ARKANSAS STEM POSTERS @ the Capitol

"It is essential, if we want to continue to reap the benefits of science, to commit as a nation to preparing more young people for extraordinary careers in science."

—Carol W. Greider, 2009 Nobel laureate in physiology & medicine

January 30, 2025

Highlights

- **92 students**
- **From 13 Arkansas colleges and universities**
- **Presenting 62 different presentations of original work**
- **Encompassing all aspects of science and technology**


STATE
ARKANSAS STATE
UNIVERSITY


1871
UNIVERSITY OF
ARKANSAS


1890
HENDERSON
STATE UNIVERSITY


OUACHITA
BAPTIST UNIVERSITY


1876
HENDRIX


ARKANSAS
TECH
UNIVERSITY


UNIVERSITY OF
CENTRAL
ARKANSAS


UALR
UNIVERSITY OF ARKANSAS
AT LITTLE ROCK


UNIVERSITY
of ARKANSAS
AT PINE BLUFF
1873


UAM
THE UNIVERSITY OF ARKANSAS AT MONTICELLO
MONTICELLO • CROSSETT • MCGEHEE


LYON
COLLEGE


JOHN BROWN
UNIVERSITY


CENTRAL
BAPTIST COLLEGE


PHILANDER
SMITH COLLEGE
EST 1877


UAFS
UNIVERSITY OF ARKANSAS
FORT SMITH


UAMS
UNIVERSITY OF ARKANSAS
FOR MEDICAL SCIENCES


SAU
SOUTHERN ARKANSAS UNIVERSITY


HARDING
UNIVERSITY

ARKANSAS STEM POSTERS@ the Capitol

Student presenter (school) ….. page with abstract

Exploring the Potential of Soilborne Bacteria to Protect Soybeans from Fungal Pathogens

Zach Rikard, Kipa Tamrakar, Mahesh Bamunusingha, Winston Miller *[Mentor: A. Wijeratne]*

Arkansas State University - Biology

Fusarium virguliforme, which causes Sudden Death Syndrome (SDS), is a significant threat to soybean yield and quality, costing U.S. farmers billions of dollars in loss. Management strategies rely on fungicides and tolerant cultivars, with varying effect. Beneficial microbes are increasingly recognized for their potential to enhance plant disease tolerance. A previous study found that certain soils can suppress SDS, likely due to microbiota. Our previous data indicates that SDS-tolerant cultivars inhibit pathogen growth by recruiting bacteria in the family Bacillaceae. Members of this family are known to suppress pathogens, promote plant growth, and enhance soil health, making them an ideal alternative to combat crop diseases like SDS. Therefore, my study aims to isolate and culture beneficial soil bacteria, particularly those from the Bacillaceae family, and evaluate their potential to suppress F. virguliforme. Using advanced DNA sequencing techniques, we identified 21 bacterial species, 15 of which belong to the Bacillaceae family. Ongoing laboratory tests are assessing the ability of these bacteria to inhibit the growth of F. virguliforme, the pathogen responsible for SDS. Our research could impact Arkansas soybean farming by developing microbial solutions to protect crops from devastating diseases like SDS. These products will promote environmentally sustainable agriculture practices and support Arkansas's reputation as a leader in innovative, and eco-friendly agriculture.

Innate immune function across three conspecific turtle species

Isabella Davis and Jennifer Terry *[Mentor: L. Neuman-Lee]*

Arkansas State University - Biology

The innate immune system is similar among all vertebrates but seems especially powerful in reptiles. However, the reptilian immune system is poorly understood, and few studies have made comparisons among different species. To address this gap, innate immune function in three freshwater turtle species found in Arkansas was evaluated. Red-eared Slider Turtles (Trachemys scripta elegans), Mississippi Mud Turtles (Kinosternon subruburm hippocrepis), and Eastern Mud Turtle (Sternotherus odoratus), are found throughout the southeastern United States. Each turtle species lives in different areas of the water column and have unique diets, reproductive strategies, and life spans. In spring 2024, male and female aquatic turtles were caught using hoop nets, and blood samples were taken to assess immune function. We assessed the ability for each turtle's serum to kill three different microbes (Gram-positive (Staphylococcus aureus), Gram-negative (Escherichia coli) and a fungus (Candida albicans)), which allows us to determine what parts of the immune system are activated. By assessing the immune function of each turtle, activation of different parts of the immune system can be observed across species. Comparing the immune function in different species of turtle can provide valuable insight into the underlying patterns of diversity.

Using Yeast To Gain Insights Into A Human Neurodevelopmental Disorder

Agustin Kalinowski and Lillian Francis *[Mentor: A. Duina]*

Hendrix College - Biology

In cells, genetic information is stored as DNA. To perform necessary functions, cells require large amounts of DNA, which must be compacted to fit within the cell. During compaction, DNA is wrapped around protein complexes, forming nucleosomes, which further condense into chromosomes. While nucleosomes are essential, they act as roadblocks for an enzyme that uses DNA to make RNA, which is used to make proteins needed for cellular functions. To overcome these roadblocks, the enzyme uses several factors including one called FACT. In previous work we showed that specific alterations in nucleosomes impair interactions between DNA and FACT. Here, we describe recent work using yeast cells to assess whether alterations in nucleosomes associated with a human neurodevelopmental condition called Bryant-Li-Bhoj syndrome (BLBS) also affect FACT-DNA interactions. Because yeast and human cells share a high degree of functional similarities, our work can provide insights into the molecular mechanisms responsible for BLBS.

The response of arbuscular mycorrhizal fungi to the early stages of the Lake Conway drawdown

Ty Tillman *[Mentor: M. Reid]*

Hendrix College - Biology

Arbuscular mycorrhizal fungi (AMF) associates with a variety of host plants. This relationship provides host plants with enhanced nutrient uptake. Most AMF research pertains to terrestrial habitats with little research on how AMF respond to rapid environmental transitions. Lake Conway is a 6,700-acre man-made lake currently undergoing an extended drawdown. To discover AMF's response to the drawdown 12 locations were established with a transect along the inundation gradient in each. We processed samples to quantify extraradical hyphal (ERH) length, a measure of AMF abundance in soil. Data obtained showed a low overall mean ERH length, ⊠11.7 mm g-1 soil, with no significant ERH length variation along the inundation gradient. From this data we concluded that AMF is not readily colonizing the lakebed. With some plants heavily relying on AMF, a low abundance would restrict plant community composition and species abundance possibly negatively affecting the developing ecosystem in the exposed lakebed.

The Kombucha Project as a Beneficial Course-Based Research Experience

Hunter Reck *[Mentor: R. Plymale]*

Ouachita Baptist University - Biology

Course-based undergraduate research experiences (CUREs) provides benefits of research to a large number of students. Ouachita Baptist University begins course-based research with first-semester freshman using a kombucha project. Kombucha is a fermented tea beverage, making it a safe model system for beginning students. In the kombucha project, students collaborate to create and study kombucha, gaining experience in experimental design, data collection, and data analysis and reporting. Students in the course evaluate their own growth using three end-of-semester surveys: the skill survey, the Laboratory Course Assessment survey (LCAS), and the Persistence in the Sciences survey (PITS). The skill survey measures students' confidence with the laboratory skills used in the course, including pipetting and graphing. The LCAS survey assesses student experiences in working with others to discover new information, while the PITS survey asks students to evaluate their feelings of project ownership and science self-identity. These survey results will be presented and are expected to positively reflect the learning development and personal growth experienced through the kombucha project.

GrandSlam Lysogen Resists Infection by Phage Ruthy

Abbigail Wood *[Mentor: R. Plymale]*

Ouachita Baptist University - Biology

It is possible in natural settings for host bacteria to simultaneously be challenged by multiple bacteriophages. Once a temperate bacteriophage infects a host and establishes lysogeny, it often decreases the chances of infection by additional phages. For this project I looked at the susceptibility of Gordonia cluster DI lysogens to superinfection by phage Ruthy. G. terrae CAG3[GrandSlam] lysogen was able to reduce Ruthy's plating efficiency 100-fold. Next, my project will evaluate Ruthy superinfection of G. terrae CAG3 [Chop] lysogen and G. terrae CAG3[DelRio] lysogen to determine if this result is specific to GrandSlam or is applicable to other DI phage.

Using Machine Learning to Predict Antimicrobial Resistance (AMR) Phenotypes

Yeojin Jung and Namkyeong Kim *[Mentor: D. Kim]*

Arkansas State University - Computer Science

Antimicrobial resistance (AMR) poses a significant global public health threat, driving a surge in hospital-acquired infections, increased morbidity, and mortality. The misuse and overuse of antibiotics have expedited the rise of drug-resistant pathogens, highlighting the urgent need for innovative approaches to predict AMR phenotypes and guide treatment strategies. Machine learning has proven to be a powerful solution for these challenges, enabling the analysis of large datasets to identify patterns and predict microbial resistance or susceptibility to antibiotics. By leveraging these techniques, we can combat AMR effectively, paving the way for improved patient outcomes and enhanced public health.

Nutritional quality of aquatic invertebrates and their resources across an agricultural gradient in the Arkansas River Valley, USA

Eli Wess *[Mentor: H. Halvorson]*

University of Central Arkansas - Biology | Environmental Science

Nearly half (47%) of U.S. stream miles are in poor condition due to nutrient pollution by nitrogen (N) and phosphorus (P). The primary source of N and P pollution is from agricultural land-use, but the impacts of N and P pollution on aquatic food webs are still poorly understood. Aquatic invertebrates are often used as a tool to assess the biological health of streams and play a crucial role in the ecosystem by transferring nutrients through the food web. To study the impacts of pasture/hay land-use on aquatic food webs, we measured the carbon (C), N, and P contents of aquatic invertebrates and their resources (coarse particulate organic matter, fine particulate organic matter, and periphyton). Sampling occurred from May-June across eight headwater streams ranging from <1% to 72% pasture/hay land-use within the Arkansas River Valley. Preliminary results show positive trends of increased %P and %N in resources alongside increased pasture/hay land-cover. Invertebrates generally appeared to remain consistent in their %P and % N regardless of pasture/hay land-use. Agricultural N and P pollution may result in degradation of stream ecosystem health via alteration of the nutritional composition of the stream's primary resources with subsequent consequences further along the food web. In the future, C:nutrient data will be paired with protein and lipid data, allowing us to further examine how the nutritional qualities of aquatic invertebrates respond to agricultural N and P pollution.

Preparation of Innately Antibacterial Chitosan-Based Hydrogels for Wound Care Applications

Alexander Browning *[Mentor: S. Hamilton]*

Ouachita Baptist University - Chemistry

In the past decade, research has shown the effectiveness of biopolymers for medical applications such as wound dressing, suturing, promoting cell proliferation, and controlled drug administration (Baranwal et al., 2022). Chitosan is a natural biopolymer of high functionality that is comprised of repeating β-(1,4)-2-amino-D-glucose and β-(1,4)-2-acetamido-D-glucose units that are linked by 1,4-β-glycosidic bonds. Chitosan is a highly biocompatible, cost effective, and versatile biopolymer that has merit in several medical applications, including drug delivery hydrogels (Nicolle et al., 2021). Due to chitosan's large number of functional groups, it is possible to modify the polymer with antibiotic and therapeutic compounds through a reversible mechanism. This study explores the effectiveness of chitosan modification for drug delivery in wound care. Chitosan was modified at primary alcohol groups with primary-amine-containing drugs, which includes many antibiotics like amoxicillin. This allows drug release at the wound site for therapeutic effects. The functionalized chitosan was then used to produce innately antibacterial hydrogels, which were compared to traditional antibiotic-loaded, chitosan-based hydrogels. Drug release rates of the hydrogels were analyzed via UV-Vis spectroscopy and antimicrobial studies. It is anticipated that the resulting innately antibacterial hydrogels have the capacity to be used in several clinical applications.

The design of new and environmentally safe herbicides using AI and molecular modeling

Micah Shaver *[Mentor: J. Darsey]*

University of Arkansas—Little Rock - Chemistry

Herbicides are biocidal chemical compounds or biological organisms used to control weeds on plants. An herbicide works primarily by inhibiting their growth. Herbicides can either be contact, translaminar, or systemic. Contact herbicides are not taken up into the plant tissue and protect only the plant where the spray is deposited. Translaminar herbicides redistribute the herbicide from the upper, sprayed leaf surface to the lower, unsprayed surface. Systemic herbicides are taken up and redistributed through the xylem. Few herbicides move to all parts of a plant. Some are locally systemic, and some move upwardly. Most herbicides can be bought in either the solid or a liquid form. Examples of herbicides are Glyphosate, Atrazine, Dicamba, Trifluralin, Beacon, Pinnacle, Harmony, etc.
Herbicide residues have been found on food for human consumption, mostly from post-harvest treatments. The goal of this research is to take known herbicides and, using molecular modeling, modify these molecules in order to identify herbicides with more potent weed-killing abilities but with reduced environmental impact. This could have a huge effect on the productivity of crops. Since Arkansas is a large agriculture state, this should have a great impact on the economy of Arkansas.

An Electrochemical Biosensor for the Detection of Alzheimer's Disease

Ezekiel McCain *[Mentor: A. Izadyar]*

Arkansas State University - Chemistry

The submitted research addresses a critical healthcare challenge: the early diagnosis of Alzheimer’s disease. By focusing on non-invasive blood-based biomarkers, particularly Amyloid Beta 42 (Aβ42), the research offers a solution to the limitations of current diagnostic methods like CSF analysis, which are invasive, expensive, and inaccessible. The vision of the research is innovative in its approach, utilizing advanced techniques such as LC-MS/MS, and aligns with the urgent need for affordable and accurate diagnostics. Furthermore, integrating multi- biomarker detection into broader sensor technologies highlights potential applications beyond Alzheimer's diagnosis, contributing to advancements in health monitoring and offering impactful solutions across the healthcare sector.

Future = AI + Database Collective Academic Database (CAD) to Manage AI in Academic Environments

Seung Ho Jeon *[Mentors: H. S. Leslie]*

Arkansas State University - Computer Science | Business

The development of Retrieval Augmented Generation (RAG) and Fine-Tuning Methods opened the doors to specialized Large Language Model (LLM) applications, such as the various GPTs found in the GPT Store. However, their sustainability is limited to the safety, accuracy, and authority of the data, with no universal way to manage the risks associated with these applications currently in the United States. Hence, discussions are ongoing within the US on how this technology can be managed, with efforts such as the Blueprint for Artificial Intelligence (AI) Bill of Rights from the White House and the AI Risk Management Framework from the National Institute of Standards and Technology. In this paper, we demonstrate why data management is important, then propose the Collective Academic Database (CAD), which, unlike other academic databases, works in harmony with ongoing discussions within the US on AI management. The CAD will provide academic researchers and experts with a safe, protected, and adaptable environment independent of LLMs, functioning as a manageable space for future experiments, research, and innovation. The CAD will also function as the extension of open-source efforts in AI into education. Ultimately, this paper aims to bridge the gap between academia and AI, to serve as a foundation for unifying the academic community through AI.

Surface Energy and Adhesion of Functionalized Silica Nanoparticle Coatings for Solar Energy Applications

Landon Rogers *[Mentor: R. Fleming]*

Arkansas State University - Engineering

Accumulation of particulate soils on the front cover glass of solar photovoltaic (PV) modules results in optical transmission losses that reduce the overall power output of PV installations. Nanoparticle coatings are often applied to the cover glass of PV modules to provide antireflective properties, as well as anti-soiling functionality by modifying the coating surface energy. In this study, nanoindentation-based surface adhesion measurements are performed on functionalized nanoparticle coatings composed of either hydroxylated silica nanoparticles or methylated silica nanoparticles, along with complimentary water contact angle (WCA) measurements to characterize the relationships between coating surface chemistry, morphology, and surface adhesion. These results are further correlated accelerated soiling/cementation testing to better understand the anti-soiling properties of functionalized silica nanoparticle coatings.

Classification of Damage State in Carbon Fiber Reinforced Composites Using Transfer Learning

Hannah Jones *[Mentor: S. Dabetwar]*

University of Arkansas—Little Rock - Engineering

Recently, composite materials have been implemented in many applications starting from micro-level to large-scale structures. With the increase in applications, the need to understand their behavior under various stress conditions has also increased. Composite materials undergo sudden damage which can lead to catastrophes. To avoid sudden catastrophes creating a framework that can effectively use the non-destructive inspection data and identify the damage accurately is important. Here we used a public dataset of carbon fiber-reinforced polymer composite which contains the Lamb wave signals of composite specimens. Deep learning can use the data and make the identification of damage levels but the selection of the correct algorithm is difficult. Thus, a comparative study of multiple algorithms including transfer learning is presented in this paper to assess the performance of transfer learning models against a general deep learning model. In this study, the signals were converted into images and multiple transfer learning algorithms such as VGG16 and incpetionV3 were implemented and compared. We compared transfer learning vs regular CNN algorithm. A sensitivity analysis based on the number of epochs was also performed. We conclude that sensitivity analysis is significantly important to provide optimum values of hyperparameters to achieve the highest performance of each algorithm. We observed that pre-trained weights provided better performance than the non-pre-trained weights.

Progress in Autonomous Vehicle Engineering

Ashton Johns, Eric Nguyen, and Jeremy Abbott *[Mentor: L. Zhang]*

University of Central Arkansas - Engineering Physics

Engineering Physics students in Senior Design 1 and 2 at the University of Central Arkansas (UCA) have been engineering autonomous vehicles for five years. Our team, UCA Jetson, was tasked with designing a better self-driving platform. This involved a new mock of the hardware upgrades and software updates to improve the robot's self-driving performance and navigation. Regarding hardware, we upgraded the camera and sensors for better computer vision and the computer for better data processing. We incorporated the new hardware into the software updates to take in more data. In addition, we improved the mechanical design by creating a robot base and crash cage brace on computer-aided design (CAD) to protect the hardware from a given environment. With the hardware upgrades and software updates, the robot successfully ran the final race track at the Conway Corporation Center for the Sciences (CCCS) Clipper.

Autonomous Driving Robot

Reagan Graff, Ethan Durham, and Kajsa Pruner *[Mentor: L. Zhang]*

University of Central Arkansas - Engineering Physics

The objective of this project is to develop an autonomous robot capable of navigating a designated track independently, detecting obstacles, and dynamically adjusting its path in real time to avoid collisions. Using the Raspberry Pi AI Kit and Camera, advanced AI-driven navigation and object detection will be implemented, allowing the robot to make intelligent decisions on the fly. This project not only focuses on achieving reliable, self-sufficient navigation but also explores potential applications in fields such as industrial automation and autonomous transportation, where real-time adaptability and precise obstacle detection are critical for operational efficiency and safety. By leveraging cutting-edge technology and innovative algorithms, the robot aims to contribute to the future of autonomous systems in various dynamic environments.

AI Can’t Write Like That!’: Testing People's Ability to Differentiate Between AI and Human-Generated Text

Honey Norfolk *[Mentors: P. Casey]*

University of Central Arkansas - Sociology | Engineering Physics

This study investigates whether individuals can accurately distinguish between human-written and AI-generated texts, and, if so, the strategies they use. Participants are shown four texts, two by humans and two by AI, across styles such as academic, newspaper, gossip/tabloid, and informal messaging.

The procedure includes a pre-test assessing participants' prior knowledge of AI and their confidence in identifying AI -generated texts. Participants then categorize each text and provide detailed explanations for their choices, allowing for analysis of the effectiveness of their strategies in identifying AI-written content.

Results suggest that commonly relied-upon tactics may not reliably distinguish AI texts from human ones. This study explores the public's capacity to identify AI-generated texts across various styles, examining the effectiveness of their tactics and their confidence levels. Insights gained contribute to understanding which strategies are most effective and have implications for fields like education, journalism, and AI development.

Testing for and comparing compactness between Arkansas State House District Maps in the years 2001, 2011, and 2021.

Carter Lemley *[Mentor: B. Pearson]*

University of Central Arkansas - Geography

This study compares the compactness of state house districts in Arkansas for the years 2001, 2011, and 2021 in order to help determine if there has been a change in the frequency of gerrymandering in the state as it reapportions its districts. The literature shows few studies on reapportionment but plenty of methods to test for gerrymandering and compactness. This study takes district boundary data from the Arkansas State GIS Office, utilizes the Polsby-Popper test to determine compactness, and compares the results using ANOVA and Tukey's Honestly Significant Difference tests. The ANOVA results showed that the three years were significantly different, but the Tukey HSD test found that the Polsby-Popper ratios for 2001 and 2021 were not significantly different. The 2011 state house district boundaries were significantly less compact than the 2001 and 2021 district boundaries.

Entity Resolution with Household Movement Discovery Using Google Generative AI

Muzakkiruddin Ahmed Mohammed *[Mentors: J. Talburt]*

University of Arkansas—Little Rock - Information Quality

This project presents a prototype system for discovering patterns of household movements using the Google Generative AI (Gemini-1.5) large language model (LLM) and implemented through the Flask web framework. The system processes unstandardized name and address data to identify instances where two or more individuals share addresses at different points in time and subsequently move together to another location. The key advantage of using LLMs is their ability to understand data regardless of syntax quality, variations in address formats, and differences in how names or personal information are recorded. This research shows that an LLM is capable of detecting these patterns and provides a roadmap for automating the extraction of complex relationships between household members. This will improve entity resolution (ER) for address-based movements, and explore the efficacy of generative models in handling unstructured, low-quality data.

Elliptic Curves as Abelian Groups

Victoria Mardis *[Mentors: W. Paulsen]*

Arkansas State University - Mathematics

A standard elliptic curve is one of the form y^2 = x^3 + Ax + B, where A and B are constant coefficients and the pair (x, y) represents a point on the Cartesian coordinate plane. Our interest is in investigating these curves as mathematical groups. That is, we define the addition of two points on the curve and must prove that this addition holds certain properties. We can then change the underlying field, or the set of numbers that x and y are chosen from. Starting with a finite field, we find that certain polynomials cannot be factored, so we extend the field to include complex numbers. However, there are still polynomials that cannot be factored within that set, so we must repeat this process an infinite number of times so as to ensure that every polynomial can be factored completely. Thus, the roots of the elliptic curve can always be found. The reason for focusing on elliptic curves this way is because these properties make it possible to create encryption keys out of them, potentially leading to a world with more informational security, especially as we move toward an age with quantum-powered decryption.

Polarization of Helium-3 for Neutron Spin Filters

Jackson Corrigan and Jonas Haguewood *[Mentor: D. Spayde]*

Hendrix College - Physics

Polarized helium-3 (3He) gas is used in neutron spin filters. A neutron spin filter absorbs neutrons of one spin state and allows neutrons of the opposite spin state to pass through creating a beam of polarized neutrons. 3He is an atom that can absorb one neutron to become helium-4. 3He gas is polarized by immersing it in a magnetic field which determines the spin state of the absorbed neutron. We performed tests of the strength and uniformity of the magnetic field across the apparatus. A uniform magnetic field is important to maintain the polarization of the 3He gas. The relaxation time is how long it takes the gas to completely depolarize. Through these tests we were able to calculate an expected relaxation time of approximately 35 hours. When we performed a direct measurement, we found an approximate relaxation time of 32 hours.

Study of a F-box protein AT1G20790 in Arabidopsis thaliana may contribute to the proper design of F-box protein inhibitors

Halen Queen and Madeline Freeman *[Mentor: M. Seong]*

Central Baptist College - Biology

F-box proteins are substrate recognition components of the SKP1-cullin 1-F-box protein (SCF) E3 ligase complex that regulates the protein degradation, and their dysregulation is involved in carcinogenesis, metastasis, and drug resistance. F-box protein inhibitors have shown promising results in reducing drug resistance in cancer. A putative F-box protein AT1G20790 was identified from its different expression in different light conditions in Arabidopsis thaliana and its interaction with Arabidopsis-SKP1-like 1 (ASK1) showed that it is a functional F-box protein. To identify the target proteins of AT1G20790 for ubiquitination and thus for degradation, proteomics of AT1G20790 and SALK133945 (AT1G20790 T-DNA insertion mutant) grown in low light and dark were performed. In low light, Glutathione S-transferase TAU 23 was the only protein upregulated in all three SALK133945 groups, indicating Glutathione S-transferase TAU 23 might be a potential target of AT1G20790 in low light. Col-0 and SALK133945 seedlings showed significantly different proteomes in the dark compared to low light. Many proteins involved in photomorphogenesis and hormone responses were upregulated in SALK133945, suggesting that AT1G20790 negatively regulate photomorphogenesis in the dark. Further studies of AT1G20790 inhibitors/agonists in the protoplast and in the regenerated plants from the protoplast will help us better understand the effectiveness of F-box protein inhibitors/agonists in cancer treatment.

Identification of dysregulated E3 ubiquitin ligases in exhausted T cells

Anna Bolding *[Mentor: B. Koss]*

University of Arkansas—Fayetteville - Biology

Applications of T cell-based immunotherapies are largely limited to hematologic cancers and efficacy in solid tumors is limited. Tumor-infiltrating lymphocytes (TILs) face a harsh environment within solid tumors, which contributes to the loss of cytotoxic function and upregulation of inhibitory receptors, leading to terminal T cell exhaustion and inhibiting the ability to control tumor growth. We aim to understand the proteins essential for T cell phenotypic plasticity, ensuring ample adaptability for TILs under these stressors. I hypothesize that E3 ubiquitin ligases play a crucial role in proteome homeostasis and preventing T cell exhaustion. Using an established in vitro model of chronic stimulation induced T cell exhaustion, we have generated exhausted T cells from three healthy humans for proteomic analysis. E3 ligase expression in these T cells will be compared to acutely stimulated T cells and T cells that receive a single restimulation. To protect T cell function, we will stably over express previously identified E3 ligases which are lost in exhausted T cells. E3 over expressing T cells will be used in a series of in vitro co-culture T cell killing experiments. Co-culture experiments will be performed to determine if the upregulation of specific E3 ligases enhances the ability of T cells to control tumor growth. These findings will further establish the role of E3 ligases in preventing T cell exhaustion and nominate candidate protein for cell engineering strategies.

New Distributional Records of Liriopogons (Liriope and Ophiopogon, Ruscaceae) in Arkansas

Jonathan Riley Kratz *[Mentor: B. Serviss]*

Henderson State University - Biology

Previous naturalized records of four species of liriopogons — Liriope graminifolia, Liriope muscari, Liriope spicata, and Ophiopogon japonicus in Arkansas were restricted to only a few south central counties, with the widest distribution exhibited by L. spicata, encompassing six counties. Additional county occurrences for all four species are documented here, with widely disjunct occurrences of L. spicata from Crawford, Phillips, and Sebastian counties. Ecological attributes, including potential for invasiveness, key characteristics for species identification, and photographs of each species in situ are provided.

Efficacy of BCL-2 Guardian-Inhibiting Drugs

Handel Justus *[Mentor: T. Moldoveanu]*

John Brown University - Biology

The BCL-2 family proteins regulate apoptosis initiation through mitochondrial poration, which releases apoptosis-inducing proteins such as cytochrome c, which then activate the caspases that execute cell death. However, the overexpression of pro-survival proteins of the BCL-2 family leads to different malignancies. This has made the pro-survival proteins a well-known target for therapeutics. However, the Moldoveanu lab has recently revealed that some of the guardian inhibitors proposed to be potent and selective for MCL-1 are not as potent in inducing apoptosis in cells that contain only the effector BAK + MCL-1 and none of the other BCL-2 family proteins, which may explain why the inhibitors failed in clinical trials due to toxicity. Building on these observations, we set out to profile the most common guardian inhibitors in cells that contain only the effector BAK ± one of the guardians (MCL-1, BCL-XL, or BCL-2) to determine their potency and selectivity in inducing apoptosis.

Synthesis, characterization and in vitro cytotoxicity of ionic-liquid based photothermal and photodynamic combination nanodrug for cancer treatment

Md. Shahedur Rahman and Zane Austin *[Mentor: N. Siraj]*

University of Arkansas—Little Rock - Chemistry

Cancer remains the second leading cause of death in the US highlighting the critical need for innovative and effective treatment strategies. Combination therapy, which employs multiple treatment methods simultaneously, reduces side effects and enhances efficacy. By leveraging ionic liquid chemistry, tunable combination drugs were developed. We introduced a novel combination nanomedicine by integrating two non-invasive phototherapies: Photodynamic Therapy (PDT) and Photothermal Therapy (PTT). Aqueous nanoparticles were synthesized using a reprecipitation method, enabling the creation of task-specific, carrier-free ionic nanomaterials (INMs). These INMs, derived from photothermal and chemotherapeutic ions, were easily modified to generate a new class of eco-friendly nanomaterials. Compared to traditional materials, INMs demonstrated advantages such as low cost, simple synthesis, broad tunability, and customizable surface chemistry. These materials exhibited advanced photophysical properties, higher cellular uptake, minimal resistance, and lower IC50 values in combination cancer therapy. By adjusting parameters like temperature, sonication time, and concentration, INMs with varying shapes, sizes, and surface charges were achieved. This study highlights the potential of organic INMs to overcome challenges in cancer therapy and drug delivery, offering an efficient, stable, and multifunctional solution against cancer and infections.

Development of a Physiological Histidine-Specific Pyrocarbonate Probe for Activity-Based Protein Profiling

Alex Van Horn *[Mentor: P. Adams]*

University of Arkansas—Fayetteville - Chemistry

Genome sequencing projects have provided on expected proteins in both eukaryotic and prokaryotic organisms. Proteomics aims to build on this by identifying the functions of these proteins, a complex task due to the vast diversity of the proteome. Activity-Based Protein Profiling is a technique that simplifies this process by directing attention towards catalytically significant amino acids within biological systems. Using these methods could extend into medicine, offering a method to target specific amino acids in the cell for drug delivery or biomarker identification of diseases. This project targets histidine. Histidine's reactivity as both a nucleophile and leaving group makes covalent modification in its native state uniquely challenging. In the past, our lab reported phosphorus species as a potential histidine probe; however, these conjugations required reaction environment outside of physiological conditions. The study's objective was to develop a histidine-specific probe and evaluate its reactivity with other nucleophilic amino acids under physiological conditions, establishing a foundation for selective histidine targeting in the body. Results from High-Performance Liquid Chromatography analysis show pyrocarbonates as an effective probe for histidine under these conditions. Future studies will explore this histidine-pyrocarbonate interaction within increasingly complex systems, progressing from small molecules to model proteins and ultimately to a lysed cell proteome.

Characterizing the Mixture Effects of Perfluorinated Alkane Systems (PFAS) with Microplastics from an All-Atom Molecular Dynamics Simulation

Elise Remerscheid *[Mentor: J. Anderson]*

Hendrix College - Chemistry

Perfluoroalkane substances (PFAS) are a class of molecules characterized by strong carbon-fluorine bonds, low polarizability, and weak dispersion forces providing numerous industrial applications. Despite their utility, PFAS has been identified by the EPA as substances of significant concern. PFAS has recently been shown to induce a structural change on microplastics, another prevalent pollutant. The PFAS-induced structural change is hypothesized to cause significant mixture effects, altering the fate and transport properties, toxicity, and associated health risks. To investigate these mixture effects, we utilize aaMD simulations of polyethylene dimer (hexane) mixed with perfluorohexane at concentrations of 0%, 25%, 50%, 75%, and 100%. In agreement with prior studies, our results demonstrate the OPLS force field does not accurately describe the conformational change observed experimentally for hexane. Additional simulations were conducted using modified hydrogen—fluorine LJ potentials, demonstrating an increase in the experimentally observed twist conformation after reducing the LJ parameter by 25%.

Developing Design Principles for Optimized Dipeptide Self-Assembly

Danny Caceres *[Mentor: J. Anderson]*

Hendrix College - Chemistry

Diphenylalanine (FF) self-assembles into highly ordered and surprisingly stable nanostructures. The characteristics of these FF nanotubes have led to a myriad of proposed applications which are predicated on the rational modification of FF to be optimized for a given application. Towards this aim, our study considers the impact of hydrophobicity, aromaticity, and sequence-dependency on the aggregation process for FF-derived dipeptides via modification of either residue to either a leucine or a tryptophan residue as compared to FF which enables a trends based on these properties. Using all-atom Molecular Dynamics simulations, our results suggest an increase in backbone monomeric conformations is correlated to a decrease in aromaticity at the C-terminus. Additionally, the backbone fractional SASA for these systems demonstrates that an increase in hydrophobicity increases the aggregation of the sidechains while inversely the backbones of LF will associate far more than either FF or WF.

Gold Nanoparticles functionalized by combination drug for improved cancer therapy

Nistha Neupane *[Mentor: N. Siraj]*

University of Arkansas—Little Rock - Chemistry

Gold nanoparticles (AuNPs) have been extensively utilized in the biomedical field for a wide range of applications, including bioimaging, photothermal therapy (PTT), biosensors, catalysis, drug and gene delivery, and surface-enhanced Raman spectroscopy (SERS). The morphology and size of these nanoparticles are crucial factors affecting their cellular uptake and bioactivity. In this study, sphere shaped AuNPs are synthesized. Furthermore, these AuNPs are functionalized with chemo-PTT combination drug based on Doxorubicin (DOX) and indocyanine green (ICG) to enhance their therapeutic properties. The nanoparticles are first be characterized using transmission electron microscopy (TEM) to determine their shape and size, followed by dynamic light scattering (DLS) to assess their hydrodynamic diameter. Zeta potential measurements are conducted to evaluate the surface charge of the nanoparticles. The functionalized AuNPs are further characterization to using FTIR and XPS to quantify [DOX][ICG] ionic material-based combination nanomedicine on the surface of AuNPs. Finally, in vitro studies will be performed to evaluate their therapeutic activity.

Enhancing chemo drug efficiency by combining therapies

Muhammad Rayaan *[Mentor: N. Siraj]*

University of Arkansas—Little Rock - Chemistry

In this study, a detailed investigation of nanodrugs derived by combining chemotherapy (chemo) and photothermal therapy (PTT) to enhance chemo drug efficacy is presented. Tamoxifen and its metabolite; N-desmethyltamoxifen are the selected chemo drugs that were combined separately with a PTT agent, NaIR820, via a metathesis approach to develop two different ionic material (IM)-based chemo-PTT drugs which does not exhibit Förster resonance energy transfer phenomena. Ionic nanomaterials (INMs) were synthesized using reprecipitation method, and these carrier-free nanoparticles were characterized in detail. Photophysical properties of the free parent compound, both IMs and their INMs revealed significant alterations in absorption and fluorescence emission spectra of IR820 in different forms. Photophysical results demonstrated that INMs exhibited promising characteristics that are beneficial for light mediated therapy. Photothermal conversion efficiency and reactive oxygen quantum yield of INMs and IMs also improved significantly in comparison to the parent IR820 compound. In vitro cell viability studies demonstrated better dark and light cytotoxicity of INMs as compared to treatments that involved either the mixture of the soluble drugs and chemo or PTT drugs independently.

Polyetherimide Polymer Membrane Separator for Batteries

Price Sheets *[Mentor: N. Siraj]*

University of Arkansas—Little Rock - Chemistry | Computer Science

Battery technologies have emerged as the preferred energy storage solution over the past 10-15 years for portable electronics, including smartphones, laptops, electric vehicles (EVs) etc. owing to its superior energy density, less affected by temperature, and long cycling performance. To further improve the life cycle of batteries, many researchers are working on different components to enhance battery efficiency along with cyclic stability. This project is designed to boost the safety and performance of the polymer membrane separator in the battery. Herein, polyetherimide (PEI) polymer is used to develop the membrane separator due to their outstanding characteristics such as thermal stability and mechanical strength etc. All these free-standing membranes are characterized in detail using tensile testing system (to evaluate their mechanical strength), and thermal gravimetric analysis (to investigate their thermal stability). Scanning Electron Microscopy (SEM) is used to investigate surface morphology, and roughness. Brunauer-Emmett-Teller (BET) analysis and Gurley testing is utilized to investigate the porosity which affects the permeability of electrolyte that consequently affect the battery performance. XPS and FTIR is performed to investigate the surface functionalities before and after coating. We were able to fabricate free standing highly therma stable membrane which are good to develop safe and durable batteries.

Low loss GaSb Waveguides for Sapphire-based Photonic Integrated Circuits Platform

Joel B.M. Ruzindana and Wisdom Ariagbofo *[Mentor: M. Shah]*

University of Arkansas—Pine Bluff - Chemistry | Physics

Photonic Integrated Circuits (PICs) offer significant advantages in size, weight, power, and cost reduction. They have been demonstrated in various material systems, including III-V, Si, Si_3N_4, and $LiNbO_3$, with varying levels of functionality. However, thermal expansion mismatch between epitaxial films and substrates contributes to defects and eventual device failure. Sapphire, with a thermal expansion coefficient closely matching those of InP and GaP, emerges as a promising substrate for III-V material growth, enabling large-scale integration platforms similar to silicon. We investigated GaSb-on-sapphire waveguides as a potential basis for sapphire-based PIC platforms using the Finite-Element Method (FEM) in Ansys software. GaSb, AlSb, and sapphire were used for the core, buffer, and substrate layers, respectively, to design rib and strip waveguides. FEM simulations evaluated multi-mode, single-mode, and cut-off conditions, as well as single-mode propagation loss, across a broad optical wavelength range of 900–2500 nm. The high index contrast between the core and substrate facilitated the design of compact, low-loss waveguides in the mid-infrared regime. This GaSb-on-sapphire PIC platform shows promise for a range of applications, including defense systems, machine learning, fiber optic communication, RF photonics, space exploration, and nuclear technologies.

Study of Temperature-dependent Raman Modes of 2D Semiconductors and their Heterostructure

Joel B.M. Ruzindana and Wisdom Ariagbofo *[Mentor: M. Shah]*

University of Arkansas—Pine Bluff - Physics

Transition metal dichalcogenides (TMDs), layered semiconductors bound by van der Waals forces, exhibit interesting layer-dependent optoelectronic properties, making them highly promising for next-generation flexible optoelectronic devices. In this study, we explored the temperature-dependent phonon dynamics of molybdenum disulfide (MoS2), tungsten disulfide (WS2), and their van der Waals heterostructures using Raman spectroscopy as a non-destructive characterization technique. Monolayers and few-layer samples were exfoliated mechanically and identified using a combination of optical contrast, photoluminescence, and machine learning techniques, ensuring high accuracy in layer determination. Temperature-dependent Raman measurements were conducted from 90 K to 300 K with 532 nm laser excitation, revealing systematic redshifts in the Raman vibrational modes with increasing temperature, indicative of phonon softening. These shifts provide insights into the anharmonic phonon interactions and thermal expansion properties of the materials. This study contributes to understanding the optothermal behavior of 2D TMDs and their heterostructures, which is essential for designing thermally robust devices. Future work will focus on exploring twist-angle effects in heterostructures and leveraging machine learning for real-time layer identification and property prediction under extreme conditions.

Spiking Neural Networks in Medical Imaging: Revolutionizing Cancer Detection

Shruti Bhandari *[Mentor: T. Ensari]*

Arkansas Tech University - Physics

Cancer identification via medical imaging has traditionally faced challenges due to the limitations of conventional computational methods. Spiking Neural Networks (SNNs) present an innovative solution, offering advanced capabilities for real-time, energy-efficient analysis of medical images. This study investigates how SNNs transform tumor detection by emulating biological neural processing, resulting in marked improvements in both computational efficiency and diagnostic precision.

Our research indicates that SNN methodologies achieve detection rates of up to 95% across various imaging techniques, including MRI and CT scans, while using around 30% less energy than traditional neural network models. By adopting event-driven, spike-based processing, these networks analyze medical images with noteworthy accuracy, lowering false positive rates and facilitating quicker, more sophisticated diagnostic tools.

The research underscores the revolutionary potential of SNNs in medical imaging, demonstrating their capability to surpass conventional computational limitations. As neuromorphic computing progresses, SNNs are poised to significantly transform cancer screening technologies, providing more accurate, efficient, and potentially life-saving diagnostic solutions.

Mapping the use of GAI in a Higher Educational Context

Cristian Del Gobbo *[Mentor: M. Birkenkrahe]*

Lyon College - Computer Science | Mathematics

The body of scholarly literature on Generative Artificial Intelligence (GAI) is rapidly growing, exploring diverse applications of these technologies. However, few studies have examined the extent and frequency of GAI usage among students, particularly in small colleges. This study, conducted between August and November 2024 at Lyon College, a small liberal arts institution in Arkansas, investigated the prevalence, extent, and nature of GAI usage by students in their academic activities. An anonymous survey of seven questions was designed to explore students' use of GAI tools. The survey included closed-ended and Likert-scale questions and was administered in classes across various departments to maximize response rates and ensure a diverse sample (n = 171). The findings revealed the proportion of students using GAI tools, the frequency of use, specific purposes, and the most commonly favored tools. The study also highlighted differences between native and non-native English speakers, with a significant sample of international students (n = 52) providing insights into unique patterns of GAI usage, such as language support. While variations across academic disciplines were observed, small sample sizes in some fields limited definitive conclusions.

This research provides valuable insights into the adoption of GAI in a small college setting, offering guidance for integrating AI technologies in higher education and promoting responsible use to enhance learning outcomes.

Autoclave Water Distillation System

Jackson Macdonald, Cody Ferguson, Renny Buchanan, and Alex Richards *[Mentor: M. Kim]*

John Brown University - Engineering

Distilled water is a crucial resource in hospitals, primarily used in steam autoclaves to sterilize medical equipment. Without distilled water, mineral deposits from ground water can cause corrosion and damage to these autoclaves over time. Many remote healthcare facilities struggle to access a sufficient supply of distilled water, leading to prohibitive costs for autoclave maintenance and replacement. In Uganda, where groundwater is the main source of water, this issue is particularly pressing. The country's groundwater is often contaminated with harmful substances such as E. coli, Salmonella Typhi, and lead, making it necessary to distill the water for safe use. The purpose of this project is to design a system to distill water and monitor quality to meet the needs of health care facilities lacking funding and resources for traditional distilled water sourcing. Distilled water is defined as water that meets specific quality standards: a resistivity greater than 1.0 MΩ/cm, conductivity below 1.0 µS/cm, and total organic carbon (TOC) levels under 50 parts per billion. The proposed system distills water through an evaporation and condensation system. This is tested through conductance measurements and displayed on an associated app. The app has additional user-friendly feature such as providing build instructions and maintenance references.

Fatigue Behavior of 3D-Printed Nylon and ASA for Aerospace Applications

Brayden May and Collin Kita *[Mentor: M. Amjadi]*

Arkansas Tech University - Engineering

Additive manufacturing, commonly known as 3D printing, has revolutionized the production of lightweight, customized, and cost-effective components across various industries. This study specifically investigates the fatigue behavior of two thermoplastics—Nylon and ASA—fabricated using the Fused Deposition Modeling (FDM) technique. These materials have demonstrated significant potential in aerospace applications, particularly for lightweight structural components in mini drones and satellites, where corrosion resistance and high performance are critical requirements. Specimens were manufactured using the state-of-the-art Bambu Lab X1 Carbon printer, and the influence of key printing parameters—such as infill density, layer height, and test frequency—was systematically analyzed under cyclic loading. Among the infill patterns investigated, the Gyroid pattern exhibited superior fatigue performance due to its isotropic mechanical properties and optimized strength-to-weight ratio. Additionally, the study revealed that higher infill densities contributed to increased fatigue life, while variations in testing frequencies provided insights into material behavior under dynamic loading conditions. These results were consistent with the behavior observed in conventionally manufactured injection-molded specimens, affirming the viability of 3D-printed components in demanding aerospace environments.

RNA-guided Transcriptional Upregulation of Duchenne Muscular Disease Modifiers Using CRISPR-DREAM

Ian Popp *[Mentor: C. Nelson]*

University of Arkansas—Fayetteville - Engineering | Chemistry

Duchenne Muscular Dystrophy (DMD) is an X chromosome related neuromuscular genetic disease that affects 1 per 5,000 male births. DMD is caused by a mutation that affects the production of the dystrophin protein, resulting in either no expression or a defective protein. Utrophin is a paralog of dystrophin which can alleviate the impact of dystrophin protein deficiency. Gene therapy techniques have been used to increase the expression of utrophin (gene name UTRN). When UTRN RNA expression is increased, more utrophin proteins will be produced by the cell, alleviating the disease. Target sequences for each gene were transformed into CRISPR-DREAM plasmids for transcriptional regulation. CRISPR-DREAM is a version of CRISPR-dCas9 with transcriptional activation domain plasmids (TADs) derived from humans rather than viruses that could elicit a lesser immune response [8]. We aim to determine the optimal use of CRISPR-DREAM in skeletal muscle tissue for guide sequences to treat DMD in a mouse skeletal muscle myoblast cell model (C2C12). The C2C12 cell line was transfected using lipofectamine to deliver the therapy. Media samples were collected after transfection, and RNA transcriptional efficacy was determined using Quantitative Reverse Transcription Polymerase Chain Reaction (qRT-PCR). Guide sequences upstream of the promoter region performed better than downstream sequences. Both TADs of CRISPR-DREAM increased the Utrn expression showing promise for the tool for DMD therapies.

Historical trends in streambed elevation changes at USGS gaging stations on the Gasconade River, Missouri Ozarks

Calvin Burdess *[Mentor: M. Connolly]*

University of Central Arkansas - Geography | Environmental Science

Natural and anthropogenic disturbances impact erosion and deposition in river systems, influencing stream channel evolution. Over the past century, Missouri's Ozark Plateaus have experienced significant land use changes and potential climate shifts, affecting local waterways. Stakeholder concerns and prior research led the USACE and MDNR to investigate erosion in the Gasconade River. Historical USGS field measurements from gages at Rich Fountain, Jerome, and Hazelgreen were analyzed to assess streambed elevation (MSBE) trends filtered by streamflow and gage proximity. These gages, representing key watershed locations, reveal distinct patterns. Rich Fountain, the most downstream gage, shares similarities with Jerome, centrally located near a major tributary confluence. Both gages were stable from the 1920s to 1950s, showed deposition trends from the mid-1980s to 2000s, and displayed steep erosion from the early 2000s to late 2010s. Hazelgreen, the most upstream gage, was stable from the 1920s to late 1940s, experienced minor deposition in the early 1950s, and showed erosion from the late 1990s to late 2010s. These findings align with USGS analyses through 1994 and suggest ongoing watershed changes that could inform future water management strategies.

AI-Driven Approaches in Aquaculture: A Review of Fish Disease Detection Techniques

Sushovon Rangon *[Mentor: M. A.S. Siddique]*

Arkansas Tech University - Engineering

The primary objective of this review study is to explore the potential of implementing artificial intelligence (AI) through various machine learning algorithms to detect fish diseases. Fish is an important source of animal protein essential for human health. The growing demand for fish production has made fish farming a significant contributor to the economy. Failure to detect fish diseases early can disrupt the minimum supply of protein and hinder the economic stability of fish farms and related industries. Traditional methods rely on experts and professionals manually detecting fish diseases, which is time-consuming and requires more reliability. To address the need for real-time disease detection in aquaculture, integrating AI offers a superior alternative to the limitations of traditional approaches. These advanced technologies enable fish farmers to reduce workload, enhance detection efficiency, and classify diseases accurately and quickly, achieving real-time results. In this study, we systematically reviewed 31 papers on fish disease detection using machine learning techniques. We comprehensively searched multiple journal databases following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines 2020. The review highlights the application of various machine learning methods, including Support Vector Machines (SVM), Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Naive Bayes, and K-nearest neighbors (K-NN).

Early plant succession following the drawdown of Lake Conway

Braeden Hurley *[Mentor: M. Reid]*

Hendrix College - Biology

Lake Conway, a large manmade lake, is in the process of being drawn down for restoration. This drawdown exposes land that now undergoes ecological succession, the process by which plant communities change over time. We investigated plant community changes along a drawdown gradient. We established twelve transects across the lake, and took three 1-m2 plots per transect. For each plot, we recorded plant species presence and abundance, canopy cover and soil pH. We calculated Shannon diversity and species richness, and we assessed overall community composition using multivariate statistics. We found that while drawdown had no effect on Shannon diversity and richness, the plant community changed significantly along the drawdown gradient. Canopy cover had a significant impact on diversity, but all other environmental factors had no effect. The data suggest rapid turnover of the plant community has occurred with lake drawdown, with further plant community changes likely to continue.

Inorganic Nutrient Dynamics within Brewer Lake, Arkansas: Seasonal Variation and Experimentally Determined Sediment Release Rates

Haley Racioppo *[Mentor: H. Halvorson]*

University of Central Arkansas - Biology

Brewer Lake serves as the drinking water reservoir for over 80,000 residents. Nutrient loading may cause this reservoir's occasional algal blooms and seasonal taste/odor issues. We have conducted routine water sampling since 2020 to measure nutrient concentrations. Generally, autumn and winter samples exhibit the highest ammonium concentrations while winter and spring samples exhibit the highest nitrate concentrations. Variation of these nutrients is likely driven by external and internal sources, contrasted by sinks such as phytoplankton uptake. During May 2024, we collected sediment cores to investigate the lake's internal loading. Nutrient release rates were calculated following an incubation experiment, where the cores experienced oxic and anoxic treatments, representing the lake's seasonally mixed and stratified periods. The anoxic sediment cores had greater ammonium and lower nitrate release rates. Mineralization continuously releases ammonium, but nitrification can only proceed in oxic conditions, possibly driving this contrast. However, phosphate release rates were not different between the two treatments. Mobile and nonmobile phosphorus fractions can be unequally distributed throughout lake sediment, so future experimentation to quantify these phosphorus fractions may explain the phosphate release. Overall, this information and continuous lake monitoring may help explain algal blooms and taste/odor events in Brewer Lake and other reservoirs.

Nanoplastics from food containers and their effects on cultured SHY5Y cells

Hannah Bearden *[Mentor: J. Hyde]*

Southern Arkansas University - Biology

Nanoplastics comprise plastic particles < 1 micrometer in diameter and can potentially have a negative effect on our bodies. Previous studies have shown that these particles are regularly shed by plastic food containers and that they can accumulate within the brain and other organs. While extensive studies have been conducted on microplastics (>1 um diameter) very little research has been done on the biological effects on nanoplastics. The overall goal of this project is to analyze and record the activity and viability of differentiated SHY5Y neurons in the presence of food container derived nanoplastics. Distilled water was boiled in three different types of plastic food containers (two polypropylene (PP) and one polycarbonate (PC)) and one glass container. Water samples were microwaved in four samples of each type of container for 3 minutes. Samples were stained with lipophilic nile red stain to fluorescently label plastic particles. Particle counts were taken with a flow cytometer. Results showed that polypropylene releases between 1 to 7 million nanoparticles per square centimeter of water exposure while polycarbonate was comparable to glass controls. Most of these particles were between 200 to 500 nm in diameter. In upcoming work, the cells will be exposed to plastic nanoparticles, and we will measure changes to cell activity, oxidative stress, metabolism, and DNA damage.

Testing Raw (Influent) Wastewater as a Seed Control for the CBOD Method

Rylee Griffs *[Mentor: G. Geme]*

Southern Arkansas University - Chemistry

Carbonaceous biochemical oxygen demand (CBOD) tests for organic pollution in effluent (treated wastewater) and treated drinking water by looking at how microorganisms use dissolved oxygen when metabolizing organic pollutants. This process can be affected by temperature, pH, the presence of specific microorganisms, and the types of organic/inorganic compounds in the water. This test also ensures that the organisms in the receiving body of water are not deprived of oxygen. Synthetic seeds provide microorganisms capable of oxidizing the oxygen in the samples; these synthetic seeds can be stored for an extended period at relatively high/low temperatures and provide a seed without using raw (influent) wastewater. However, with rapidly increasing prices, the variability of the synthetic seed from capsule to capsule, and the inability to match the matrix of the effluent wastewater, synthetic seeds introduce errors in glucose-glutamic acid (GGA) recovery. This is used to determine the accuracy of the CBOD test and has to be included in every batch of samples run. Influent seed is more cost-effective, matches the matrix of the effluent wastewater, and varies, along with the samples, with changes in the environment (pH, temperature, weather, etc.). This experiment aimed to determine if raw (influent) wastewater acted as a better seed source than synthetic seed by comparing the accuracy provided by the comparison of the GGA recoveries.

A Ni-N4 Model Complex of Ni F430 Cofactor to Investigate the Methane Release Mechanism of MCR

Satya McCarthy-Rotella *[Mentor: P. Truong]*

Hendrix College - Chemistry

Methane is a very small and potent greenhouse gas, accounting for 16 percent of greenhouse gas emissions while being 28 times more potent than CO2. This means that methane has much stronger short-term effects than CO2. Methane emissions come from mainly anthropogenic sources such as methane flaring in petroleum industry, animal agriculture waste, and landfills. Methyl coenzyme M reductase (MCR) is an enzyme present in methanogenic, or methane generating, anaerobic bacteria. This enzyme and the methane generating reaction it catalyzes holds the potential for the creation of methane storage via chemical bonds. We take inspiration from nature to study methane storage by designing catalysts that can efficiently store and release methane from a chemical carrier. The Ni-containing redox-active metalloenzyme, MCR, can catalyze the generation of methane from the H3C–SR bonds in its active sites. The exact mechanism of this process is still under debate, mainly due to the high sensitivity of the Ni F430 cofactor found in the active site, which oxidizes into an inactive species that cannot be investigated when in the presence of O2.To gain a better understanding of the mechanism of operation of MCR, we use non-heme ligand, LN4Im, as a synthetic model to approximate the coordination environment for Ni found in the Ni F430 cofactor of the active site. In this work, we will present the synthesis and characterization of the ligand and the subsequent metalated complex, [NiN4Im]2+.

Investigating changes in compaction of PEP-19 by neurodegenerative oligomers

Emma Brown *[Mentor: T. Dunlap]*

University of Central Arkansas - Chemistry

PEP-19 is a disordered protein that regulates the binding of Calmodulin (CaM) to calcium. With calcium signaling, PEP-19 is able to bind to CaM, increasing the rate of calcium binding in the C-terminal lobe of CaM. PEP-19 is strongly associated with neurodegenerative diseases. It is found in higher levels in brain areas spared in Alzheimer's Disease and found at a deficit in brain areas affected by Parkinson's disease. PEP-19 has also been shown to prevent excess calcium signaling caused by an overload of calcium ions within the brain. However, excess PEP-19 can lead to premature neuronal differentiation and learning deficiencies. We investigated how PEP-19 and the CaM/PEP-19 complex are affected by neurodegenerative oligomers through the use of fluorescence resonance energy transfer (FRET). We used this to measure the end-to-end distance of PEP-19 by itself, in complex with CaM , and with the neurodegenerative proteins alpha synuclein and A-beta peptide.

Revolutionizing Medical Image Segmentation with Unmatched Precision and Efficiency with PH-SAM

Malak Bachri, Christian Young, and Dalton Grissom

[Mentor: A. Al-Shami]

Southern Arkansas University - Computer Science

Persistent Homology (PH) has emerged as a prominent tool in topological data analysis. Building on this foundation, we present PH-SAM, an innovative hybrid framework designed for segmenting X-ray images with targeted implants in medical imaging. This approach combines the strengths of PH and the Segment Anything Model (SAM) to generate detailed image feature profiles. These profiles effectively highlight the unique characteristics of regions of interest (ROIs), such as knee implants, facilitating accurate differentiation between implants and surrounding normal tissues. The primary objective of PH-SAM is to deliver automated, fast, and highly accurate segmentation of knee implants in X-ray imaging.

Sacred Marriage Life Program: An Initiative of Center for Healthy Relationships

Robin Chavez and Marlon Gaitan *[Mentor: J. Selwyn]*

John Brown University - Computer Science

According to 2022 Census data Arkansas had a higher marriage rate than the national average, with 19.5 marriages per 1,000 people from ages of 15 and older, compared to 17.3 nationally. However, Arkansas' divorce rate is nearly 67% higher than the national average, the state experienced 11.5 divorces per 1,000 residents from ages of 15 and older, compared to 6.9 nationally in 2022. This data reflects an alarming trend for new marriages in the state. The Sacred Marriage Life Program (SMLP) is a digital platform designed to revolutionize the way Center for Healthy Relationships at John Brown University collects, manages, and analyzes relationship data from churches, pastors, and church members.

The software development platform is C#.NET framework enabling a responsive and modern user interface. Microsoft Azure SQL Database handles data storage, providing reliable and scalable options for managing large datasets. For data analysis, machine learning algorithms will be built and integrated into the system, offering insights and predictions to users. Microsoft Azure App Service will host the platform, ensuring consistent availability and minimal downtime.

SMLP has the potential to create lasting positive impacts on marriages across NW Arkansas, extending CHR's reach and addressing the high divorce rates afflicting the state. This initiative aims to redefine how church communities approach relationship building, fostering resilience and unity in the face of societal challenges.

Optimizing Poultry Processing Efficiency: Automating Chicken Nugget Weighing and Counting with Computer Vision

Noah Olson and Roberto Aguero *[Mentor: J. Selwyn]*

John Brown University - Computer Science

The world of software is constantly evolving, driving the automation of numerous human processes to enhance efficiency across various sectors, including the food industry. Tools such as computer vision and machine learning allow for a significant improvement to accuracy and speed in certain processes. Understanding the benefits of such advancements and their ability to modernize daily operations is crucial to leverage their full potential.

A multi-national poultry processing company is striving for operational excellence, and they seek to optimize its processes by leveraging a CVML (Computer Vision and Machine Learning) system. Currently, quality checks are performed manually by operators and technicians who obtain product weight and count data. To improve the efficiency of said process and optimize resources, one solution is to use a computer-vision aided system that will identify the nugget samples to perform these calculations. The goal is to have a properly trained model that is able to accurately determine what is a chicken nugget despite the potential edge-cases. Upon this identification, the nuggets would then be counted/weighted and categorized accordingly to the given parameters. To achieve these goals, OpenCV is used with a trained YOLOv10 (You Only Look Once) model.

Additionally, broader implications of computer vision in the food industry will be incorporated, aiming to highlight the transformative role of these advanced technologies in our traditional workflows.

Deep Learning-Based Multi-Class Classification of Breast Cancer Ultrasound Images Using Convolutional Neural Networks

Andres D. Urdaneta *[Mentor: R. Ghosh]*

Arkansas Tech University - Computer Science

The National Cancer Institute forecasts 2,001,140 cancer diagnoses in 2024, with approximately 600,000 expected deaths. Breast cancer is projected to be the most prevalent, with about 310,000 cases. Early diagnosis is critical for improving outcomes, and various diagnostic technologies, including imaging, biopsies, and blood tests, play a vital role. Image testing methods encompass X-rays, ultrasounds, MRIs, and PET scans. Artificial intelligence (AI) has recently significantly enhanced cancer detection, improving speed, accuracy, and effectiveness. This research project utilizes a convolutional neural network (CNN) to analyze ultrasound breast images, classifying them as benign, malignant, or normal. Our CNN model was trained on a dataset of 1,664 images: 556 normal, 548 malignant, and 560 benign. The images were obtained from four sources, preprocessed to greyscale, and resized to 50x50 pixels. After dividing the dataset into training, validation, and testing sets, the model was trained for 100 epochs with a learning rate 0.1e-3. The results indicated a training accuracy of 99.3% and a validation accuracy of 85%, revealing some overfitting. We are exploring techniques like data augmentation and dropout layers to address this and improve generalization. Ultimately, we aim to incorporate bounding boxes or segmentation algorithms to identify tumor locations, providing medical professionals with enhanced diagnostic tools for cancer detection.

Detection Strategies for Prompt Injection Attack in Large Language Models (LLM)

Angelina Das *[Mentor: R. Ghosh]*

Arkansas Tech University - Computer Science

The increasing use of Large Language Models (LLMs) in various applications highlights the need for robust security measures against threats like prompt injection attacks. These attacks can manipulate model inputs, resulting in undesirable outcomes like data deletion or alteration. This research focuses on developing a security system to detect and prevent such attacks, particularly within a campus health center's appointment scheduling system. We proposed a solution that utilizes ALBERT (A Lite BERT), a lightweight version of the BERT model, to identify prompt injection attempts. The model is fine-tuned to classify user inputs as legitimate or malicious, concentrating on detecting prompt injections that could compromise appointment -related data. It is trained on two datasets: legitimate student queries for booking, rescheduling, or canceling appointments and malicious attempts to manipulate or erase others' appointment details. The model uses binary classification to recognize subtle differences between regular requests and those embedded with injection tactics. Its performance metrics ensured the effective detection of harmful queries while minimizing false positives. This project provides a practical solution to enhance the security of LLM-dependent systems by detecting prompt injection attacks.

AI-Driven Chatbots for Mental Health Care: A New Frontier

Anish Illapaka *[Mentor: R. Ghosh]*

Arkansas Tech University - Computer Science

The growing prevalence of mental health concerns worldwide underscores the urgent need for accessible, scalable, and supportive solutions. Artificial Intelligence (AI) has emerged as a promising tool in this domain, capable of delivering immediate and empathetic interactions to complement traditional methods of mental health care. This project introduces a conversational AI system to assist individuals experiencing mental health challenges. The proposed system is built on a LLaMA model fine-tuned with a dataset of 10,000 mental health-related dialogues; the system leverages advanced natural language processing and machine learning techniques for meaningful engagement. The core functionality of this tool lies in its ability to understand user inputs, retain context across conversations, and offer tailored responses. By utilizing LangChain's Conversation BufferMemory, the system ensures seamless and personalized conversation flow. Inferencing is managed efficiently through deployment on Ollama, while ethical principles such as user privacy, inclusivity, and sensitivity remain central to its design. This study evaluates the chatbot's effectiveness in recognizing nuanced user expressions, providing constructive suggestions, and bridging gaps in AI-based mental health support systems.

SPS@UCA: Small Parallel Supercomputer at UCA

Shawn Govitz and John Phillips *[Mentor: J. Lusk]*

University of Central Arkansas - Computer Science | Engineering Physics

Modern scientific computing often requires large scale high performance computing which typically costs millions of dollars. This project allows students to learn about everything that goes into building a small scale parallel supercomputer. Students will interact with the hardware, software, and simulations that are handled by the computer. The way a parallel computer operates is different from how a normal computer operates, so it is important for students to interact with the machine.

The AI Center at LISA Academy

Shruti Bhandari *[Mentor: T. Ensari]*

Arkansas Tech University - Computer Science

LISA Academy, a public charter school, initiated the AI Center in 2024. It has established a dynamic range of activities aimed at fostering an inclusive and forward-thinking AI ecosystem. These include starting a school-wide AI Committee to guide our initiatives, hosting research talks, forums, and inviting guest speakers to inspire our students, parents, and community. We organize training and workshops to enhance AI literacy and host Parent Academies to engage families. Our research and development center (R&D) department actively applies for research grants through science-based agencies. By involving students, teachers, and parents, we aim to cultivate an AI culture, establishing cutting-edge AI Labs and developing an AI-focused curriculum for AI-driven education. We also offer an 'AI Club' for students, an AI Career Day, and opportunities for cooperation and publication. To enrich the learning experience, we organize STEM festivals, science fairs, field trips, book clubs, and numerous forums for interdisciplinary engagement.

Separating Signal From Noise in Annotator Disagreement

Jonathan Ivey *[Mentor: S. Gauch]*

University of Arkansas—Fayetteville - Data Science

Many AI models learn their behavior from human annotations (e.g., having people label whether a Twitter post is hate speech). This data is important because it determines what opinions and values are represented in the machine learning models that train on it. To improve the training data, researchers often attempt to remove spam annotations that do not provide useful information for the model. Most noise reduction methods assume there is only one possible label for each data point (e.g., every tweet is either hate speech or not hate speech). However, there are subjective tasks, like determining offensiveness, where annotators may have a valid disagreement. In this project, we use synthetic data experiments to evaluate noise reduction methods on data with genuine disagreement, and we find that current methods actively suppress dissenting opinions. Additionally, we find that these methods consistently rate minority annotators as worse than their majority counterparts and significantly underrepresent minority opinions in their final ground truth estimates. Then, we develop new Bayesian methods that use group-level variation to reduce spam while retaining disagreements, and we perform experiments demonstrating that our new methods are effective at recovering ground truth in both synthetic and real-world data experiments.

Hybrid PV-TEG System

Thomas Dodds, Anna-Marie Pesaresi, Paige Woolheater, Nicholas Colburn, and Chance Eoff *[Mentor: Z. Zamanipour, S. H. Hosseini]*

Arkansas Tech University - Engineering

The aim of this research project is to develop an innovative approach to improving the efficiency of a well-established renewable energy source. Solar cells are becoming more prominent as the power industry moves towards clean energy sources. Photovoltaic (PV) solar cells can only absorb a portion of the irradiance spectrum. The portion that is not absorbed transforms into heat, raising the system temperature. PV cells' efficiency drastically decreases as the module temperature rises and more energy is lost in heat waste. Thermoelectric generators (TEGs), when combined with PV panel, thrive off PV panel drawbacks. The hybrid system in this study consisted of an array of TEGs attached to the back of a PV cell. Power generation, efficiency, and temperatures of both hybrid and standalone panels are measured and compared.

The results show that the hybrid panel generated higher output power by 1.84% and efficiency by 2% at the peak irradiance. However, the data shows no temperature reduction. It is expected that the use of this renewable energy source will increase as hybrid systems are more efficient and generate more power than standalone PV cells.

Examining the Effects of Quercetin on Mesenchymal Stem Cell Potency

Thomas Needy and David Heinrichs *[Mentor: R. Samsonraj]*

University of Arkansas—Fayetteville - Engineering | Biomedical Engineering

Mesenchymal Stem Cells (MSCs) can self-renew and differentiate into cell lines such as osteoblasts, adipocytes, and chondrocytes. An obstacle to obtaining large populations of potent, and functional cells crucial to regenerative therapies is senescence, an irreversible cessation of replication associated with age-related dysfunction. Senolytics, such as quercetin, may be beneficial in eliminating senescent cells while preserving non-senescent populations, increasing the therapeutic value of older MSC passages. This study investigated quercetin's phenotypic, genotypic, and immunomodulatory effects using in vitro models. Senescent cells and non-senescent controls were treated with 10 µM quercetin, differentiated into osteocytes, adipocytes, and chondrocytes, and analyzed to observe the effect of quercetin. Quercetin did not demonstrate consistent senolytic effects, as shown by SAβ-gal and live dead staining. Additionally, it impaired short-term cell proliferation and lowered the expression of osteogenic markers COL1A1 and ALP. However, quercetin treatment did not negatively affect adipogenesis, chondrogenesis, or the secretion of the immunomodulatory enzyme indoleamine 2,3 dioxygenase. These findings indicate that quercetin may not be optimal for enhancing in vitro MSC function. Further research into alternative senolytic compounds and long-term senolytic treatment could provide better strategies for increasing in vitro MSC lifespan and therapeutic utility.

Nuclear Localization and Function of Endosomal Toll-like Receptor 8 Uncovered by a Proximity-Ligation Assay

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Toll-like receptors (TLRs) recognize pathogen-associated molecular patterns (PAMPs) and activate pro-inflammatory signaling cascades in innate immune cells. Toll-like receptor 8 (TLR8) is expressed primarily by macrophages, where it recognizes single-stranded RNA (ssRNA) and RNA degradation products. TLR8 is linked to foam cell biogenesis in atherosclerotic cardiovascular disease (ASCVD). To better understand how TLR8 contributes to foam cell biogenesis, we sought to identify the interactome of TLR8 in cultured cells. We developed a proximity ligation strategy in which a split N-terminus of a biotin ligase (TurboID) was cloned to the cytosolic domain of TLR8, and the split C-terminus of TurboID was cloned to Rab5, an endosomal GTPase. HEK293T cells were transiently transfected with split-TurboID plasmids, and biotinylated proteins were captured from protein lysates using streptavidin beads. We discovered 73 proteins enriched in cell lysates in which TLR8 was overexpressed in the presence of a ssRNA ligand. Unexpectedly, pathway analysis of TLR8-interacting proteins revealed enrichment for proteins localized to the nucleus, and more specifically the spliceosome. Moreover, our pathway analysis identified enrichment for genes linked to mRNA processing (30%) and splicing (27%). Putative TLR8-interacting proteins for ongoing validation are DEAD-box helicase 46 (DDX46), an RNA helicase linked to non-coding RNA splicing, and CACTIN, a negative regulator of TLR signaling.

Radio Observations of the April 8, 2024 Total Solar Eclipse at 1420MHz

August Childress and Blayne Griffin *[Mentor: J. Lusk]*

University of Central Arkansas - Physics

We present radio telescope observations of the 08 April 2024 total solar eclipse from the University of Central Arkansas campus in Conway, Arkansas using a 2.3-m SPIDER 230C parabolic radio telescope tuned to a frequency of 1420 MHz. Observations began approximately 19 minutes before first contact, and ended approximately 2.5 minutes after fourth contact, tracking the sun across the sky using a German equatorial mount. Our observations show a reduction in relative radio intensity from the beginning of the lightcurve to the middle of totality of approximately 72%. In our current work, we aim to compare this radio lightcurve with theoretical lightcurves of the eclipse as observed from our location, as well as a relative visible lightcurve derived from the archived livestream of the eclipse broadcast by the University of Central Arkansas observatory. Our goal is to compare these observations in order to determine the relative size of the visible and radio sun.

Pass Me a Beer and a Controller: College Students' Alcohol Use While Playing Video Games With Friends

Zander Putman, Clara Pool, and Madelyn Null *[Mentor: B. Zamboanga]*

University of Arkansas—Fayetteville - Psychology

Among college students, drinking alcohol socially and playing video games with friends is widespread. Research suggests that gaming is related to increased alcohol use and drinking while gaming can increase one's risk of experiencing negative alcohol-related consequences. As well, drinking motives are predictive of alcohol use (quantity/frequency/problems); however, their link to drinking while gaming with friends is unclear. We investigated two relationships: frequency of drinking while gaming with friends and alcohol use (AUDIT-C) and endorsement of drinking motives and frequency of drinking while gaming. Multiethnic/racial undergraduate drinkers (N=439/female=59%/White=58%/Hispanic=17%/Asian=6%/African American=5%) from eight colleges/universities completed a self-report survey. Correlations (adjusting for age, sex, ethnicity, and Greek status) indicated that frequency of alcohol use while gaming with friends was positively associated with AUDIT-C scores ($r=.37$, $p<.001$). Enhancement motives ($r=.32$), social motives ($r=.24$), and coping motives ($r=.14$) were significantly associated with drinking while gaming with friends. Students who drink while gaming with friends are more likely to be frequent drinkers and report drinking motives tied to higher alcohol consumption, suggesting they may be at greater risk for drinking consequences. Universities could hold tabling events to educate students about the risks of drinking and gaming with friends.

Monitoring Water Quality in Freshwater Ponds and a Natural Spring in Ouachita County, AR

Grace Edwards, Rylee Griffs, Colton McPherson, and Victoria Allison *[Mentor: G. Geme]*

Southern Arkansas University - Chemistry

Ponds are essential ecosystems inhibited by a diverse population of organisms. A spring is formed when natural pressure forces groundwater above the land surface. This spring is a source of one of the ponds tested in this study. In the past, little to no forest management has been performed in the forests surrounding these ponds; this eliminates the possibility of pollution by controlled burns and other applications. However, once forest maintenance begins, the ponds could be exposed to pollutants. Climate change could also affect ponds; Arkansas' temperatures are steadily rising, and precipitation levels are increasing. Samples were collected over one year in two-week increments to analyze the dissolved oxygen, pH, total coliforms, biochemical oxygen demand, and concentrations of total suspended solids, chlorophyll, total phosphorus, and total nitrogen in the ponds. The weather and air temperature were noted during sampling. Different instruments were utilized to perform these analyses: a pH probe, filtration, two DO probes, a total nitrogen analyzer, UV-Vis Spectrophotometry, a digestor, and incubators.

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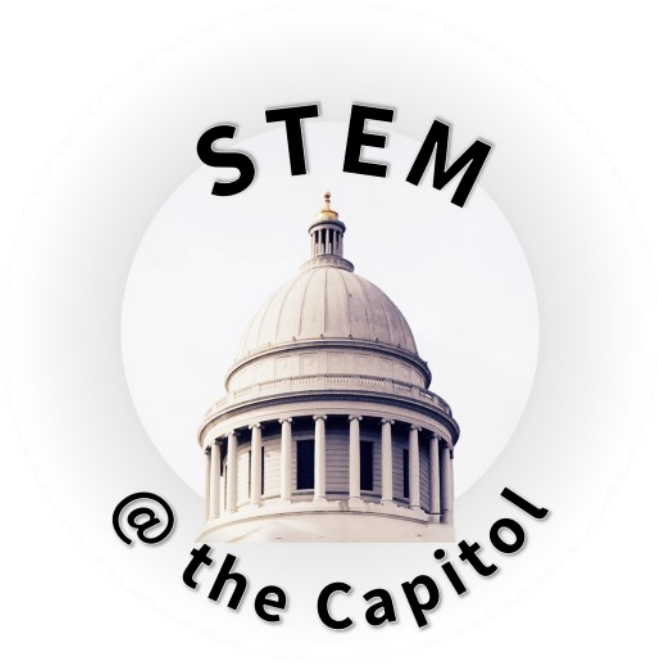

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