teachers. In addition, varying degrees of teachers' emphasis across evolutionary theory concepts in their classrooms were noted.

Assessing Evolution Education In Public Schools In The State Of Arkansas: Is The Light On?

Student Author: Misty Boatman
Faculty Mentor: Mark Bland

Evolution provides evidence and context for all other biological concepts and thus is a threshold concept of the biological sciences. Evolution is also a core theme in the Next Generation Science Standards and the "Arkansas K-12 Science Standards: Biology Integrated", adopted by the Arkansas Department of Education in 2016. Although public school teachers are required to teach state standards, evolution is often excluded from the classroom. Despite major court cases that have ruled in favor of teaching evolution and not creationism in public school classrooms, many teachers continue to include creationism, in addition to or at the expense of evolution. Surprisingly, many teachers who include creationism are unaware of the unconstitutionality of doing so. We sought to ascertain the current views of Arkansas public high school teachers regarding evolution and the current state of evolution education in Arkansas.

Teachers were invited to complete a survey instrument comprised of items from the Measure of Acceptance of the Theory of Evolution, plus questions designed to assess their evolution teaching practices. First year-college students enrolled at the University of Central Arkansas were asked to complete a survey designed to assess their perspectives regarding evolution instruction in their high school courses and their understanding of basic evolution concepts. Teachers were found to have high rates of acceptance, but creationism is still prevalent in Arkansas public high school biology classrooms. Students were found to have both low knowledge and low rates of acceptance, and student acceptance was strongly correlated with student knowledge of evolution.

Does Diet of *Luxilus pilsbryi* Vary in Response to Stream Drying?

Student Authors: Rebeka Bradford, Sahara Morgan, Jessica Rath, Chance Garrett
Faculty Mentors: Ginny Adams and Reid Adams

Intermittent streams, characterized by cessation of flow over lengthy periods of time, play an essential role in maintaining biotic diversity and integrity of perennial streams. Adaptations of fishes to these conditions include increased diet breadth and, in one study, changes in gut length when food quality and quantity decreased. *Luxilus pilsbryi*, found in both intermittent and main channel perennial streams, feeds primarily on macroinvertebrates and some vegetation.
Individuals were collected across all seasons from Rockhouse Creek, an intermittent tributary of the Kings River. We found that gut length (adjusted for standard length) varied significantly across seasons, with the longest guts in spring (ANCOVA, $p<0.01$). To explore the possible cause, gut contents were examined and identified to the lowest possible taxon, enumerated, and massed. Fish collected in spring consumed more total food (by mass) relative to all other seasons. Winter and spring stomachs contained mostly aquatic invertebrates; summer and fall stomachs largely contained amorphous material- plant/detritus. The shift to a plant/detritus diet did not correspond with increased gut length, suggesting that *L. pilsbryi* cannot compensate during low/poor food periods through morphological adjustments of gut length and may reflect their facultative association with intermittent headwater streams.

ANNUAL AND SEASONAL NUTRIENT DYNAMICS IN A CENTRAL ARKANSAS DRINKING WATER RESERVOIR

Student Author: Lydia Bradshaw
Faculty Mentor: Dr. Halvor Halvorson

In reservoirs, rising temperatures coupled with nutrient loading via rainfall and urban/agricultural runoff are supporting factors in the growth of phytoplankton. These organisms create secondary metabolites (taste and odor compounds), and some can produce cyanotoxins harmful to the health of humans and animals. Beginning in November 2019 and still ongoing, we conducted weekly to biweekly monitoring of physico-chemistry, nutrient concentrations, and phytoplankton at three depths at the municipal intake of a drinking water reservoir, Brewer Lake, in central Arkansas. Brewer Lake increasingly experiences elevated levels of the taste and odor compounds Geosmin and 2-Methylisoborneol; this may be due to changes in lake nutrient dynamics seasonally or annually. We found that across years, ammonium and nitrate levels remained low throughout Summer, likely due to high algal uptake. Phosphate and ammonium levels peaked during Fall as algal activity declined and the lake mixed. Ammonium declined and nitrate levels increased throughout mid-Winter into early Spring, likely due to nitrification by bacteria. With continued analysis and data collection, these seasonal nutrient dynamics are helpful to understand the lake trophic state and will inform lake management actions and drinking water treatment for this reservoir.

Investigating the transcriptomic responses in rice roots during interactions with plant growth-promoting bacteria, *Burkholderia unamae*

Student Author(s): John Cook, John Pope, Jayden Carter*
Faculty Mentor(s): Dr. Arijit Mukherjee

*Student presenter

Major crops such as rice and maize benefit from associations with different plant growth-promoting bacteria (PGPB). Studies have shown that these PGPB (e.g., *Azospirillum*, *Herbaspirillum*, *Burkholderia*) promote plant growth primarily via nitrogen fixation and phytohormone secretion. However, our current understanding of the underlying molecular mechanisms involved in these associations is limited. For instance, very little is known about the associations between plants and the symbiotic *Burkholderia* species, *B. unamae*, at a molecular level. Earlier, we set up an experimental system where PGPB such as *Azospirillum brasilense* could colonize rice roots and promote plant growth. In this study, we used the same experimental system and showed that *B. unamae* could promote growth and colonize the roots of rice plants. Next, using RNA sequencing, we identified the transcriptomic responses in rice roots, one day post-inoculation. We identified 1128 differentially expressed genes in rice roots and validated the expression pattern of few genes. We identified genes involved in the flavonoid biosynthesis pathway, defense, hormone signaling, and photosynthesis to be differentially expressed. We also identified several genes encoding for transcription factors, protein kinases, and transporters in our dataset. Comparison of our dataset to existing RNA-seq datasets in rice roots during interactions with other plant-beneficial *Burkholderia* species indicated downregulation of defense genes. We also identified 398 differentially expressed genes in rice roots during interactions with *B. unamae* and *A. brasilense*. Some of these genes are likely to play important roles during these interactions. Overall, our study has identified several promising targets for future genetic studies.

Examining the Physiological Stress Response of the Prairie Lizard, *Sceloporus consobrinus*, following Extirpation of a Keystone Predator, *Crotaphytus collaris*

Student Author(s): Michael Deutsch
Faculty Mentor(s): Matthew Gifford

Keystone predators, defined by their pivotal role in food webs, exert top-down control via predation and competition, which promotes biodiversity by regulating population abundances at lower trophic levels. Under the risk of predation, prey organisms must trade off opportunities for foraging, mating, and growth, with other physiological requirements for more immediate energetic mobilization. Consequently, these physiological and behavioral trade-offs further alter community dynamics and nutrient cycling, through modified energy allocation and fitness. In the Ozark Highlands of Arkansas and Missouri, regionally-imperiled glade habitat is home to state-threatened keystone predator, the Eastern Collared Lizard, *Crotaphytus collaris*. Habitat degradation has led to local extinctions which enables comparative studies of keystone predator-prey interactions between glades with and without *C. collaris*. While keystone predator studies often focus on resulting diversity and abundances of prey in response to presence/absence of keystone species, here I investigate the physiological stress responses and life history trade-offs of collared lizard prey, *Sceloporus consobrinus*. Specifically, I assess metabolic, morphological, and reproductive metrics, through corticosterone, glucose, and lactate concentrations between *S. consobrinus* populations which are sympatric and allopatric to *C. collaris*. Results indicate *S. consobrinus* sympatric to *C. collaris* are significantly larger than allopatric populations. While circulating glucose and lactate concentrations did not differ in relation to predator presence, corticosterone was significantly higher in gravid females sympatric to *C. collaris* relative to non-gravid females, and gravid females from allopatric populations. These findings provide a physiological context to keystone species extirpation. Future work will address maternal effects on offspring phenotypes.

Exploring the Effects of Fertilization and Defoliation on Carbohydrate Remobilization in Northern Red Oak (*Quercus velutina*) and River Birch (*Betula nigra*) Saplings

Student Author(s): Joseph Dunlap, Emiley Sorge
Faculty Mentor(s): Erin Wiley

Nonstructural carbohydrates (NSC) play an important role as storage molecules in trees, providing a source of carbon when photosynthesis is limited. Because climate change may increase the frequency of defoliation events that demand a reliance on NSC remobilization, a better understanding of this process is needed to predict how trees will respond. Currently, we do not know if NSC remobilization is controlled by sink demands for growth or whether NSC storage is maintained at the expense of growth. It is also unclear if remobilization occurs equally between different NSC pools in different organs. In this study, we investigated how fertilization impacted leaf reflush and NSC remobilization in the roots and stems of one year old Northern Red Oak (*Quercus velutina*) and River Birch (*Betula nigra*) saplings following complete defoliation. After defoliation, trees were differentially fertilized and harvested 3.5 weeks later after leaf reflush. Starch and sugar concentrations of roots and stems were then measured. Defoliation decreased starch levels across all groups observed compared to initial levels. Interestingly, sugar levels in Oak roots increased post defoliation. Differential fertilization had no significant impact on starch or sugar concentrations. A preference for starch remobilization in Oak stems rather than roots was observed, with 87% versus 50% remobilized, respectively. The greater NSC remobilization from stem versus root reserves may be the result of their greater proximity to the growing leaves. The lack of fertilization effect suggests that remobilization is not simply limited by a low C sink demand due to N limitation.

Land use effects on water quality in the rapidly urbanizing White Oak Bayou watershed, Arkansas

Student Author(s): Brandy N. Everett
Faculty Mentor(s): Matthew H. Connolly, Halvor M. Halvorson

Maumelle, Arkansas, a growing suburban area in central Arkansas, has experienced rapid conversion of land from forest to urban within the White Oak Bayou watershed. As human activities change terrestrial land uses and convert forested watersheds into urban or agricultural landscapes, there is usually an increase in the loading of key pollutants into nearby freshwater systems. Pollution loading potentially has an adverse impact on water quality. Between March 2021 and February of 2022, we collected water from 10 streams draining various land uses and flowing directly into White Oak Bayou. Each sample was evaluated for physico-chemical attributes, concentrations of heavy metals, total nitrogen and phosphorus, and total suspended solids. In-situ parameters measured from these sample locations include dissolved oxygen, specific conductivity, turbidity, and pH. We compared the water quality data to percent catchment coverage by urban, agriculture, and forested land use across all 10 sites, using Pearson correlation tests to detect relationships between water constituents and land use. The Pearson's correlation coefficient test found that specific conductivity was positively correlated with the percent of urban land across catchments ($p=0.0119$). These results will help the city of Maumelle plan for future growth, further water quality research in the White Oak Bayou and to support development of a watershed management plan.

Investigating the Role of FszA in Mitochondrial Dynamics of *Dictyostelium discoideum*

Student Author(s): Madeline Frazier & Dayoung Eom
Faculty Mentor(s): Dr. Kari Naylor

Abstract: *Dictyostelium discoideum* is a well-established mitochondrial model system for both disease and dynamics, yet we still do not understand the actual mechanisms of mitochondrial dynamics in this system. The FtsZ proteins, including FszA, found in *D. discoideum* are hypothesized to operate similarly to dynamin-related GTPases in humans, the driving force behind dynamics. The loss of these dynamics ultimately causes the mitochondria to malfunction, which can cause or contribute to neurodegenerative diseases such as Parkinson's disease and Alzheimer's disease. Understanding the role FtsZ plays in *D. discoideum* mitochondrial dynamics will allow us to gain insight into the evolutionary shift from FtsZs to DRPs. To better understand the role of these proteins in mitochondrial dynamics we will determine the effect of overexpressing FszA-GFP and knocking-down FszA to determine whether the protein inhibits mitochondrial dynamics in *D. discoideum* by quantifying fission, fusion and motility rates. Currently, we have transformed *D. discoideum* via electroporation with vectors that encode the reverse complement of FszA to knock down expression of FszA or FszA-GFP to overexpress FszA. Additionally, we have conducted a semi-quantitative reverse transcriptase PCR to observe mRNA changes. Upon establishing our strains are expressing FszA correctly, we will quantify dynamics to identify the effects under expression of FszA has on these cellular processes.

Evidence of Coevolution in the Phylogenies of Chlamydiae Bacteria and Their Social Amoebae Hosts

Student Author(s): Hailee Gerner
Faculty Mentor(s): Dr. Tamara Haselkorn

Symbiosis is a range of interactions between two organisms that can span from pathogenic to mutualistic depending on many factors including the length of time of the interaction and symbiont transmission patterns. Mutualistic bacterial symbionts are often vertically transmitted and coevolve with hosts whereas more pathogenic bacteria are more often horizontally transmitted. Certain bacteria in the phylum Chlamydiae have been found to be symbionts in *D. discoideum* and other species of amoebae. While Chlamydiae bacteria are mostly considered pathogens, the role of Chlamydiae in amoebae is currently unknown, and mutualistic interactions have been observed in some species. The *D. discoideum* Chlamydiae endosymbionts are novel bacterial lineages, and while they do not seem to have any fitness costs in the lab, their function in natural populations is unknown. Recently, Chlamydiae bacteria have also been found to be highly prevalent in natural populations of other species of social amoeba. I hypothesized that if Chlamydiae bacteria have a mutualistic relationship with social amoebae then there will be evidence of coevolution in the phylogenies of the Chlamydiae bacteria and the social amoebae. I sequenced full length 16SrRNA genes for Chlamydiae bacteria in five different social amoebae species to reconstruct a robust phylogeny and look for evidence of coevolution. The results suggest that there is host specificity as the Chlamydiae phylogeny generally lines up with the amoebae phylogeny; there is evidence that Chlamydiae has evolved uniquely for each amoeba species and may have a mutualistic relationship. Future studies are needed to determine their specific effects.

The Effect of Season and Microhabitat on Soil-Dwelling, Social Amoeba

Student Author(s): Kira Gibbs
Faculty Mentor(s): Tamara S. Haselkorn

Abstract - Terrestrial, soil dwelling protozoans, particularly amoebae, play a key role in primary production and contribute to decomposition, mineralization, and have a significant role in nutrient cycling transferring nutrients to higher order consumers in the soil food web. While some amoebae have been observed and studied in laboratory conditions, soil amoebae are still largely understudied, particularly in their natural habitat. Sampling microbial eukaryotes is challenging given their microscopic nature. Furthermore, only a small proportion of microbes can be seen at any point in time due to optimal conditions varying throughout a year that impact activity. We are using newly developed molecular methods to PCR-amplify social amoeba DNA directly from soil samples. We have sampled 10 sites from within Woolly Hollow State Park in Arkansas during the four seasons, culturing and counting the amoebae that grow in the lab from each sample. We have also PCR amplified and cloned the social amoebae 18S rRNA genes, identifying amoeba species using NCBI Blast. We are currently comparing these molecular identification methods to traditional morphological methods and assessing how amoeba diversity varies by season and microhabitat. There is a significant effect of microhabitat on social amoeba diversity by traditional assessment. There is a higher diversity found at the log and tree microhabitats than leaf litter microhabitats. There was no significant effect of season on social amoeba diversity by traditional assessment. This study will shed light on the variability of this important group of soil-dwelling microorganisms and the ecological factors that affect them.

The Effects of Hydrilla Presence on Macroinvertebrate Communities in Lake Maumelle, Arkansas.

Student Author(s): Tyler Grandjean
Faculty Mentor(s): Halvor Halvorson

The invasive exotic submerged aquatic vegetation *Hydrilla* poses risks for aquatic environments by homogenizing macrophyte communities, disrupting nutrient cycles (phosphorus, chlorophyll-a) and degrading water quality (higher pH, lower dissolved oxygen). Prior research further suggests *Hydrilla* can alter the food web starting with macroinvertebrate communities. We used visual surveys, rakes and a transducer to map the presence or absence of *Hydrilla* in Lake Maumelle, Arkansas during Summer and Fall 2021. Recently reported in 2017, *Hydrilla* has now established in all but 6 coves of the lake. A collection of sediment using a dredge was taken in three *Hydrilla* established coves and three non-*Hydrilla* water-willow coves. Sieves were used to filter debris and organisms were stored in nalgene bottles with ethanol for preservation. Taxon identification down to Order and counts of each individual were obtained for all six sites. Statistical analysis showed a major shift in macroinvertebrate communities present in homogenous *Hydrilla* habitat vs. heterogeneous native water-willow sites. Lumbriculida was negatively impacted in *Hydrilla* presence with a 2.92% mean abundance compared to the 25.63% mean abundance in native water willow (p-value 0.016). Trichoptera responded positively with an increase from 1.98 % to 14.71% mean abundance (p-value 0.045). Odonata responded positively to *Hydrilla* presence as well from a 1.98% mean abundance in native habitat to 8.89% mean abundance (p-value 0.048). This shift in communities of macroinvertebrates alters the food web of available prey and predators up the trophic food web.

The MAP kinase effectors, TaoK1, TaoK2, and TaoK3, are differentially expressed during early embryogenesis in *Xenopus laevis* and may play critical roles in gastrulation

Student Author(s): Kamryn Humphrey, Alexis Vann, and Amy Tran
Faculty Mentor(s): Michael Yoder

Embryonic development requires an intricate symphony of coordinated changes in cell signaling and cell adhesion in order to properly execute the morphogenetic program. Errors in these critical pathways can lead to a number of birth defects, such as neural tube closure defects and limb abnormalities. The lab has previously investigated the role of a protocadherin 1 (pcdh1) in early embryonic development and identified Thousand and One Amino Acids Kinase 3 (Taok3) as a potential functional partner in development. The MAPK pathway employs a cascade of proteins, starting with MAP kinase kinase kinases (Map3K), leading to phosphorylation of MAP kinases, such as p38 and JNK, and subsequent activation of downstream targets. TAOKs are a family of Map3ks, with three paralogs: TaoK1, TaoK2, and TaoK3. Using *Xenopus laevis* as a model organism, our goal is to characterize the spatiotemporal expression of the TAO kinases and determine how Taok3 functions during development, through a combination of qPCR, *in situ hybridization*, embryology, and Western blotting. Our data show that the TAO kinases all exhibit a similar, yet slightly different, spatiotemporal pattern of expression, with TaoK3 more strongly expressed through the blastula and early gastrula stages than the others. Perturbation of TaoK3 expression results in abnormal blastopore closure. These results indicate that TaoK3 is an essential signaling effector for the proper development in *X. laevis.* Since TaoK3 could act upstream of either p38 and JNK signaling, we are currently investigating the specific mechanisms of function to determine its place within these complex signaling pathways.

The Impact of Heat Waves and Defoliation on the Stomatal Density of Pin Oak (*Quercus palustris*)

Student Author(s): Kai Johns, Benjamin O'Connell
Faculty Mentor(s): Erin Wiley

Stomata are pores on the epidermis of leaves and other organs that regulate CO_2 uptake and H_2O loss. Stomatal density can be affected by the environmental conditions during leaf development, and this can influence the rate of gas exchange between the plant and the environment. In two experiments, we tested how defoliation and leaf size affect stomatal density in green ash (*Fraxinus pennsylvanica*), and how defoliation and temperature affect stomatal density of pin oak (*Quercus palustris*). In the first experiment, we defoliated field-grown green ash trees and allowed them to regrow their leaves for 5 weeks. Stomatal density of the new leaflets was compared with that of leaflets from undefoliated trees. However, because reflush leaves develop under warmer temperatures, stomatal density differences could be driven by temperature instead of defoliation. To disentangle these effects, potted pin oak saplings were subjected to four treatments: heatwave and defoliation, heatwave and no defoliation, ambient temperatures and defoliation, ambient temperatures and no defoliation. Stomatal density of new leaves produced in each treatment was compared. Defoliation significantly increased stomatal density in green ash trees, which may increase the rate of photosynthesis, allowing trees to make up for lost carbohydrates used in the regrowth of the leaves. While defoliation often reduces the size of leaves, we found that leaf size was not significantly related to stomatal density in ash. For oak, we found that defoliation decreased stomatal density, but only at ambient temperatures, and bigger leaves had slightly higher stomatal density.

Relationships Between Phycocyanin, Dissolved Oxygen, and Lake Stratification in Brewer Lake, a Monomictic Southern Reservoir

Student Author(s): Celeste Johnson
Faculty Mentor(s): Halvor M. Halvorson, Ph.D

Brewer Lake, Arkansas, is a reservoir that serves as the primary drinking water source for Conway and its surrounding county. Routine monitoring holds importance to better understand organism's relationships with drinking water quality in this reservoir. Cyanobacteria are known to contribute to issues such as taste/odor and cyanotoxins in water supplies, and can be tracked using phycocyanin, a pigment unique to cyanobacteria. Beginning May 2019 through October 2021, two sites at the drinking water intake (surface and 4.5m depths) were sampled bi-weekly for temperature, dissolved oxygen (D.O.) levels, and phycocyanin RFUs (relative fluorescence units) using a YSI brand Multiparameter Sonde equipped with an EXO Total Algae Smart sensor for measuring pigment RFUs, and an EXO Optical D.O. sensor for measuring the levels of D.O. From these data, we observed a positive correlation between phycocyanin and D.O. at the deepest site. D.O. levels also fluctuated over time with stratification of the lake's water column. Understanding how organisms such as cyanobacteria relate to different seasonal and annual environmental change such as stratification and D.O. levels can help predict algal bloom events and improve drinking water treatment.

The Role of Vitamin D Supplementation in *Caenorhabditis elegans* Stress Resistance for Aging and Lifespan

Autumn Kennedy & Julian Stobaugh
Dr. Mindy Farris

Natural aging can lead to the onset of age-related diseases like obesity, diabetes, and cancer as well as Alzheimer, Parkinson, and Huntington diseases. These features of aging place significant stress on aging populations and no medical or scientific treatments are currently available. Studies link vitamin D to aging pathways, making it a promising approach to developing neurodegenerative disease treatments. Given that Vitamin D deficiency is strongly linked to neurodegeneration and cognitive decline as individuals age, there is a need for research to be done so that more understanding might be gained on how to treat and/or cure said effects.

Investigating vitamin D supplementation incorporated an analysis of its effects on the *C. elegans* wildtype (N2), Alzheimer mutant (*gnals*), and introduced homolog of vertebrate vitamin D receptors (*nhr-8*) nematode strains. Concerning the relationship between Vitamin D, neurodegeneration, and stress, it is expected that those strains of *C. elegans* which are treated with Vitamin D will have more stress resistance and longer life spans compared to the control groups. Those strains which are not treated with Vitamin D will likewise not have the biochemical and/or physiological responses necessary to withstand severe stressors, and thus will not have more stress resistance and longer life spans compared to the experimental groups.

According to our data, vitamin D supplementation produced minimal stress resistance in only the *nhr-8* strain 1-day-old worms. Our future research will focus mainly on the stress resistance of older adult (7-day-old) worms.

The Effects of DJ-1 Protein Mutants on Mitochondrial Dynamics in Dictyostelium discoideum

Hyoju Kim
Kari Naylor

Mitochondrial dysfunction plays a role in the progression of Parkinson's Disease (PD), thus understanding mitochondrial dysfunction is one of the important keys to finding PD treatment. The study of the relationship between the cytoskeleton and fission and fusion in our model, Dictyostelium discoideum suggests that insufficient fission can cause a tangle of interconnected mitochondria and insufficient fusion can cause mitochondrial aggregates that lead to a decrease in mitochondrial motility and potentially damaged organelles. To continue to understand the relationship between mitochondrial dynamics and PD, we are determining the rates of
fission, fusion, and motility when overexpressing and under-expressing DJ-1 in D. discoideum. DJ-1 is a protein linked to PD and mitochondria, yet its function is poorly understood. Our results will help clarify its function and the relationship between DJ-1, dynamics, and mitochondrial dysfunction. We have analyzed 7 DJ-1 mutants to identify fission and fusion events and calculate the average number of events/min/cell in 30 cells. Our preliminary data suggest that overexpression of DJ-1 has little effect on the rates of fission and fusion compared to wild-type cells (AX2), while knockdown of DJ-1 increases fission. These results suggest that DJ-1 is an inhibitor of fission. There appears to be no effect on fusion. Our future work includes an analysis of mitochondrial motility and the cytoskeletal structure in these cells which plays a role in mitochondrial dynamics. Ultimately, this work will contribute to a better understanding of the DJ-1function and pathogenesis of PD.

Influence of Land Use on Fish Assemblage Patterns Across the South Central Plains of Arkansas: A Preliminary Analysis

Student Authors: Ryne Lehman & Molly Wozniak
Faculty Mentors: Hal Halvorson, Ginny Adams, and Reid Adams

Land use changes are known to alter physical in-stream habitat, water quality, and community structure within aquatic ecosystems. Streams located across the South Central Plains Ecoregion of Arkansas are no exception. Sites were classified into three different types of land-use categories: agriculture, urban, and forest. These land-use classifications are based off landcover percentages calculated within the upstream catchment area of each site using USGS Stream Stats. Understanding the relationship between land-use and patterns of fish assemblage structure can provide insight into how fishes respond to potential disturbances. Eighteen out of thirty sites were sampled during summer 2021 with relative abundance data calculated for fishes at each site. Non-metric multidimensional scaling (NMDS) was used to examine how sites were distributed based on species relative abundances. A two-axis solution was generated with a final stress value of 10.4. We used Multi Response Permutation Procedure (MRPP) to test group differences between land use based on species relative abundance across sites. Fish community structure varied across sites, but no differences were detected among agriculture, urban, and forest. However, a trend between urban and forest land-use was observed. *Ameiurus melas, Gambusia affinis,* and *Micropterus salmoides* were associated with urbanized streams, whereas *Erimyzon claviformis*, *Etheostoma parvipinne,* and *Lepomis miniatus* were associated with forested and agricultural streams. These preliminary analyses suggest streams sampled at this point in time in the South Central Plains Ecoregion have overall similar fish assemblages across major land-use designations, but patterns were evident due to other variables (e.g., hydrology) that will be discussed.

The physiological response of sweetgum (*Liquidambar styraciflua*) to fire restoration management efforts in Central Arkansas

Sam Little
Dr. Erin Wiley

Fire has historically been an integral part of southeastern temperate forests, but fire suppression over the past 200 years has led to plant community shifts and woody encroachment. In response, land managers use prescribed fire to promote fire-tolerant species and forest conditions. However, it is unclear how to best apply prescribed fire to control encroaching woody species and whether the seasonal timing (growing versus dormant season) of the burn matters. One challenge of restoration work is that a lot of woody plants resprout and we don't know if the seasonal timing affects their resprouting vigor. In this study, we are monitoring sweetgum tree resprouting and carbohydrate storage for a year in two sites with similar conditions but different disturbances - site 1 was burned in August 2021 and site 2 was burned in March 2022. Additionally, we are collecting temperature data and fuel moisture levels from prescribed fires across central Arkansas to better understand fire behavior throughout the year in Arkansas. Preliminary data suggests that maximum fire temperature declines as fuel moisture increases but that fuel quantity doesn't affect maximum fire temperature. We also report initial differences in root starch concentrations between sites. Restoration practitioners need information on sweetgum's response to fire so management can be more effective in supporting native community structure across Arkansas and the southeastern US.

A nutritional intervention to attenuate upper respiratory tract infections in collegiate distance runners

Student Author(s): Emily Newberry
Faculty Mentor(s): Candice Thomas, PhD.

The purpose of this in vivo study was to determine if the consumption of berries can reduce upper respiratory tract infection (URTI) incidence in collegiate distance runners. We hypothesized that URTI incidence would be reduced in the study population after long term consumption of berries, as quantified by increased levels of salivary Immunoglobulin A (SIgA) and decreased salivary cortisol. 14 trained collegiate distance runners completed a weekly survey detailing their running mileage, illness symptoms, and dietary intake throughout their competitive seasons, and provided saliva samples. Athletes consumed their normal diet during the control phases and added 2 cups of berries to their daily diet in the intervention phase. SIgA and cortisol levels were determined using ELISA. SIgA levels decreased from control to intervention phase. Salivary cortisol levels displayed a net increase between control and intervention phases. Although insignificant, these data suggest that the berry intervention did not attenuate URTI. Higher weekly running mileage was positively correlated With illness symptoms and interference with activities of daily living (ADLs) in both control and intervention phases, but to a greater extent in the control phase. Taken together, our data suggest the presence of a confounding variable that reduced the effect of the berry intervention. Future research will look at total energy balance and its effect on immune health.

The interactive effects of heatwaves and defoliation on tree performance

Benjamin O'Connell
Erin Wiley

Abstract - In recent decades, mass forest die-off events around the planet have been observed, often resulting from the interaction of multiple stressors. As many of these stressors—including biotic attacks and heatwaves—are expected to increase in frequency with climate change, a better understanding of how these stressors limit growth and survival is needed in order to predict forest responses. Severe defoliation is a common stressor that requires trees to regrow a new canopy to recover, but it is unclear what limits canopy regrowth, including the impacts of co-occurring stressors. In this experiment, we examined how defoliation may impact trees in a warmer world, by comparing experimentally defoliated (DEF) and undefoliated (UNDEF) pin oak (*Quercus palustris*) seedling responses to simulated ambient (AMB) and +10°C heatwave (HW) late spring conditions for 25 days. Impacts were assessed in terms of biomass and leaf area, gas exchange rates, leaf N concentration, and carbohydrate storage.

Initially, respiration rates were significantly higher across HW treatments, but were near fully acclimated after three weeks; photosynthesis remained higher under the HW throughout the experiment. HW trees also had increased leaf [N], possibly accounting for the enhanced photosynthetic rates; there was no difference in leaf area recovery between temperature treatments. Among DEF trees, percent leaf area recovery and leaf [N] were not related, suggesting N does not limit leaf regrowth. Overall, our results suggest that tree recovery from spring defoliation will not be negatively impacted by rising temperatures, suggesting more resilience from our forests in the future.

Slower eye movements to incongruent targets may underlie the size congruity effect in digit perception.

Student Author(s): Nickolas Paternoster, Emily Andrews, Julia Williams, Taylor Dague
Faculty Mentor(s): Amrita Puri and Ken Sobel

The size congruity effect occurs in tasks in which digits are either congruent or incongruent regarding semantic (numerical size) and perceptual (physical size) information. For example, participants are slower to identify a physically large digit as numerically small (incongruent) compared to when it is physically small (congruent), and vice versa. Although this phenomenon is well established, the stage of processing at which this conflict, or interaction, occurs is still unclear. We recorded eye movements as participants searched for either numerically large or small digits (regardless of physical size) and reported their location within a display (left or right). We hypothesized that if the interaction occurs at an early stage, the time until the first fixation (TFF) would be longer for incongruent compared to congruent targets due to interference experienced immediately upon viewing the display, prior to attending to the target. Alternatively, if conflict occurs later, at a decision stage, we predicted similar TFF across conditions, but longer duration and/or number of fixations on incongruent targets. We found that TFF was longer for incongruent targets, suggesting early interaction. Furthermore, these differences between the TFF for incongruent compared to congruent targets were positively correlated with differences in response times between conditions. To test whether attention was captured by incongruent distractors, we examined eye movements to distractors. However, TFF on distractors was no faster for incongruent compared to congruent trials, suggesting otherwise. Instead, an increased number and duration of fixations to incongruent distractors may explain the delay in TFF to incongruent targets.

Variation in Fish Communities of Boston Mountain Streams in the Ozark National Forest

Student Author(s): Jackson Pav
Faculty Mentor(s): Ginny Adams, Reid Adams

The Boston Mountains of the Ozark-St. Francis National Forest have a rich history of conservation spanning hundreds of years. This Pennsylvanian Period Mountain range yields high amounts of sandstone and shale, resulting in aquatic ecosystems unique to the state of Arkansas. Thirty-five sites across Big and Little Piney creeks, Illinois Bayou, Mulberry River and Lee Creek watersheds were analyzed using nonmetric multidimensional scaling to examine fish community level differences among sites using relative abundance data. Fish community composition was significantly different across watersheds (multi-response permutation procedure, $p<0.001$). An indicator species analysis identified ten species of fish as significant ($p<0.05$) indicators of specific watersheds including *Etheostoma pulchellum 1* in the Big and Little Piney creeks, *Micropterus dolomieu* in the Illinois Bayou, *Pimephales notatus* in the Mulberry River, and *Fundulus catenatus* in Lee Creek. Stream catchment size was one of the strongest drivers in determining relative abundance of each species per site. Additional variation is likely related to abiotic factors such as differing substrate and water physicochemical properties. This study will provide useful insight into the community structure and habitat associations of fishes in streams of the Boston Mountains.

Survey of Bee Communities in Differently Managed Sites in Central Arkansas

Student Author(s): Jackson Renfroe
Faculty Mentor(s): Ben Cash

With increased concern over pollinator decline, it is important to understand the effect of management on pollinator communities. Bees have been consistently shown to be the most effective animal pollinators. Our study was conducted to expand the knowledge base on species presence of bees in Central Arkansas, as well as evaluate the potential benefits the habitat restoration of Northern Bobwhite quail (*Colinus virginianus)* could have on species diversity. Additionally, sampling across multiple seasons offered a more complete picture of the communities present in our differently managed sites. Bees were collected across 3 research sites for 3 sampling seasons (Spring, Summer, Fall) from March to November 2021. Sample sites were a pasture maintained through mowing and cattle grazing, a prairie managed for Northern Bobwhite quail with prescribed burning and replanting of native plants, and a rocky outcrop site managed by prescribed burning. Bees were captured through pan trapping for 24 hour periods plus 1 hour of hand netting per site per day. Across all study sites 832 bees representing 93 species were collected: pasture (348 individuals from 52 species), prairie (313 individuals from 57 species), rocky outcrop (171 individuals from 47 species). Using Shannon's diversity index we found no significant difference in diversity across and between sites (SDI Prairie=1.53±0.20SE, SDI Pasture=1.48±0.17SE, SDI Outcrop=1.51±0.14SE; $p=0.97$). When comparing community similarity using Sorenson-Dice index, the rocky outcrop and pasture sites had the highest correlation (DSC = 0.57) followed by the prairie and pasture (DSC=0.55) and the rocky outcrop and prairie (DSC=0.50). These results suggest that differences in management of land have a demonstrable effect on the makeup of bee communities present.

The Associative Learning Capability of *C. elegans*

Student Author(s): Katlyn Reynolds and McKenzie Cheek
Faculty Mentor(s): Dr. Mindy Farris

Memory has always been an aspect of the human brain that mankind has investigated. We investigated how short-term and long-term memory are impacted by vitamin D (VD3) and Alzheimer disease (AD). We also examined the impact of age on different types of memory. Using the nematode *Caenorhabditis elegans*, we were able to study processes homologous to those in a human brain. We paired the neutral odorant butanone, which is a conditioned stimulus, with food. This results in an enhanced attraction to butanone that can be quantified using a chemotaxis assay. We used butanone to train the worms to have an association with food and butanone after the they are starved. After they were trained, they were then either immediately assessed for short-term memory through a chemotaxis assay or left to sit until a certain time had passed before assessing for long-term memory. Once either was done they were compared to the chemotaxis assay done to worms before they were trained (naïve). The assays done suggested that whether the worms had short-term training or long-term training, they maintained their association with butanone and food and traveled towards the butanone more than to a control odorant (ethanol). Our work has so far focused on young (1-day-old) adult worms. Thus at least at early ages, worms with mutations in *C. elegans* VD3 receptor (*nhr-8*) and worms expressing Alzheimer-associated proteins (*gnals2*) can make odorant associations and remember them. Future directions include measuring the effects on middle-aged (7-day-old) and older (13-day-old) adults.

Comparison of Field Acclimatization and Lab Acclimation Approaches to Measuring Fish Thermal Tolerance

Cade Richesin and Canyon Vickers
Matthew Gifford, Ginny Adams, and Reid Adams

Increased temperature may negatively impact fish in freshwater systems, particularly fish in urban streams. Measures of thermal tolerance, such as critical thermal maximum (CTMax), are often used to measure and indicate species' vulnerabilities to increased environmental temperatures. Historically, CTMax was commonly measured for fish acclimated to lab conditions over time. More investigation into protocols used to measure CTMax are needed to determine methods that best reflect fish CTMax measures in the field since laboratory acclimation protocols might introduce confounding factors or other sources of variation. We measured CTMax of 150 Highland Stoneroller (*C. spadiceum*) and 150 Blackspotted Topminnow (*F. olivaceus*) individuals collected from an urban stream, Tucker Creek. Groups of fish were tested for CTMax using a field acclimatized approach on the same day of capture and after being held overnight. Groups of fish were also tested for CTMax following acclimation to ambient and constant temperatures after 10 and 20 days in the laboratory. Individuals of both species tested on Day 0 and Day 1 did not exhibit significant differences in CTMax. After ten days acclimation, both species exhibited differences in CTMax that were dependent on acclimation regime.

Macroinvertebrate Colonization of a Newly Constructed Stream Channel Restoration

Student Authors: Misty Boatman, Michael Deutsch, Chance Garrett, Tori Hebert, Sam Little, Joseph Miller, Daniel Morrill, Alec Reep, Jackson Renfroe, Dylan Romine, Lauren Smith, Danielle Talbot
Faculty Mentor: Reid Adams

Freshwater biodiversity is declining globally at a faster rate than terrestrial and marine systems combined via a multitude of anthropogenic stressors, including habitat fragmentation. Extensive efforts have been implemented to re-establish longitudinal connectivity in streams negatively impacted by barriers, yet there is a general lack of biomonitoring following restorations. In January of 2020, the Nature Conservancy in Arkansas constructed a new stream channel, using Natural Channel Design, to bypass a low-water crossing barrier on a tributary to the Kings River in northwest Arkansas. Our objective was to study initial colonization of the new stream channel by aquatic macroinvertebrates, a critical component in evaluating stream restoration. We sampled across a variety of habitats within the new channel and in a reach just upstream of the restoration 46 days following establishment of connectivity. We identified specimens primarily to the family level and assigned functional feeding groups. Assemblages in the new channel were a subset of macroinvertebrates upstream, and were lower in taxa richness, diversity, and abundances of sensitive taxa. The new channel was dominated by collector/gatherer taxa, such as Perlodidae (early instar) and Chironomidae. Initial colonization of the new stream channel was relatively rapid, since colonizers who were abundant upstream dispersed to the new channel via drifting and fed on basal resources. By comparing macroinvertebrate assemblages following restoration, our study highlights the importance of monitoring to adequately assess impacts on biodiversity.

Magnetic water effect on tomato plant physio-anatomical features when exposed to the combined stress of drought and heat

Student Author(s): Erica Sac
Faculty Mentor(s): Dr. Candice M Thomas

The present study investigates the combined effects of drought and heat stress on tomato plants exposed to magnetic water (MW) and tap water (TW) in relation to the physio-anatomical changes in leaf area, height, relative water content (RWC), and chlorophyll contents. Magnetic water treatments will be conducted using seeds irrigated with tap water under drought conditions, seeds irrigated with magnetized water under drought conditions, seeds irrigated with tap water under drought and heat-stressed conditions, and seeds irrigated with magnetized water under drought and heat stress conditions. Drought stress will be analyzed using water-deficient at 100%, 60%, and 40% field capacity (FC). 100% FC as the control, 60% FC as moderate stress, and 40% FC as severe stress. Previous research has shown that plants treated with MW at 60% and 40% FC have the most positive outcomes relative to overcoming drought-stressed conditions. Magnetic water has been shown to give plants an advantage over drought stress but how magnetic water affects plants when both stressors are applied is unknown. It is well known that at high temperatures magnets lose their magnetism, therefore; our hypothesis is that magnetic waters' protective abilities will assist plant growth in drought-stressed conditions but temperature increase (heat stress) will negate the positive outcomes of the magnetic water.

The Relationship between Cortisol and incidence of Upper Respiratory Tract Infections (URTIs) in College Athletes participating in High Intensity Exercise regimens

Mercy Sebastian
Dr. Candice Thomas

The purpose of this study is to determine whether naturally occurring flavonoids in berries are associated with a decrease in URTIs in college football players by altering the body's ability to manage stress. Salivary cortisol levels will be used as a marker of the body's stress response and will be determined using a cortisol enzyme-linked immunoassay kit. Twenty UCA football players have volunteered to be a part of our study during their spring season which consists of 4 weeks of very high intensity training. The players have been split into two groups; control and intervention. All participants have been asked to fill out a brief survey about their overall health and stress levels and provide a saliva sample at three time points throughout the study period. The baseline collection point is obtained during a period of rest when no formal training is scheduled. The high stress collection point is two weeks into the high intensity training period. After the completion of the high stress phase, the intervention group was provided with frozen blueberries and asked to consume two cups per day for a period of two weeks. Our final data collection point was taken at the conclusion of the intervention period. Though this study is ongoing, preliminary data from the survey collected after the high-stress collection point reveals that 72% of all participants had symptoms that are synonymous with URTIs compared to the 28% that did not experience URTI symptoms indicating a potential relationship between high stress and URTI symptoms.

Effects of Fertilization on Defoliation Recovery in River Birch and Northern Red Oak

Student Author(s): Emiley Sorge
Faculty Mentor(s): Dr. Erin Wiley

Defoliation is a common stressor that can decrease tree growth, inhibit forest carbon uptake, and even cause tree mortality. However, it is currently unclear how defoliation limits tree growth and canopy recovery. While defoliation may cause a carbon limitation to growth as the trees decline in photosynthetic capacity, nitrogen may also become limiting following defoliation due to the loss of foliar nitrogen. This ambiguity around nutrient limitations after defoliation—and how they may change over time—makes it difficult to predict function and growth of defoliated trees in a changing climate. To address this knowledge gap, we compared the short-term (3.5 weeks) and long-term (4 months) responses of two species with contrasting growth patterns—Betula nigra (River Birch) and Quercus rubra (Northern Red Oak)—to differential fertilization after a full defoliation event. Diameter, height, and leaf growth were measured at short-term and long-term harvests. Leaf photosynthetic rates were also measured as they may indicate a difference in foliar nitrogen concentration. In the short-term, leaf mass recovery of defoliated trees was not increased by fertilization in either species, indicating that leaf growth was not limited by nitrogen. Birch diameter growth was significantly higher in the controls versus the defoliated trees. In the long-term, defoliation reduced oak diameter growth compared to fertilized controls, and birch diameter growth was significantly higher in the control fertilized trees than in control and defoliated trees. We discuss how long-term canopy recovery differed from the short-term, and what this indicates about the cause of growth limitation after defoliation.

Effect of Wind Speed on Caterpillar Behavior

Student Author(s): Blayne Terrazas
Faculty Mentor(s): Dr. David Dussourd

Predators and parasitoids rely on visual, vibrational, and olfactory cues to locate caterpillar prey. Wind masks all three cues by moving and vibrating leaves and by dispersing plant volatiles that attract caterpillar enemies. This project tests if caterpillars can detect wind and if they increase their activity under windy conditions when it is presumably safer to feed. We plan to build a wind tunnel to test caterpillars at various wind speeds in a controlled environment. We will measure how quickly caterpillars initiate movement after being disturbed. Faster movement at higher wind speeds would document that the caterpillars can detect wind directly or vibrations created by wind. If wind increases caterpillar activity and decreases predation and parasitism, then caterpillar populations may increase rapidly under windy conditions, resulting in population outbreaks. Prediction of these outbreaks is crucial for protecting agriculture and forestry.

Investigating Mechanisms of Cell Death in C3H-10T1/2 Cells upon Intracellular Acidification

Student Author(s): Yasmine Toudji
Faculty Mentor(s): Dr. Runge

The inversion of pH gradient- high pH_i & low pH_e- in solid tumor cells is an early event in cancer development. It is known to promote cell survival, proliferation, directed cell migration, metabolic reprogramming, resistance, and protection against hypoxia and reactive oxygen species. pH_i dynamics are crucial in apoptosis, though it is unknown whether they play a role in caspase independent cell death (CICD).
The goal of this project is to find a pH_i threshold at which apoptosis is optimal upon intracellular acidification in cultured C3H-10T1/2 cells, and to assess whether intracellular acidification induces CICD in the absence of caspases.
To assess if our designed protocols work and if our planned flow cytometer protocols were functional, we conducted preliminary experiments including one control group (untreated cells) and induced apoptosis in a second group of cells through serum withdrawal (SW). We stained both following a modified EtBr staining protocol and then measured apoptosis levels in both groups using flow cytometry. We hypothesized that the SW group would have high rates of apoptosis compared to the control.
Our results showed that the SW group had higher rate of apoptosis compared to the control, although the number of dead cells in the control was unexpectedly high. The cell count was unexpectedly low for all groups. Even though we were able to measure apoptotic vs. non-apoptotic cells, we attribute the unusually low cell count to clumping and as a result, we will further refine our protocol before conducting the intracellular pH and CICD experiments.

The Effects of Time of Year and Microhabitat on the Prevalence of Bacterial Symbionts in Social Amoebas

Student Author(s): Alexis Villalobos, Kira Gibbs
Faculty Mentor(s): Dr. Tamara Haselkorn

The soil dwelling social amoeba *Dictyostelium discoideum* is a common model organism used for a variety of reasons including studying eukaryotic host cell interactions with bacteria. *D. discoideum* is known for forming symbiotic relationships with bacteria in the genus *Paraburkholderia* and the phylum Chlamydiae. Recently, these bacteria have also been found in other species of social amoeba, although the function of these symbionts is currently unknown. For my research I measured the effects of time of year and microhabitats on the prevalence of these bacterial symbionts within populations of different species of amoebas to begin to understand what drives symbiont distribution. We collected and plated soil from three different microhabitats at Woolly Hollow State Park during the winter, spring, summer, and fall; identifying, collecting, and DNA-extracting the amoeba fruiting bodies that grew from each. We then used PCR with symbiont-specific primers to determine prevalence. While we found no *Paraburkholderia* infections, there was a high but variable prevalence of Chlamydiae infection. This preliminary data suggests that Chlamydiae infection prevalence varies by amoeba species, microhabitat, and time of year. *D. giganteum* has the highest prevalence levels, and prevalence is highest in the summer and at log sites. We performed a phylogenetic analysis on the Chlamydiae 16S rRNA gene sequences and found that different haplotypes infect the different species of social amoebas, suggesting that these symbionts are host specific and ecologically relevant. Social amoebas appear to be a common host for this diverse group of bacteria, and more studies will need to be done to determine its function in the different social amoeba species.

Attention! Tracking the Eyes to Assess the Influence of Priming on Congruity Effects in Visual Search

Nathaniel Wilson, Caroline Dacus, Nickolas Paternoster
Kenith Sobel, Amrita Puri

When viewing an object, we not only perceive its physical characteristics such as color, size, and shape, we also sometimes associate it with an abstract meaning. For example, green lights are generally accepted to mean “go.” What if the physical appearance of an item conflicts with its associated meaning? In the famous Stroop task, it takes longer to report the ink color of a word when its meaning conflicts (BLUE written in red ink). Similarly, the size congruity effect (SCE) refers to a delay in locating digits with conflicting compared to consistent physical and numerical size (a physically large “2” vs. a physically small “2”). Here, we examined whether priming, or repetition, of a target’s perceptual attributes - shape and physical size - impacts the SCE. Participants searched for numerically small or large target digits and reported whether the target was on the left or right. We recorded the time it took for participants to initially look at, or fixate, each target (TFF). Longer TFF for incongruent compared to congruent targets suggest that delayed eye movements to incongruent targets could explain the SCE. Regarding priming effects, when the current target shape (2 or 3) or physical size (large or small) matched that of preceding target, responses and TFF were faster compared to nonmatch trials; for shape, this effect was stronger for physically large targets. The SCE was present regardless of priming condition, suggesting that it is independent of perceptual priming.

Land use impacts on water chemistry in low-gradient Arkansas streams

Student Author: Molly Wozniak
Faculty Mentor: Dr. Hal Halvorson

Anthropogenic land use changes not only alter terrestrial ecosystems, but the aquatic ecosystems that flow through them. Land use changes around lotic ecosystems can alter water chemistry and biotic communities within them. This study aims to address water quality stressors in lowland streams of the South Coastal Plains of Arkansas how they are associated to land use. Thirty sites across the South Coastal Plains were sampled monthly for water chemistry (e.g., nutrients, heavy metals, physicochemistry) starting in February 2021 through February 2022. Water samples were collected using a bucket at each bridge crossing at each stream. Samples were aliquoted into different bottles based on parameters being tested (e.g., nutrients, total metals, physicochemistry). Using Spearman's correlations, results indicated that as percent agriculture land use increased, there was a positive association with alkalinity (rho=0.41), nitrate/nitrite (rho=0.48), pH (rho=0.47), and potassium (rho=0.38) and negative associations with total suspended solids (rho= -0.32) and total organic carbon (rho= -0.35). There were no significant associations with forest land use, but urban land use was negatively correlated with nickel (rho = -0.36) and iron (rho= -0.46). Principal Component Analyses and further water chemistry data will also be reported to understand the impacts of land use on the water quality of these ecosystems.

Department of Chemistry

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The Optimizations of N,N'-diarylurea :Repurposing Failed Antimalaria Drugs for Snail Fever

Student Author: Rachel Barnhardt
Faculty Mentor: Greg Naumiec

Neglected tropical diseases (NTDs) are a group of diseases mostly caused by parasites that widely affect poorer regions of the globe. Snail Fever (Schistosomiasis), one of the most common NTDs, affects 200 million people globally mainly in underdeveloped nations. Alongside investigation into a vaccine, new drugs are being examined and tested for activity, selectivity, toxicity, and chemical attractiveness. One of the most active chemical moieties are the diarylureas. These compounds are relatively nontoxic and have shown a reduction rate of parasitic flatworms by as much as 52.5%, which means not only is this group of compounds highly active, but they can be explored more for improvement.

We are investigating the effects of a broad range of aniline compounds to produce a small library of diarylureas to increase the reduction rate of the Schistosoma parasites closer to 100%. The bulk of the current progress is in optimizing the reactions to produce the diarylureas. Literature sources indicated the synthesis of diarylureas required overnight heating at 55 °C for roughly 80% yield. Initially, we heated the reaction at 55 °C and analyzed using thin-layer chromatography (TLC) to monitor reaction time and reduced the waiting period to 2 hours for completion of the reaction. We are currently changing the reaction temperature for optimization of reaction conditions. Additionally, we are exploring both microwaving and sonicating the same reaction. Each reaction to produce a diarylurea is run in all three conditions and results compared to determine the best method of production.

Sex and Age Determinations of Longnose Gar, (*Lepisosteus osseus*)

Nathan Bowers
Robert Mauldin, Ph.D.

Determining the sex of gars based on external characteristics is impossible to do with the naked eye. Thus, sacrifice of the organism and gross examination are required to accurately identify the sex of these apex predators. In this study, we attempted to develop a program to identify the sex of longnose gar, *Lepisosteus osseus*, based on weight and 21 specific external measurements. We also extracted otoliths to determine the age of the gar being studied. Dead specimens were collected from a local fisherman who had accidentally caught them in his nets in the Arkansas River. Several measurements were taken before gross examination of sex organs and extraction of various tissues and otoliths. Otoliths were ground and sanded to expose annuli and were examined using both light and scanning electron microscopy. Otolith examination by light microscopy was successful due to reflection of light from annuli, however SEM showed little to no annuli based upon the homogeneous surface topography resulting from sanding. Data calculations resulted in no significant differences between the sexes in terms of external measurements normalized to standard length, probably due to the small sample size (n=9) with only one male included. While no significant differences were detected, opercle plate width and anal fin height showed promising differences that may be seen in a larger sample size. More specimens of various sizes and both sexes will need to be examined to ultimately determine sexually dimorphic traits.

Investigation of Calmodulin and PEP-19 surfaces in biological systems

Student Author(s): Adrian Brown
Faculty Mentor(s): Tori Dunlap

Calmodulin (CaM) is a calcium sensing protein that plays a vital role in regulating within cell signaling pathways. CaM binds to its targets while also bound to calcium, allowing for it to have an altered conformation, such as a helical structure. Disruptions of calcium signaling pathways CaM is involved in are also associated with certain neurological diseases, such as Alzheimer's Disease. PEP-19 is a disordered protein that binds to CaM and alters its calcium binding kinetics and target protein binding. Along with understanding how CaM and PEP-19 behave when binding, it is vital to understand how the protein surfaces behave in biological settings. We plan to observe the physiological role of PEP-19s surface by measuring the equilibrium thermodynamics and kinetics in living E. coli. This will be done by labeling PEP-19 with fluorine and then using NMR to observe the behavior of the folded and unfolded states of the proteins.

Extracting Volatile Organic Components from Arkansas Honey

Student Author(s): Taylor Canada, Taylor Coulson, Briawna Stigall
Faculty Mentor(s): Richard Tarkka, PhD.

The increasing prevalence of antibiotic resistance and the resulting rise in superbugs such as MRSA and C. difficile demand new techniques for treating wound infections. Long before the discovery of synthetic antibiotics, honey was used as a medicinal wound treatment for thousands of years. Its medicinal use could be due to several factors, including compounds like peroxides, methylglyoxal, and polyphenols. Currently, the only FDA-approved honey for wound and burn dressing is Manuka honey, which is rare and expensive. Honey's efficacy for antimicrobial behavior is measured by a low Minimum Inhibitory Concentration (MIC). Our lab is testing for comparable MIC values between cheaper, more accessible Arkansas Wildflower Honey and Manuka Honey, as well as similar fingerprint antimicrobial qualities between Arkansas Wildflower and Manuka Honeys using 1H NMR. Several experimental methods can be used to extract the anti-microbial, organic materials from honey. We have used primarily the Liquid-Liquid Extraction (LLE) and Ultrasonic Extraction (USE) techniques for isolating volatile organic compounds from Arkansas Wildflower and Manuka honeys. The organic components of samples from around the state were extracted using LLE and USE, and the statistical Principle Component Analysis (PCA) was used to identify overlaps of compound profiles and assess similarities and differences between AR and Manuka honeys. Our lab is continuing to collect data to explore the possible antimicrobial similarities between Arkansas Wildflower and Manuka Honeys.

Cadmium and Mercury Levels in Longnose Gar from the Arkansas River

Student Author: Vlad Ciocan
Faculty Mentor: Dr. Mauldin

This research focuses on determining cadmium and mercury levels in longnose gar (*Lepisosteus osseus*) in the Arkansas River, with the hope of this top predator serving as a bioindicator of heavy metal pollution in this ecosystem. To get flesh samples into solution, they were digested in 70% HNO_3 at 100 °C, allowed to dry, and then redissolved with 1% HNO_3. Using Graphite Furnace Atomic Absorption Spectroscopy, cadmium levels were measured in the digested flesh samples. Also, flesh samples were sent to Milestone Inc. for mercury analyses using a Direct Mercury Analyzer. Mercury and cadmium levels were present at mid to high μg/kg levels and they both increased with the ages of the fish, consistent with the hypothesis that these metals accumulate in muscle tissues of this apex predator.

The Synthesis of a Low Cost Disquaramide Drug Library for Chagas Disease

Student Author(s): Psalm Dang
Faculty Mentor(s): Dr. Gregory Naumiec

In essence, neglected tropical diseases (NTDs) are a broad category of viral, parasitic, and bacterial diseases that disproportionately impact approximately more than 1.7 billion people in 149 countries annually. The WHO estimates that NTDs contribute to "nearly 19 million disability-adjusted life years," which is approximately "1% of the global burden of disease." This research is primarily focused on Chagas disease, or American trypanosomiasis. It has been identified as a potential cause of heart failure due to "Chagas cardiomyopathy." The treatment for Chagas disease is currently limited to nifurtimox and benznidazole, drugs that can cause serious adverse side effects, such as peripheral neuropathies, gastrointestinal issues, and neurological damage. Consequently, this presents an urgent need for new drug research. Thus, the purpose of this research is to create a "drug library" of disquaramides by altering the amines and amino groups that are attached to create alternative candidates for antiparasitic drugs.

Zinc-Mediated Coupling In The Synthesis Of An Amino Acid Radical Precursor

Student Author(s): Brett Daughdrill
Faculty Mentor(s): Dr. Nolan Carter

Free Radicals play a large role in the damage of biomolecules, specifically proteins and DNA. We are synthesizing a compound designed to generate a radical at the beta-position of the amino acid phenylalanine to investigate its role in damage to incorporated proteins and possible transfer of damage to DNA. This seminar will include the steps of synthesis and highlight the zinc-mediated coupling reaction with diphenyl diselenide. Carbon-selenide bonds are extraordinarily weak and can be cleaved through UV exposure, producing an amino acid centered radical. The incorporation of phenyl selenide at the beta-position of phenylalanine has proved to be the most cumbersome reaction in the synthesis of the amino acid radical precursor. I will be exploring the role of zinc, some of the challenges we have faced, and how we are combatting these challenges to complete our synthesis.

Investigating the conformational ensemble of calmodulin-binding protein PEP-19

Student Author(s): Mattie Gordon, Macllain Edington
Faculty Mentor(s): Dr. Tori Dunlap

PEP-19 is a small, intrinsically disordered protein (IDP) that regulates the binding kinetics of the protein calmodulin (CaM) to calcium. Calmodulin is a calcium signal messenger, responding to changes in intracellular calcium levels to regulate hundreds of different pathways. PEP-19's role is crucial, with inappropriate expression leading to calcium signaling disruption that can contribute to neurodegenerative diseases, cardiac hypertrophy, and cancers. Despite playing such an essential role, little is known about the conformational ensemble of PEP-19 and how it affects calmodulin binding to target proteins. Our goal is to study this conformational ensemble using time-resolved fluorometry, labeling with the organic fluorophore IAEDANS. This allows us to measure the end-to-end distance of PEP-19 to look for changes in its compaction or expansion. By measuring FRET in the presence and absence of different crowding agents, denaturants, and osmolytes, we can observe the effect of the local environment on the PEP-19 conformational ensemble.

Novel Anionic Ni-Ni and Co-Co Dimers as Potential Molecular Magnets

Student Author(s): Andrew Griffin
Faculty Mentor(s): Patrick Desrochers

An entirely new class of metal-metal dimers will be described, in which two nickel (II) or cobalt (II) centers are held close together (3.2 Å) by a trio of bridging pyrazolide ions. These [Cl- $M(\mu\text{-pz})_3M\text{-Cl}]^-$ dimers are synthesized by a direct reaction of the corresponding sodium or potassium pyrazolide and tetrachloronickelate (II) or tetrachlorocobaltate (II) ion in DMF. This general method of synthesis is effective with a variety of bridging R-pyrazoles. These dimer salts were characterized by MALDI-TOF-MS and UV-visible electronic spectroscopy. The $[PPh_4][Cl\text{-}Ni(\mu\text{-}Me_2pz)_3Ni\text{-}Cl]$ salt was characterized by single crystal XRD, confirming for the first time the formation of this novel structure. The common $(fac\text{-}N_3)Ni\text{-}Cl$ nickel(II) environment in this dimer and the well-characterized Tp*NiCl monomer invites contrasts and comparisons. For example, the new dimer $(fac\text{-}N_3)Ni\text{-}Cl$ environment is unusually unresponsive to Lewis basic DMF molecules, where Tp*NiCl binds this solvent (and other Lewis bases) immediately and reversibly. The nickel and cobalt dimers are stable in the solid-state as their PPh^+, Na^+, K^+, Cs^+ salts. Room temperature magnetic measurements suggest each nickel dimer possesses two independent high spin nickel (II) centers. They also suggest that the cobalt dimer possesses two independent high spin cobalt (II) centers. While their novel architecture makes these metal-metal dimers interesting on their own, these discrete high spin complexes can also be molecular magnets, well-defined magnetic centers, that can be incorporated into nanoscale devices.

Using N-Heterocyclic Carbenes to Reduce Carbon Dioxide into Alternative Fuel Sources.

Student Author(s): Liz Hicklin, Haley Cox, James Buckley, Alec Filson
Faculty Mentor(s): Dr. Marsha Massey

The burning of fossil fuels creates an excessive amount of the byproduct Carbon Dioxide (CO_2) This has directly resulted in the anthropogenic changes observed in Earth's atmosphere. An alternative source of energy is highly sought after to reduce or eliminate the stresses created on the atmosphere. Through the creation of an electrocatalyst, the reduction of to a starting material for synthesizing alternative fuel can become energy efficient. In addition, using CO_2 as a starting point for the creation of alternative fuels could be more dependable than other proposed alternative energy sources. An electrocatalyst could allow the reduction of CO_2 to become a reality. The synthesis of the proposed electrocatalyst uses 2-bromopyridine and benzimidazole to create Bim-py. The two reagents are attached to each other using potassium carbonate and a solvent, assuring that the solvent is green. The synthesis of Bim-py utilizes a microwave, reducing the time required for production from the reported 18 hours, down to 30 minutes. Manganese was also chosen over other transition metals due to its cost effectiveness. Electrochemical techniques will be employed to determine the electrocatalyst efficiency as a reducing agent. This is done by using cyclic voltammetry in an electrolytic cell. The creation of an effective electrocatalyst could not only ease the reduction of CO_2, it could reduce the dependence on fossil fuels and catalyze a cleaner future.

An inexpensive and efficient approach to cure Chagas disease

Student Author(s): M. Johanna Lasiter
Faculty Mentor(s): Gregory R. Naumiec

Abstract - Neglected Tropical Diseases (NTDs) pose an enormous threat to those in poverty-stricken regions of the world such as Central and South America. NTDs have affected the lives of nearly 2 billion people worldwide. With limited funds and resources, research on NTDs is lacking. Chagas disease, one such NTD, is a parasitic infection that is now becoming increasingly common throughout the southwest United States. Chagas disease is caused by the parasite *Trypanosoma cruzi*, carried by an insect known as the “kissing bug”. Once infected, the insect passes parasites through their feces and can eventually cause “Chagas heart disease,” resulting in death.
There are currently two drugs in the market for treating Chagas, benznidazole and nifurtimox. Benznidazole is the only drug of the two that is FDA-approved (only in children), and both drugs have severe side effects along with alarming reports of treatment failures due to drug resistance in *T. cruzi*. We aim to make a new class of anti-Chagastic compounds using disquaramide structural motifs. Disquaramides have shown to have anti-parasitic activity and are facile and cost-efficient to synthesize. Our research has incorporated the use of diamines in order to make cyclic disquaramides. To date, we have successfully synthesized three of these compounds with moderate to high yield (21-96%). The main focus of this research is to create inexpensive drugs to aid in the fight against Chagas disease.

Synthesis and Characterization of Copper Complexes Supported by A Binucleating Amide Ligand

Student Author(s): Dillon Rea
Faculty Mentor(s): Lei Yang

The goal of our work is to develop new copper complexes with potential application on carbon dioxide conversion. A binucleating amide ligand was employed in order to construct binuclear copper complexes with side-open topology. A group of Cu(II) complexes have been synthesized and characterized by X-ray crystallography, UV-vis and FT–IR. The diverse structural features of these complexes clearly demonstrated the flexibility of the ligand platform. Further characterizations of these complexes are currently in progress.

Synthesis and Characterization of Cu(I) and Cu(II) Complexes Supported by Binucleating Ligands

Student Author(s): Hannah Russell
Faculty Mentor(s): Lei Yang

This project focuses on the development of binuclear copper complexes for CO_2 activation. So far, a group of Cu(I) and Cu(II) complexes have been synthesized by the reaction of copper salts and the N,N'-bis(2-pyridylmethyl)acetamidinato ligand. The resulting products were characterized by X-ray crystallography, FT–IR, UV–vis, EPR, NMR and cyclic voltammetry. Preliminary test of the Cu(I) complexes with CO_2 and O_2 showed some interesting results, and the characterizations of the products are under investigation.

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

Student Author(s): Garrett Spears
Faculty Mentor(s): Lei Yang

Small molecule activation using first row transition metal catalysts is a current area of intense research. In our effort to convert carbon dioxide (CO_2) to value-added chemicals by using copper complexes, a group of binucleating ligands have been adapted to our research. Several new dinuclear Cu(II) complexes have been synthesized and characterized by UV–Vis, FT–IR, X-ray crystallography, cyclic voltammetry and EPR. Currently, our work is focusing on the reduction of the copper centers to Cu(I) complexes, followed by reactions with CO_2. Characterization of products is under active investigation.

Analysis of Lead and Mercury Concentrations in Longnose Gar

Student Author: Brittany Story
Faculty Mentor: Dr. Robert Mauldin

The longnose gar (*Lepisosteus osseus*) is considered a large, top predator species in Arkansas, living upward of 50 years. These characteristics suggest a concern for both bioaccumulation and biomagnification effects of heavy metals in these fish. Lead and mercury are commonly found in air, water, and sediment, and their toxic natures pose a threat to the health of ecosystems and communities. To study gar for these metals, the fish were first collected from the Arkansas River, and then dissected for sample collection of the flesh and otoliths. The ages of the fish were determined through light microscopy of the otoliths, and the nine fish collected ranged between 6 and 20 years of age. Mercury analysis of the flesh samples was completed using a Direct Mercury Analyzer using solid samples. To analyze lead concentrations in flesh samples, they were first digested using concentrated nitric acid and then resuspended into solution. Using a graphite furnace atomic absorption spectrophotometer, the concentration of lead was measured using a calibration curve. Lead was found to be present at levels below the detection limit (< 3 μg/kg), which is consistent with other studies showing that lead bioaccumulates but does not biomagnify. Regardless, it was a surprise not to detect any lead in the 20-year-old specimen. Mercury levels, however, were high (200-800 μg/kg) as expected since mercury is well-known for its ability to both bioaccumulate and biomagnify.

Department of Geography

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Irrigated and rainfed soybean classification using Landsat and Drone Imagery

Student Author(s): Marisol Filares
Faculty Mentor(s): Dr. Yaqian He and Dr. Matthew H. Connolly

The Arkansas Delta grows a large portion of the soybeans in the country, and is Arkansas's largest row crop utilizing 3.1 million acres of land. Soybean production is used as a food source to supplement livestock and is becoming popular as a meat substitute given its high protein content. The irrigated and rainfed land is not delineated for the region leaving a knowledge gap that is essential for monitoring the local climates and reducing groundwater depletion. This study aimed to differentiate irrigated and rainfed soybeans using random forest and support vector machine learning algorithms with Landsat 7 imagery referenced by drone imagery. The use of drones in geography is relatively new, the ease of drones allows them to fly below the cloud ceiling, provide high temporal and spatial resolution and is inexpensive compared to other low-altitude collection methods. We extracted 228 sample points from drone images and 7 classification features including RGB and two shortwave bands references, Normalized Difference Vegetation Index (NDVI), and Modified Normalized Difference Water Index (MNDWI) from Landsat 7 imagery to train the random forest classifier in R. The NDVI measures plant health by quantitatively detecting visible and infrared light absorption and reflection. Similarly, the MNDWI measures the amount of water in the area . Our results showed that the random forest classifier and support vector machine could successfully distinguish irrigated and rainfed soybean crops.

Reconstructing Pre-EuroAmerican Settlement Forest Composition in the Ouachita Mountains, Polk County, Arkansas

Student Author(s): Willow Harper
Faculty Mentor(s): William Flatley, Yaqian He

Prior to EuroAmerican settlement the Ouachita Mountains were dominated by shortleaf pine woodlands and oak woodlands. These woodlands provide habitat for a number of Arkansas' threatened plant, insect, bird, and reptile species. Today these woodland habitats are in decline due to the removal of wildfire that maintained their unique composition and structure. It is for these reasons that shortleaf pine-oak woodlands are a focus of conservation and restoration in Arkansas. However, little is known of the historical distribution of these fire-adapted habitats in the Ouachita Mountain region. Early 19th century General Land Office (GLO) surveys provide data on the composition and structure of vegetation during early EuroAmerican settlement in the Ouachitas. The goal of this research was to reconstruct pre-EuroAmerican forest composition and structure in Polk County, Arkansas by mapping GLO survey data and to establish historical vegetation-site relationships. We hypothesized that pre-settlement shortleaf pine and oak woodlands would be primarily found on steep south-facing slopes, along ridgelines, and other dry sites conducive to frequent low-intensity wildfire events. Location and species information for 888 line trees were extracted from GLO survey notes using optical character recognition (OCR) software and then mapped using scripts written in R. To establish vegetation-site relationships, we related the presence of line tree species to edaphic site conditions, including elevation, slope, aspect, topographic wetness index, dominant soil order, soils' available water storage, and distance from streams.

Department of Physics and Astronomy

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Europium Abundances with Varied Halo-Star Parameters

Student Author(s): Julia Hambuchen
Faculty Mentor(s): Dr. Debra Burris

This research focus on measuring the abundance of Europium (Z = 63) in metal-poor halo stars. By altering some of the stars main characteristics (temperature, surface gravity, and metallicity) with SIMBAD database measurements, we can find the minimum and maximum abundance values for the star by analyzing the altered spectra with MOOG software. This allows us data to help understand the r-process formation, which still has many mysteries. Currently, we have data with varied temperature and surface gravity values.

An Investigation of an Autonomous Robotic Glider

Student Author: Will Ward
Faculty Mentor: Dr. William Slaton

This project explores how to implement autonomous glider soaring with an Arduino Nano microcontroller and an Inertial Measurement Unit (IMU). Unlike other aircraft, gliders have no engine or propeller to generate thrust, so in calm, stable air, gliders are always falling. However, gliders can increase their flight time by adjusting their angle of attack and optimizing their
lift-to-drag ratio. The Arduino collects g-force data from the IMU chip's accelerometer that indicates whether the glider is flying level to the ground or tilted at an angle. If the glider's angle of attack is too low (nose-diving) or too high (which can cause a stall), then the servo motor connected to the elevator flap is adjusted to try to level out the flight. Data is collected and analyzed through photographs and sensors to determine the performance of this autonomous system.

Study of Optical Properties and Structure of Cu_2O Thin Film by Chemical Bath Deposition with Graphene

Hinata Yokoyama
Dr. Mohammed

Copper oxide (Cu_2O) thin films with graphene were deposited on a substrate of glass and silicon by the method of chemical bath deposition (CBD). Graphene was mixed with Cu_2O in the process of the CBD. The samples were characterized by Scanning Electron Microscope (SEM), Ultraviolet spectroscopy (UV-spectroscopy), Energy Dispersive X-Ray spectroscopy (EDX) to determine the optical features, nanostructures of Cu_2O thin films, and their bandgaps, this result indicated that graphene boosts the optical properties of Cu_2O thin film.

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