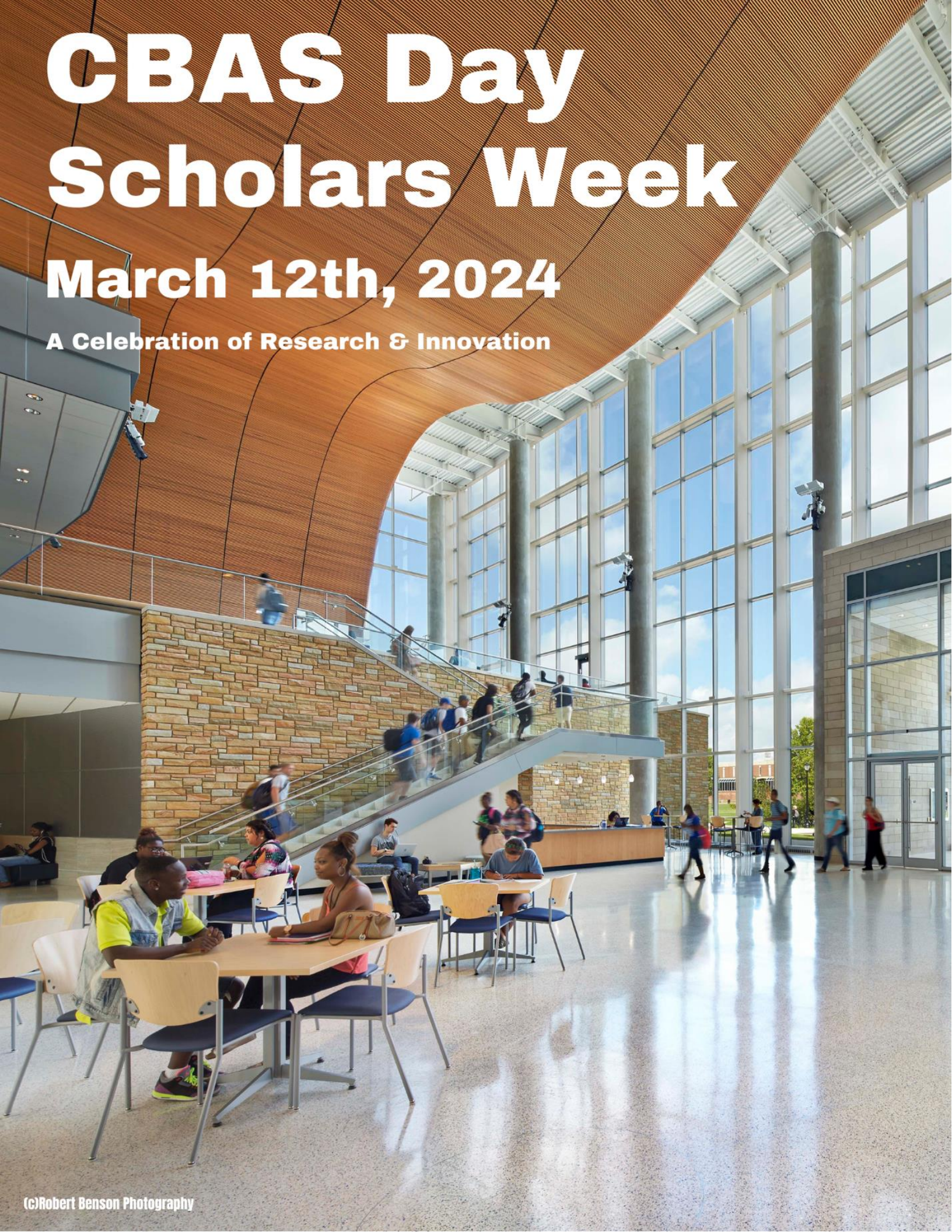
CBAS Day Scholars Week

March 12th, 2024

A Celebration of Research & Innovation



Welcome to the College of Basic and Applied Sciences Scholars Day. I appreciate your attendance at and support of this important day in the life of our College. Scholars Day is a wonderful opportunity for CBAS faculty and students to showcase their research work and for the entire college community to come together to celebrate the fruits of that labor.

Research is central to the CBAS mission. It is but one way that the College contributes to society, by addressing important problems and generating new knowledge. More importantly, it is vital to the education of our students, as it teaches them to use the scientific method, provides hands-on practice of disciplinary skills, requires them to apply knowledge learned in the classroom, and allows them to experience firsthand the excitement of discovery. Research is never complete until results have been communicated, so Scholars Day itself also represents as important step in the research process.

I am delighted to see continued growth in the event with more than 100 posters entered this year. I am extremely proud of the high quality of research consistently produced in our College. I hope you enjoy these presentations and feel the same sense of pride as you participate in this year's event.

-Greg Van Patten, Dean

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Dr. Aaron Bender (Asst. Director of Medicinal Chemistry at the Warner Center for Neuroscience Drug Discovery) – *New Opportunities for Serotonergic Drug Discovery*

2:00 pm – 2:30 pm: Poster Session Awards, *School of Concrete and Construction Management Building, Room 105*

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Abstracts

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Faculty Mentor: Jeremy Strayer
Mathematics – Doctoral

Preservice Teachers' Knowledge and Understanding of Fraction Division

It is important for preservice teachers (PSTs) to have a deep and connected conceptual understanding of mathematical concepts they will teach in their future classrooms (Ball, 1990; Da Ponte & Chapman, 2015). For this reason, teacher education programs work to provide opportunities for preservice teachers' (PSTs') to build understanding of the various ways students conceive of significant mathematical ideas and practices (e.g., Ball et al., 2008; Hill, 2010; Li, 2008; Li & Kulm, 2008; Lo & Luo, 2012; Tirosh, 2000). Therefore, it is important to investigate PSTs' conceptions, connections, notions, and understandings of specific mathematics concepts so that results can be used to inform effective instruction in content courses for future teachers.

38. Ashiat Adeogun
Faculty Mentor: Dr. Misagh Faezipour
Engineering Technology – Masters

Patient-Centric Paradigm: A Systems Thinking Approach to Enhance Healthcare

This study is a vital exploration into advancing patient-centered treatment through a systems thinking approach. At its core, patient centricity involves integrating actions that actively listen to and interact with patients, prioritizing their well-being in all healthcare initiatives. The prevalence of patient centricity in contemporary healthcare can be attributed to factors such as the increasingly connected and well-informed nature of patients, reflecting a societal shift. It also signifies a conscientious acknowledgment of the ethical responsibilities inherent in the healthcare system, emphasizing the importance of putting the welfare of patients at the forefront. The primary goal of this work is to identify strategic intervention opportunities by intricately examining the subtle interactions and feedback loops within the healthcare system. Globally, healthcare systems are undergoing a transformative shift towards patient-centric methodologies, recognizing the imperative need to place patients at the epicenter of healthcare delivery. The study significantly contributes to this paradigm shift by demonstrating how a systems thinking lens can strategically enhance the quality and effectiveness of patient-centered care. It underscores the potential of incorporating a systems thinking perspective into healthcare practices, serving as a guiding beacon for healthcare professionals, policymakers, and stakeholders towards a future where patient-centric approaches are not merely a goal but an integral part of the healthcare ethos.

40. Rahmi Aini
Faculty Mentor: Dr. Elizabeth Barnes
Biology – Doctoral

Going Beyond Correct Answers: Evaluating Metacognitive Monitoring in Evolution Understanding

Evolution is a key concept of biology, yet students often have a poor understanding of evolution and reject evolution. Several factors have been suggested as factors contributing to the difficulties students face in understanding evolution, including 1) students' beliefs about the nature of knowledge, and 2) the feeling of certainty of information they currently have. Therefore, students need to be aware of what they know about evolution, how they evaluate scientific evidence, and how they know what they know. However, traditional assessment often disregards metacognitive aspects, an awareness of students' thought processes, when assessing students' evolution understanding. This research aims to measure students' metacognitive monitoring, a process of assessing students' understanding of particular evolution concepts. 2,622 students from 18 introductory biology courses in 11 states took the newly adapted assessment. 14 statements about evolution are provided and students chose "True", "False", or "I don't know enough to answer". The new assessment showed three different properties of students' understanding: accuracy, inaccuracy, and uncertain conception. Over 50% of students hold an inaccurate understanding that evolution is a progression towards more advanced species, had an informal explanation of natural selection, and indicated a Lamarckian conception of evolution. However, the concepts that hold the most uncertainty were natural selection concepts and fundamental concepts of phylogenetics. This study overall will contribute to the advancement of metacognitive research and perhaps help promote the development of metacognitive skills among students. Investigating methodological issues offers valuable insights for researchers in education and psychology, refining future methodologies and ensuring research validity and reliability in the domain of metacognitive monitoring assessment. The next step of this research is item analysis and comparing other demographic information such as religious identity or level of evolution acceptance to see if the changes are generalizable across undergraduate biology students.

3. Ian Alcox
Faculty Mentor: Dr. Hanna Terletska
Physics and Astronomy – Undergraduate

Research of Quantum Materials with MuST Software

In traditional studies, designing and fabricating new materials is often very expensive and time-consuming. With the advent of higher computational power, we have been able to use tools such as Density Functional Theory (DFT) to computationally model materials and predict their physical properties. It is the goal of the MuST Project to develop a software that can more accurately handle these systems while accounting for the disorder and complexity present in real-life systems. Specifically, more recent implementations of MuST have provided the ability to more precisely handle disorder effects in materials such as semiconductors and high entropy alloys (HEA). The goal of this research is to test and evaluate MuST's predictions of such materials via comparison to literature relating experimental results and predictions of similar software. Applying the MUST software to several semiconducting and HEA systems, we benchmark our results with other DFT methods finding a good agreement. We will continue to expand the existing capabilities of the MuST software and its application in an important class of quantum systems.

42. Nicholas Reed Alexander
Faculty Mentor: Dr. Donald Walker
Biology – Doctoral

Leveraging Fine-Scale Variation and Heterogeneity of the Soil Microbiome to Predict Nutrient Flux on the Landscape

Shifts in agricultural land use over the past two hundred years have led to a loss of nearly 50% of existing wetlands due to expanding agricultural practices. Modern agricultural activities contribute up to 65% of the nutrients that reach the Mississippi River Basin, directly contributing to biological disasters such as the hypoxic Gulf of Mexico "Dead" Zone. Federal efforts to construct and restore wetland habitats have been employed to mitigate the detrimental effects of eutrophication, with an emphasis on restoration of ecosystem services such as nutrient cycling and retention. Soil microbial assemblages drive biogeochemical cycles and make direct contributions to nutrient availability, allowing microbial assemblages to offer a unique and sensitive framework for the accurate evaluation, restoration, and management of ecosystem services. The purpose of this study was to elucidate patterns of soil bacteria within and among wetlands by developing diversity profiles from high-throughput sequencing data, link functional gene copy number of nitrogen cycling genes to measured nutrient flux rates collected from flow-through incubation cores, and to predict potential nutrient flux using microbial assemblage composition. Soil microbial assemblages showed fine-scale turnover in soil cores collected across the topsoil horizon (top vs bottom partitions) and have been shown to be structured by restoration practices on the easements (tree planting, shallow water, remnant forest). Connections between soil assemblage composition, functional gene copy number, and nutrient flux rates show the potential for soil bacterial assemblages to be used as bioindicators for nutrient cycling on the landscape.

5. Momina Liaqat Ali
Faculty Mentor: Dr. Zhou Zhang
Computer Science – Doctoral

Natural Human-Computer Interface Based on Gesture Recognition with YOLO to Enhance Virtual Lab Users' Immersive Feeling

There are several uses for hand tracking and gesture recognition in the quickly expanding disciplines of human-computer interaction. With the use of this technology, computers can now identify and react to hand gestures and movements, resulting in an interface that is more logical and natural. The need for sophisticated hand tracking and gesture detection technology is rising as augmented reality and virtual reality devices are gaining popularity. The goal of this research is to examine the state-of-the-art gesture detection and hand tracking in order to create new and enhanced methods for HCI applications that leverage "You only look once" models and enhance the user sense of immersion in virtual environments. The results of the research and the learning management system will be utilized in a virtual electrical power lab. The questionnaires will be sent both before and after the classes in order to assess the implementation. The research will advance the field of technology by creating new and enhanced hand tracking and gesture recognition algorithms and incorporating them into HCI applications.

2. Eden Anderson
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Detecting Estrogen Pollution in the Stones River Waterways Using the Yeast Estrogen Screen (YES) Test of Saccharomyces Cerevisiae

Estrogen is a steroid hormone, most well-known as being associated with the female reproductive system. Estrogen is used in the dairy and livestock industry as a muscle enhancer and used to increase growth rates. Once in the environment, estrogen enters the estrogen transmission chain, and the effects have been connected with disruptions in waterway ecosystems. This study aims to identify the levels of estrogen pollution for each site at the Stones River Watershed. Using the Yeast Estrogen Screen (YES), Saccharomyces cerevisiae was scientifically engineered to carry one DNA (either ERα or ERβ) sequence and two estrogen-responsive sequences (ERE). The ERE controls the reporter gene, lac-Z, which encodes for the enzyme β-galactosidase, and in the presence of estrogens, is secreted. The lysis buffer contains chlorophenol red-β-D-galactopyranoside (CPRG). When cleaved by β-galactosidase, it produces a colorimetric product. This study distinguishes a practical way to identify said pollutions and promotes a better understanding of what estrogen pollution can do towards biodiversity. The study also confirms why testing our local Stones River Watershed is very important, as it improves our ability to protect against threats towards biodiversity and possible contamination.

7. Ghada Asaf
Faculty Mentor: Dr. Misagh Faezipour
Engineering Technology – Masters

Enhancing Sustainability in the Fashion Industry Supply Chain: A System Dynamics Exploration

This study investigates the complex dynamics of sustainability in the fashion industry, with a focus on Spinnova company’s supply chain, a leader in sustainable textile manufacturing. Our study employs system dynamics modeling to analyze various scenarios and assess what key factors influence the long-term sustainability of Spinnova's final product. The study is built upon a Causal Loop Diagram (CLD) that graphically depicts the complex relationships that impact sustainability. Subsequently, the Vensim PLE 10.1.0® software is used to create and run simulations of the System Dynamics Model (SDM). The model is tested extensively for optimum scenarios, followed by model validation for extreme conditions to guarantee its long-term reliability and functionality for the intended purpose. The results highlight the crucial importance of reducing the company's carbon footprint on the environment, improving the company's brand image, investing in energy-efficient equipment, and meeting consumers' preferences for advancing sustainable practices. Furthermore, the study provides valuable insights to strengthen Spinnova's strategic positioning and outlines sustainable practices in the fashion sector from a system thinking perspective, including actionable solutions and future research opportunities such as collaborations, workplace diversity, and continuous improvement, particularly in socioeconomic aspects.

44. Solyana Asefa
Faculty Mentor: Dr. Scott Handy
Chemistry – Undergraduate

Knoevenagel Condensation: Influence of Catalysts and Solvents

Aurones are a naturally occurring subgroup of flavonoids responsible for the yellow pigmentation found in flowers. Prior research has demonstrated the diverse properties of aurones including antimicrobial, antifungal, anti-inflammatory, and anticancer effects. Additionally, their inherent fluorescent properties position aurones as potential candidates for utilization as investigative tools in biological systems. Over the years, various methods have been suggested to create synthetic aurones in laboratory settings. Our study focuses on their fluorescent property to analyze the condensation reaction rate of 2(3H)-Benzofuranone and 4-(Dimethylamino)- benzaldehyde to make the synthetic aurone 2- [(4 dimethylaminophenyl)methylene]-3(2H)-benzofuranone. This study's objective was to investigate the impact of catalysts and solvents on the initial rate of this Knoevenagel condensation reaction. Various amino acids, along with commonly used catalysts and solvents, were examined for their catalytic effect, measured in initial rate (RFU/min) using a fluorescence spectrophotometer. Glycine and DMSO were used as a standard catalyst and solvent, respectively. Amino acids with basic or acidic side chains, with the exception of alanine, exhibited significantly accelerated initial rates compared to the reaction with glycine. Contrariwise, DMSO consistently demonstrated the highest reaction rate as a solvent. In summary, the combination of histidine as a catalyst and DMSO as a solvent yielded the most favorable results. Further research is needed to explore these findings on other Knoevenagel reactions.

9. Elijah Atkins
Faculty Mentor: Dr. Wandi Ding and Dr. Dongliang Wang
Computer Science – Undergraduate

Major Depressive Disorder (MDD) Classification Using Three Types of Correlations and Biomarker Exploration

Major depression disorder (MDD) is a type of mental health disorder that is very serious and can affect daily life. It is estimated that 280 million people experience MDD worldwide, and a diagnosis is typically based on a patient’s medical history and mental examination. Utilizing resting state function magnetic resonance imaging (rs-fMRI), classification can help with an individual’s assessment. We considered three types of correlations including Pearson correlation, partial correlation, and tangent correlation together based 116 of regions of interest (ROIs) from the automated anatomic labeling (AAL) atlas. Two deep neural network models were used to train on 2380 subjects with 5 k-fold and 10 k-fold cross validation on two types of spit methods including stratified and non-stratified sampling. The seven metrics computed are F1-Score, precision, recall, accuracy, specificity, and the area under the Receiver Characteristic Operator curve (ROC). The study achieved the highest accuracy rate of 63.69% for 5-fold cross-validation, and 64.87% for 10 k-fold cross-validation. A permutation test was performed on the three types of correlation data individually, and 89 possible biomarkers of MDD were detected with a p value less than or equal to 0.0001 for tangent correlation.

46. Oluwatobiloba Ayangbola
Faculty Mentor: Dr. Katy Hosbein and Dr. Sarah Bleiler-Baxter
Mathematics and Science Education/Chemistry – Doctoral

Learning Assistants in Science Classrooms and Students' Science Identity

There has been an increasing focus on shifting the learning environment of undergraduate science education from traditional lectures to active and participatory classroom environments. Several recent studies have explored using learning assistants (LAs) to foster a more inclusive learning environment. LAs are undergraduate students prepared to engage students and facilitate learning during class. These studies show that having LAs boosts students' sense of belonging and fosters interest, especially for historically underrepresented groups of students such as first-generation college students. Research indicates that first-generation college students face challenges integrating academically and socially, leading to a disproportionately high exit rate from STEM fields without completing their degree. As part of the efforts to increase science participation and retention, researchers have focused on furthering the understanding and development of science identity. Various studies suggest that developing a strong science identity can increase persistence and retention in STEM fields, including Chemistry and Biology. The learning environment plays a critical interactional impact on science identity development. To further understand the development of science identity, it is imperative to acknowledge the role of the learning environment. However, research has yet to investigate how science identity development is impacted by a learning environment supported by LAs. This study aims to investigate how the presence of LAs in a General Chemistry and Biology course impacts the science identity of first-generation college students. To explore this, an instrumental case study design was employed. Using the criterion sampling technique, first-generation students participated in a longitudinal three-interview format. These three semi-structured interviews were conducted early in the semester, mid-semester, and at the end of the semester. Results revealed that students frequently described their interactions with the LAs as making them feel more like science people, which contributed to their science identity.

4. Hardik Bansal
Faculty Mentor: Dr. Kiel Ormerod
Biology – Masters

Motor Neurons Require Specialized Proteins for Intracellular Trafficking of Neuropeptides in Drosophila Melanogaster

Trafficking of cargoes along the microtubule tracks within the axons of neurons is a critical process necessary for development, maintenance, physiology, and behavioral function. Unlike a typical cell, neurons have axons that can travel long distances, exceeding a meter in humans. Incredible variability exists within the type of cargo and proteins/molecules associated with the cargo vessel. It is well-established that the motor protein kinesin is responsible for anterograde trafficking of axonal cargo, while the dynein/dynactin complex regulates retrograde trafficking. However, there is still much to uncover regarding the various isoforms of these motor proteins as well as the adapter and cargo-associated proteins involved in the precise trafficking dynamics. Here we use a targeted genetic approach using the UAS/Gal4 system combined with RNA interference (RNAi) to knockdown candidate genes and proteins involved in trafficking the organelles synaptic vesicles, mitochondria, and dense core vesicles in motor neurons. Using fluorescently tagged cargo proteins, we conduct fixed and live-imaging experiments to quantify changes in trafficking in our RNAi candidate lines. Of the 30 lines we have currently screened, 9 strong trafficking phenotypes were observed when examining cargo localization in the somas, axons, and at the neuromuscular junction. We are currently looking for changes in NMJ structure using immunostaining for pre-and post-synaptic proteins as well as performing electrophysiological recordings to examine changes in synaptic efficacy. We are additionally looking for changes in larval crawling behavior associated with these strong deficits. Taken together, we are uncovering novel roles for motor proteins, adapter and cargo-associated proteins involved in axonal trafficking of organelles, and assessing how deficits are associated with the downstream function of motor neurons.

6. James Barnes
Faculty Mentor: Dr. Warner Cribb
Geosciences – Undergraduate

Geology and Petrology of The Ducktown Mining District

This project investigates the origin of a copper ore deposit in Ducktown, TN, located in the Tennessee Copper Basin. This deposit served as a crucial source of copper from the mid to late 1800s through the 1960s, with significant economic implications. However, extensive mining and ore processing during this period adversely affected the surrounding landscape and ecosystems. Although efforts have been made to restore the local environment, ongoing challenges persist. During the peak of production, the economic importance of the deposit attracted numerous geologists to study the rocks of the ore deposits and their surrounding areas. Despite thorough studies conducted at the time, a consensus on the origin of the deposit remained elusive. Recent advancements in understanding ore mineral formation and analytical methodologies allow a better understanding of the geologic conditions that form copper ores. This project focuses on core samples extracted from the Boyd mine near Ducktown. Utilizing polarized light microscopy, core samples are classified according to their mineralogical relationships. X-ray diffraction (XRD) is used to examine crystal habits and polymorphs, thereby confirming the mineralogical composition and potentially discovering minerals not identified by polarized light microscopy. The rocks under study originate from an area subjected to significant regional metamorphism during the formation of the Appalachian Mountains. By studying the core samples using modern polarized light microscopy and XRD, it is possible to identify the pre-metamorphic rock type and geological environment in which the ores formed. The research results may be applied to exploration efforts for geologically similar ore deposits worldwide, including critical minerals needed for green energy technologies.

11. Tori Bascou
Faculty Mentor: Dr. Mengliang Zhang
Chemistry – Undergraduate

Investigation of Water Effect on Ignitable Liquid Residue Analysis by Coupling Solid-Phase Microextraction with Direct Analysis in Real Time Mass Spectrometry

Arson investigation and explosive analysis is a subfield of forensic science that focuses on examining the physical evidence that is collected from a scene in which a fire occurred. Accelerants and ignitable liquids (ILs) are often used in arson fires to maximize the damage that the fire creates. Common ILs include lighter fluid, kerosene, and gasoline, with gasoline being one of the most volatile compounds. Direct analysis in real time-mass spectrometry (DART-MS) is known for its ability to analyze volatile compounds that have been exposed to weather conditions and its ability to demonstrate the sensitive detection of explosives. In recent research, the DART-MS was coupled with an extraction method called Solid Phase Microextraction (SPME), in order to aid in the analysis of IL residue on substrates (i.e., wood floor, paper). This study hypothesizes that water could interfere with gasoline residue analysis by DART-MS which is dependent on the gasoline to water ratios and the type of substrates. The objective is to conduct a comprehensive evaluation of the water effect in gasoline residue detection by DART-MS method and is expected to provide results that will aid in the better understanding of water and substrates factors in the IL detection method.

48. Kathryn Baumann
Faculty Mentor: Dr. Warner Cribb
Geosciences – Masters

Chunky Gal Mountain: The Baked and Squeezed Entrails of an Ancient Mountain System

The Blue Ridge terrane formed approximately 300-250 million years ago when the pre-Atlantic Ocean basin closed, resulting in the collision of multiple, lithologically different landmasses. Chunky Gal Mountain, of the N.C. Blue Ridge geologic province, is a tectonic mélange of medium to high-grade metamorphic rocks emplaced along the Chunky Gal Mt. Fault. It is hypothesized that at least two protolith rock types underwent metamorphism at this location: 1) a sedimentary mudstone, indicated by high concentrations of Al and minerals that form Al: quartz + biotite + phologopite + garnet, and 2) an igneous ocean-floor rock, indicated by high concentrations of Ca+ Fe+ Mg and minerals that form these elements: hornblende + plagioclase + chlorite + epidote. In addition, it is hypothesized that Chunky Gal Mountain is a thrust sheet overlying Shooting Creek Window, a structural window composed of mafic and ultramafic rock. A thrust sheet and structural window are geomorphological landforms produced from compressional tectonic events that require extreme temperature and pressure differences. Evidence of high metamorphic-grade ductile deformation and shearing occurs along the north side of the Chunky Gal Mountain fault. In contrast, lower-grade cataclastic deformation occurs on the south side of the fault. It is hypothesized that the higher-grade, ductile deformed rock formed closest to the base of the thrust sheet and that the lower-grade and younger, cataclastically deformed rock was uplifted above it along the fault. With the use of fieldwork, a petrographic microscope, and x-ray diffraction, this research aims to construct a detailed mineralogical description and geochemical classifications of rocks exposed from the base of Chunky Gal Mountain, identify metamorphic reactions resulting in observed parageneses, and correlate geochemical and mineralogical variations to specific protolith compositions.

50. Christopher Bonnesen
Faculty Mentor: Jeremy Strayer
Mathematics – Doctoral

Exploring Cognitive and Attitudinal Traits in Prospective Secondary Mathematics Teachers Using MODULE(S2) Materials

MODULE(S2) materials provide opportunities for prospective secondary mathematics teachers (PSMTs) to integrate content and pedagogy. This has the potential to impact teachers' content knowledge for teaching (CKT) and their expectation and value for enacting core teaching practices. These core teaching practices are (1) learning about student understanding using their explanations, justifications, and representations, and (2) generating questions and discussion that promote students exploring conjectures and justification. Within this context, the following research questions are considered: (RQ1a) How did PSMTs' content knowledge for teaching change over the duration of a term-long experience with coordinated instruction and applications to teaching? (RQ1b) How did PSMTs' expectancy and value for carrying out core teaching practices change? (RQ2) To what degree do attitudinal and cognitive aspects of competence associate? For each research question, there were between 100-200 participants enrolled in courses using MODULE(S2) materials across universities in the USA and Canada. CKT was measured using pre- and post-assessments specific to each of the four content areas. Expectancy and value were measured using Likert scale items on surveys, also administered at the beginning and end of the course. Score changes from pre to post were used to look for net increases (for RQ1) and correlations (for RQ2), with an emphasis on Cohen's d, Pearson's correlation coefficient r, and p-values. For RQ1, statistically significant net increases in each of CKT, expectancy, and value were found in each content area. Overall mean increases were higher for expectancy than for value. For RQ2, no significant correlations between CKT gains and expectancy or value gains were found within each content area, with the possible exception of CKT versus value in statistics.

52. Shontal Botros
Faculty Mentor:
Engineering Technology – Undergraduate

"FlowFusion: Enhancing Phone Production Line Continuity"

The vertical rotary carousel buffering system is an industry-sponsored capstone project for mechatronics engineering seniors at Middle Tennessee State University. As per the insurance company Assurant's request, the project was issued to the team following a need for a buffering system for the company's existing phone conveyor belt system. The buffering system would resolve any clogs along the production line and allow for the continued flow of phones. As with all the mechatronics capstone projects, finding a solution to Assurant's buffering system needs would allow the team to relate their learning thus far to a real-world application and challenge the members by more independently seeking solutions to real problems. Moreover, the project presents the unique benefit of corroborating with real engineers in an industry setting where the project team members can see their design ideas incorporated into an established company's existing functions. Amongst the mechatronics capstone projects, the nature of collaboration between Assurant and the team members most identically resembles how the students will interact with clients in any future engineering careers they pursue. Taking on a request from an existing company gives the team members the added benefit of potentially securing a job post-graduation.

13. Jocelyn Bransford
Faculty Mentor: Dr. Kiel Ormerod
Biology – Undergraduate

Flight to Discovery: Automating Drosophila Activity Analysis for Rapid Insights

Drosophila melanogaster, or fruit flies, have served as model organisms in biomedical research for over a century due to their short generation time, well-understood genetics, robust assays, and conserved molecular pathways (Sokolowski, 2001). Their utility in studying complex biological phenomena like development, behavior, longevity, and disease pathology continues to grow as we gain more advanced experimental and analytical tools (Verheyen, 2022). Modern fruit fly research facilities may conduct an array of behavioral assays on thousands of flies per week across genetically diverse cohorts (Bivort et al, 2022). However, these increasingly data-intensive studies create bottlenecks in the manual analysis workflows. For example: the Drosophila behavioral research currently ongoing in the Ormerod lab utilizes crawling assays to assess how activity patterns are affected by mutations in genes associated with neurodegenerative disease like Huntington's Disease (HD). For just 50 assay videos of 10 larvae each, manual data processing requires over 16 hours of work in ideal conditions, and conditions are never ideal. As our assays scale up (we are currently screening hundreds of mutations for HD, and more for other projects) and data needs grow more complex, relying on tedious by-hand analysis procedures is becoming intractable. By integrating computer automation, we can strengthen the existing foundation of Drosophila discoveries with higher-throughput data pipelines to unlock more advanced insights, in a fraction of the time. In this project I will pioneer automated solutions tailored to the specific needs of two behavioral assays employed in the Ormerod lab, which monitor changes in larval and adult stages of Drosophila. Establishing efficient data handling frameworks could then be extended to further core assays across many ongoing and future Drosophila studies in our lab group.

15. Amy Brown
Faculty Mentor: Dr. Souvik Banerjee
Chemistry – Undergraduate

Molecular Modeling Guided Design and Synthesis of Novel Autotaxin Inhibitors to Enhance the Antitumor Effect of Paclitaxel in Breast Cancer Model

Autotaxin (ATX) is an enzyme pivotal in catalyzing the hydrolysis of lysophosphatidylcholine (LPC) into lysophosphatidic acid (LPA), a bioactive phospholipid akin to growth factors. LPA exhibits binding affinity to various receptors, orchestrating cellular responses such as proliferation, migration, and inflammation. Mounting evidence underscores the pivotal role of ATX-LPA receptor interactions in fueling the growth, metastasis, and notably, the development of chemoresistance in several cancers, including melanoma and breast cancer. Hence, targeting ATX emerges as a promising strategy for intervention. Notably, prior ATX inhibitors have demonstrated significant efficacy as adjuvants in conjunction with established chemotherapeutics like doxorubicin and have shown promise in sensitizing cancer cells to paclitaxel. Despite the progress, only a handful of ATX inhibitors have progressed to clinical trials, with none achieving regulatory approval. Among these, GLPG1690 faltered in Phase III due to insufficient clinical benefits, emphasizing the urgent need for novel ATX inhibitors. Leveraging molecular modeling techniques, our research group has identified a promising candidate from a diverse compound library. Through enzyme inhibition assays, we validated the efficacy of this compound, which also exhibited synergistic effects with paclitaxel against the 4T1 murine triple-negative breast cancer cell line. Furthermore, employing molecular dynamics (MD) simulations, we delved into the binding mechanisms and interaction profiles of our compound with ATX, gaining invaluable insights for optimization. Our current endeavors aim at synthesizing analogs of the identified lead compound to bolster its efficacy, thereby paving the way for a novel class of ATX inhibitors with enhanced therapeutic potential.

54. Mia Bush
Faculty Mentor: Dr. Andrienne Friedli
Chemistry – Undergraduate

Copper or Acid/Base Complexes with Pyridines for Self-Organizing Materials

Blatter radicals (BR) are a group of 1,4-dihydrobenzo[e][1,2,4]triazin-4-yl systems that have exhibited unique stability and have potential application as magnetic or optoelectronic materials. A derivative of BR containing a pyridine ring could not be characterized due to insolubility and it precipitates as a powder. Self-organization through complexes with a variety of mono-, di-, and triacids also resulted in powders. Model Cu complexes with bipyridine, 1,4-dipyridylbenzene prepared with hydrothermal synthesis gave single crystals, and the results were reproduceable. This process was unsuccessful for hydrothermal Cobalt II complex with H2PYDC, and methanol/water methods (at room pressure/ temperature) along with other attempts using other solvents. Other characterization included IR and MS spectroscopy, thermal and elemental analysis, and X-ray crystallography. Complexes with intermediates in the BR synthesis are being investigated.

17. Hannah Butler
Faculty Mentor: Dr. Beng Guat Ooi
Chemistry – Masters

Chlorine Dioxide and Ozone as Agents for Removing Contaminants

Chlorine dioxide (ClO2) can be used as a disinfectant in medical and food applications as well as wastewater treatment. The susceptibility of selected contaminants to breakdown by ClO2 in the treatment solutions or through fumigation is studied. The method of ClO2 produced in solution would be utilized in wastewater treatment, whereas the fumigation method would be useful for sterilizing rooms and buildings. Although fumigation is less effective than the dissolved ClO2 method, it has the added benefit of being able to disinfect hard to reach places including crevices and porous materials. Tobacco related chemicals such as nicotine, benzyl alcohol and N-nitrosodimethylamine were treated with ClO2 gas for 1 hour and 2 hours. GC-MS analysis of ClO2-treated samples showed that nicotine is more susceptible to ClO2 treatment than either benzyl alcohol or N-nitrosodimethylamine. The percentage degradation of nicotine, benzyl alcohol, and N-nitrosodimethylamine after 1 hour of treatment with 25.6 mM ClO2 are 76.8%, 9.4%, and 8.4%, respectively. The rate of chemical degradation, percentage breakdown, and by-products formed for 2-chlorophenol were also determined. The effects of ClO2 gas on amino acids such as tryptophan and tyrosine were determined using q-TOF mass spectra and fluorescence spectroscopy in order to determine the presence of less volatile or trace level degradation by-products not amenable to GC-MS analysis. A comparison of the effect of ozone on the same chemicals is also studied, especially for those chemicals less susceptible to degradation with ClO2. The pros and cons of oxidative degradation of chemical and biological constituents using ClO2 and ozone will be discussed.

8. Noah Buttrey
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann and Dr. Cole Easson
Biology – Undergraduate

Alternative Splicing of the CMK-1 Gene, Exon 5 with Hypoxic Stress in C. Elegans

C. elegans CMK-1 Shows Unexpected Alternative Splicing Under Hypoxic Stress. Aging is a deterioration of physiological functions of survival and reproduction. One gene implicated in aging in both the model organism Caenorhabditis elegans (C. elegans), a soil nematode, and humans is Calcium/calmodulin-dependent protein kinase type 1 (CMK-1). Repression of CMK-1 in nemotodes results in a 15% extension of lifespan. CMK-1 encodes a protein gene that has kinase activity and functions in both nutrient-sensing and cell signaling. Both de-regulated nutrient-sensing and faulty signaling are hallmarks of aging. In addition to the role of genetics, environmental stress plays a role in aging. The focus of this study was to compare gene expression changes, in particular alternative splicing, of CMK-1 when nematodes were stressed by low oxygen (hypoxia) and under normal oxygen conditions. Based on prior studies, we would expect that, similar to aging, stressed nematodes would produce RNAs encoding only functional CMK-1 protein (include exon 5) while unstressed nematodes might produce a combination of RNAs encoding functional and non-functional proteins (skipping exon 5). To test this, reverse transcription-polymersase chain reaction was performed on RNAs from nematodes treated with hypoxic and non-hypoxic conditions. Both hypoxic and non-hypoxic nematodes produced RNA encoding the functional protein (including exon 5), while only hypoxic nematodes produced two additional unpredicted forms. Skipping of exon 5 was not detected in either sample. This surprising result suggests that alternative splicing may be more complex in this region and that other ways of regulating CMK-1 function, such as post-translation may be involved. Future studies should investigate the undpredicted RNA versions and also other gene regulation mechanisms for CMK-1.

19. Skylar Carson-Reynolds
Faculty Mentor: Dr. Cole Easson
Biology – Undergraduate

Exploring the Genetic Diversity of Freshwater Sponges in Tennessee Utilizing Genetic Barcoding

Sponges, belonging to the phylum Porifera, are the most ancient and primitive animals that are widely distributed across the globe today. While members of Porifera are typically restricted to marine environments, approximately 150 sponge species have evolved to inhabit freshwater environments, including 14 species across the state of Tennessee. At MTSU, we have collected and identified 11 of these 14 recorded freshwater sponge species using morphological analysis of spicules. Despite their broad distribution, we still have very little understanding of the conservation status of freshwater sponges in Tennessee, how genetically diverse they are, and the anthropogenic-induced climate threats they may face. To date, no genetic data has been generated on any freshwater sponge species in the state. Using DNA extraction and Polymerase chain Reaction amplification, we generated high-quality sequences for 38 freshwater sponge samples. These sequences were used to create the first genetic records of freshwater sponges in Tennessee and build a phylogeny to explore the evolution of these ancient animals. Together with the morphological data, our genetic records provide us with a new perspective on freshwater sponge ecology and evolution.

10. Selena Casey
Faculty Mentor: Dr. Keely Obrien
Fermentation Science – Undergraduate

Comparative Analysis of Antioxidant Activity in Dairy and Water Kefir Exopolysaccharides

This study pioneers the comparative analysis of exopolysaccharides (EPS) extracted from dairy and water kefir, aiming to unveil their antioxidant activities. Utilizing refined extraction protocols, water kefir EPS and kefiran, was isolated from both kefir variants and subjected to a series of assays to quantify their free radical scavenging capabilities. The research integrates methodologies from existing microbial strain antioxidant analysis literature, emphasizing the DPPH assay for efficacy measurement. This project is the first to explore such comparative antioxidant activities globally. The findings are expected to establish a foundational understanding of kefir EPS's role in health-promoting dietary applications and potential nutraceutical development.

56. Kevin Cavey
Faculty Mentor: Dr. Mengliang Zhang
Chemistry – Doctoral

Every Ligand Counts: Quantitative Analysis of Nanoparticle Surface Ligands via DART-MS

The characterization of surface ligands on colloidal nanoparticles remains an underdeveloped area of research. The methods currently used for surface characterization often lack specificity and sensitivity, making the identification of specific ligands and ligand mixtures complicated, if not impossible. To overcome these limitations, direct analysis in real-time–mass spectrometry (DART-MS) was used to discriminate between bound and unbound species in colloidal suspensions of cadmium selenide quantum dots (QDs). Beyond the identification of bound species, we show that this method allows for the quantitative analysis of ligands on the surface of QDs. The oleate coated QDs were analyzed and the quantity of oleate was determined by an external calibration curve constructed based on oleic acid standard solutions. The 1H NMR was used as a reference method to validate the quantitative results for oleate ligands. Our study demonstrates DART-MS as a valuable tool to study surface chemistry of QDs.

21. Christopher Clark
Faculty Mentor: Dr. Souvik Banerjee
Chemistry – Doctoral

Development of Potent Colchicine Binding Site Inhibitors for the Treatment of Taxol-Resistant Metastatic Melanoma

Melanoma is a type of skin cancer that arises from melanocytes. When this cancer metastasizes or spreads to other parts of the body, it becomes one of the deadliest types of cancer. Currently, there are several treatment options for patients with melanoma. This includes Paclitaxel, BRAF and MEK inhibitors, and immune checkpoint blockers. Unfortunately, some patients do not respond well to these treatments, and some develop resistance over time. At the onset of resistance, the treatment no longer works and there is a rapid increase in disease progression. One potential strategy to overcome metastatic and drug-resistant cancers is colchicine binding site inhibitors (CBSIs). These CBSIs bind to the colchicine site which is at the interface of α- and β- tubulin monomers. Successful binding of these inhibitors prevents polymerization of tubulin into microtubules. This leads to the arrest of the cell cycle and eventually apoptosis, also known as cell death. The ability of CBSIs to effectively kill cancer cells is well established in the literature, but there is a great need for a new generation of inhibitors with desirable drug-like properties. In this work, 22 novel compounds were synthesized through a molecular modelling-based strategy to act as CBSIs. First, all compounds were screened against a diverse panel of malignant and metastatic melanoma cell lines. Top compounds were further characterized by mechanism of action studies. The lead compound, CJC-1D-R9, was identified as a potent CBSI. This compound was shown to induce cell cycle arrest and apoptosis, inhibit the colony forming ability of melanoma cells, and was able to overcome Taxol drug resistance in an in vitro assay. Finally, an ongoing in vivo study reveals that CJC-1D-R9 effectively overcomes Taxol resistance and significantly inhibits tumor growth in a Taxol-resistant A375 xenograft mouse model.

23. Molly Cooper
Faculty Mentor: Jessica Carter
Agriculture – Undergraduate

Effects of Corn Silage Cropping Methodology on Milk Quality and Production of Holstein Cows

This study assessed the effects of corn silage cropping methodology on milk quality and production. Chopped, whole plant corn was collected from four test plots, each exposed to different cropping methods to include no tillage and no cover crop (NTNC), tillage and no cover crop (TNC), no tillage and a cover crop (NTC), and tillage and a cover crop (TC). Uninoculated corn was ensiled in airtight plastic bags for 225 d prior to initiation of data collection. A random sample of lactating Holstein cows (n=30) were selected from the MTSU dairy and fed a TMR ration that included corn silage from one of the four cropping methods. Cows were consecutively fed each corn silage treatment, with cows receiving each diet for 3 d followed by a 1 d washout period (fed standard TMR) in between silage treatments (16 d study total). On d 2 and 3 of each feeding period, milk samples were collected during the PM milking session using a DeLaval® parlor system equipped with milk sampling cups. Milk samples were frozen (-4°C) immediately after collection and subsequently analyzed for SCC, fat, protein, MUN, total solids, and lactose (Dairy One, Ithaca, NY). Cow production parameters measured using the DeLaval® parlor system included milk yield and conductivity. Data were analyzed using the GLIMMIX procedure of SAS. Corn silage cropping method had no influence ($P<0.05$) on milk yield but did affect milk conductivity. Milk from cows receiving the NTNC treatment had a 4.4% lower conductivity than TC (6.05 v. 5.78 mS/cm). The effect of treatment on milk constituents was variable. Silage treatments did not influence SCC ($P>0.05$). Although inconsistent, the results of this study indicate the use of cover crops and no tillage in corn silage production did not substantially enhance milk production or milk constituents.

25. Kate Coscia
Faculty Mentor: Dr. Liz Barnes
Biology – Doctoral

Exploring the Impact of a Science Communication Lesson on Undergraduate Biology Students' Ability to Communicate About Culturally Controversial Science Topics

Better communication about science for a more general audience can promote wider engagement, trust, and understanding of science, particularly when it comes to culturally controversial science topics (e.g., vaccines, climate change, and evolution) which may be more difficult to discuss. Undergraduate students span a wide diversity of identities and career paths, so they play an important role as communicators within their various communities, some of which may have negative attitudes toward science. Further, few undergraduate students are receiving instruction on effective science communication. Thus, they feel unprepared to engage in conversations about controversial science topics. The goal of this study is to develop and test a standard for succinctly teaching science communication to undergraduate students with the hopes of helping them to engage in impactful dialogue with their peers and family. We implemented science communication instruction into an introductory biology course where students were introduced to both effective and ineffective communication strategies and given examples of each. Finally, we interviewed students to see how instruction impacted their experiences in communicating about controversial science topics. Interviews (n=6, with at least 20 more to come in the Spring) were coded by inductive thematic analysis. Based on our current analysis, three major themes arise. First, we noticed that most students avoided discussing controversial science topics with people who did not agree with them prior to receiving instruction. Many of the students also used more effective communication strategies in their conversations following instruction. Finally, students recognize that science communication skills can be beneficial within their future occupations. These preliminary findings suggest that science communication instruction may be valuable for undergraduate students and help them to more effectively communicate about science.

27. Sierra Cruz
Faculty Mentor: Dr. Daniel Erenso
Physics and Astronomy – Undergraduate

Neuroblastoma Cells in Ultraviolet Laser Trap with Magnetic Beads

Year after year, cancer continues to be the second leading cause of death in the United State, following heart disease. Cancer is defined as a disease caused by an uncontrollable amount of abnormal cell division in the body, leading to tumors. Tumors can malignant (cancerous) or benign (non-cancerous). Neuroblastomas, the cells being used in this research project, are the most frequently occurring tumors found outside of a child's cranium (extracranial). The tumor can manifest anywhere along the sympathetic nervous system, originates from neural crest progenitor cells, and is categorized as a neuroendocrine tumor. Surgery and chemotherapy are the most common treatments of cancer with both being aggressive on the body. The purpose of this research project is to measure radiation dose at a single cell level for Neuroblastoma Cells. The project has three components: (a) Neuroblastoma cells without magnetic beads (control group), (b) Neuroblastoma cells with magnetic beads, and (c) Creation of visible light from Neuroblastoma cells. We use an ultraviolet laser trap to measure the radiation dose. This laser trap will be used to individually ionize the cells causing the breakage of chemical bonds at the cellular level. By comparing the radiation dose measured in (b) with (a), we want to investigate if the presence of the magnetic beads would result in reduced radiation does. Furthermore for (b) we want to study the possibility of visible electromagnetic waves creation from neuroblastoma cells.

58. Samuel Dolinger
Faculty Mentor: Jeremy Strayer
Mathematics – Undergraduate

Student Understanding of the Limit Definition of the Derivative

The study of Calculus requires an understanding of the limit-definition of the derivative. This study examined students' concept images of functions, limits, and average rate of change, and how these relate to their understanding of the limit-definition of the derivative. Four Calculus II students were given a task-based interview, and their responses were coded via a framework. The results suggest that students tend to rely on graphical representations, and that students require a symbolic understanding of average rate of change to be able to have a concept understanding of the limit-definition of the derivative.

29. Himashaili Donavalli
Faculty Mentor: Dr. Joshua Phillips
Computer Science – Masters

Image Steganography Using Deep Neural Networks

In today's cybersecurity landscape, the protection of sensitive information during its transmission over insecure networks remains a paramount concern. While encryption is widely employed to secure data, the visibility of encrypted text to potential threats has raised doubts about its effectiveness in ensuring confidentiality. Steganography emerges as a vital solution, offering a means to conceal confidential information within seemingly harmless multimedia files. Unlike encryption, which focuses on rendering data unreadable, steganography hides information in plain sight, making it virtually undetectable to unauthorized parties. This project aims to explore advanced deep learning techniques, specifically Convolutional Neural Networks (CNNs) with ResNet architecture and Generative Adversarial Networks (GANs), particularly Wasserstein GAN (WGAN), for steganography. The objective is to assess the capability and resilience of these models in concealing text within images while preserving data integrity and avoiding detection. Evaluation will be conducted using metrics such as Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), and perceptual quality measures across various scenarios and datasets. Moreover, the project will investigate the integration of image processing filters to enhance the robustness and efficacy of concealing information within images. Techniques such as noise removal and visual quality enhancement will be explored to address challenges posed by diverse multimedia content. By adopting a comprehensive approach, the project seeks to gain insights into the strengths and limitations of each method, thereby advancing the field of steganography and steganalysis. The findings of this project hold significance for researchers in computer science and cybersecurity, as well as students and faculty in digital media production and analysis. Through interdisciplinary collaboration and innovative methodologies, this project aims to contribute to the development of more secure communication protocols and digital security practices. Ultimately, it exemplifies the synergistic relationship between research endeavors and academic programs, driving advancements in both theoretical understanding and practical applications.

60. Wenbo Dong
Faculty Mentor: Vishwas Bedekar
Engineering Technology – Doctoral

Design, Modeling and Feasibility Analysis of Rotary Valve for Internal Combustion Engine

There have been several studies focused on improving the efficiency of internal combustion engines using various techniques such as better design, better materials, regenerative technologies etc. Recently, in 2016 Toyota reported 40% gas engine efficiency with their Prius model however, there remains a lot more room for improvement towards the theoretical maximum value of 73% using Carnot Theorem. In this research, we present a fresh designed valve-train that has potential to improve the efficiency of a known conventional valve designed engine. The goal of this research was to prove the feasibility and significance of the new valve design. This research developed a simulation model of the new valve design and produce its physical property data. The data of the new design was compared to the conventional poppet valve design with respect to several parameters to discuss its working principle and advantages over the conventional valve mechanism. Modeling was performed using Python programming to predict the valve opening mechanism. The design of experiments was setup to control and tune different parameters accordingly within the reasonable range of engine speed viz. 1000-6000 RPM to simulate various working conditions. The maximum opening area for the rotary valve is calculated to be 0.795 sq.in which is smaller than the poppet valve's area of 1.315 sq.in. However, under an example of 2900 RPM, the rotary valve was able to remain fully opened with constant efficiency of about 54% from 40 to 160 degrees of the crankshaft angle. While the poppet valve can achieve 88% efficiency at 90 degree of the crankshaft angle and the efficiency significantly drops on either sides of the maxima. Authors believe that this research would help explore improvements in the performance of a combustion cycle due to the novel rotary valve design that is investigated in this research.

31. Carissa Elonen
Faculty Mentor: Dr. Saeed Foroudastan
Fermentation Science – Masters

Career Advantages of Business Education Courses for Science Master's Degree Students

MTSU and the College of Basic & Applied Sciences created the Master of Science in Professional Science (MSPS) program in 2004. Also known as a Professional Science Master's (PSM) degree, these interdisciplinary programs provide Middle Tennessee with the best-educated and well-trained scientific workforce. The Tennessee Board of Regents honored the MSPS program with its Academic Excellence Award in 2010. The program was also awarded the U.S. Department of Education's Graduate Assistance in Areas of National Need (GAANN) grant for Engineering Management in the fall of 2019. The program comprises core science classes, business management classes designed for science, math, and engineering students, and a capstone internship to gain real-world experience. In 2023, we examined numerous categories from the student's capstone internship evaluations from their employers during Spring 2015 through Fall 2022, including, but not limited to, Interpersonal Skills, Overall Performance, Quality of Work, Knowledge of Concentration, and Oral and Written Communication Skills.

33. Meirola Endraws
Faculty Mentor: April Weissmiller
Biology – Undergraduate

Biological Evaluation of Novel Tubulin Inhibitors

Cancer is a leading cause of death worldwide. Cancer cells are defined by uncontrolled and abnormal cell division. Therefore, inhibiting cancer cell division is a validated anti-cancer approach clinically. Both cell structure and cell division depend on active microtubule dynamics, which is a process in which alpha and beta subunits of tubulin polymerize and depolymerize. Small molecule tubulin inhibitors are used in chemotherapy cocktails to treat various cancers, however current tubulin inhibitors are toxic and cancer cell resistance can occur. To overcome these issues, we have been part of a research project to discover novel tubulin inhibitors that target the colchicine binding site on the beta subunit. Paneling of these novel small molecules that are potential tubulin inhibitors reveals that out of those tested, two compounds show the potential to inhibit tubulin polymerization directly and cause effects consistent with tubulin inhibition in cancer cell lines. The data from this research will help to understand which chemical structures function best to impair microtubule dynamics. Design and testing tubulin inhibitors like these may be able to overcome issues with those currently in the clinic and ultimately could be developed to aid patients in their fight against cancer.

35. Roger Fallon
Faculty Mentor: Elissa Ledoux
Engineering Technology – Undergraduate

Titan 2: Electric Boogaloo

Current hull inspection methods for large ships are both costly and resource intensive, requiring the use of heavy equipment. This project aims to eliminate these costs entirely by performing in-water hull inspections, negating the need to lift ships from the water. Our team is dedicated to developing a submersible inspection drone that can be operated easily by any crew member, requiring minimal training. This drone is designed to be cost effective and simple enough for private use, while also being robust and dependable for regular commercial applications. To meet our objectives, we have extensively researched and developed specifications for material strength, energy efficiency, electrical durability, ease of use, and technical features suited for our use case. The drone's design prioritizes simplicity of repairs, featuring a modular electronics system that is fully removable, minimizing downtime and maximizing inspection time. The subsea inspection drone designed by our team has control within 5 degrees of freedom, a top mounted camera with swivel and tilt function, a target battery life of over one hour, as well as a robust electronics container and frame assembly. It also can track position via GPS, capture photos, as well as alert the user in the event of emergency. By completing this project, we aim to reimagine hull inspections, offering a cost-effective, reliable solution that benefits the maritime community.

62. Liam Flahaven
Faculty Mentor: Dr. Beng Guat Ooi
Chemistry – Undergraduate

The Effects of Chlorine Dioxide on Lysozyme Activity and Crystal Structure

Proteins have folding specificity, and their biological functions are attributed to the precise folding of their structures. Hence, denaturation of enzyme structures will result in enzyme inactivation. Lysozyme, an enzyme associated with cell lysis, was used to study the effect of chlorine dioxide (ClO2) on protein folding and crystallization since ClO2 is an effective oxidant, disinfectant and sterilizing agent. Lysozyme dissolved in deionized water at 150 mg/mL concentration was treated for 30 minutes with different concentrations of ClO2 ranging from 0.18 mM to 0.40 mM. After treatment, the remaining ClO2 in the samples were removed either with activated charcoal or by aeration. Untreated and ClO2-treated lysozyme were then allowed to crystallize in solutions containing 0.08 M sodium acetate at pH 4.76 and 40 mg/mL sodium chloride using the sitting drop vapor diffusion technique. Lysozyme activity assays were performed on the untreated and ClO2-treated samples using the M. lysodeikticus lysis method. The crystals formed were analyzed using a Raman microscope to determine subtle changes in crystal structure due to treatment with ClO2. A comparison of Raman spectra of untreated versus ClO2-treated lysozyme crystals showed spectral differences or changes in structure due to ClO2. A 6.0-mL aliquot of 150 mg/mL lysozyme was also treated with 16.7 mg of ozone for 2 minutes to study the effect of low levels of ozone treatment on lysozyme crystal structure. The ClO2 and the ozone treatment affected the lysozyme activity as well as the rate of crystallization of the lysozyme.

64. Samantha Fletcher
Faculty Mentor: Dr. Alyson Lischka
Mathematics and Science Education PhD – Doctoral

"It's Easy. We Got Desmos Right Here": The Role of Mathematical Action Technology in Positioning Students as Mathematical Explorers

The positive impact on student learning and continued support of mathematical action technology (MAT) in classrooms deems a need to better understand what teaching practices maximize the affordances of MATs.The purpose of this study was to better understand the technology-centered teacher moves that allow students the opportunity to be positioned as mathematical explorers and sustain mathematical authority during a MAT task. In this case study of a MAT task designed to leverage the power of sliders in Desmos to explore key characteristics of the sine function, participants were two ninth-grade students (age 14), who engaged with a task-based interview. By coding the transcript of the task-based interview, the findings identified and described the teacher's actions with the technology that resulted in meaningful mathematical activity for the two students. Along with teacher actions with the technology, evidence showed the importance of the design of the MAT task and the ability of students to troubleshoot the technology. Ultimately, we identified important considerations for teaching mathematics with technology as well as several technology-centered teaching moves, leaving room for the students to perform as mathematical explorers. Applying these research methods for future cases could help generalize these technology-centered teaching strategies that position students as mathematical explorers, thus strengthening students' mathematics identities.

37. Monika Fouad
Faculty Mentor: Dr. Hanna Terletska
Physics and Astronomy – Undergraduate

Modeling Disorder Effects in Quantum Materials

In condensed matter physics, disorder refers to asymmetries in the crystal structure at the atomic level. There, materials can undergo phase transitions such as the Anderson Localization Transition (ALT), which is responsible for the conductor to insulator transition. Understanding the impact of disorder on quantum materials is critical for material design, as materials' properties can be manipulated to improve material durability, cost effectiveness, and other desirable characteristics. Such types of improved materials can be used in buildings, airplanes, and machinery. When studying the effects of disorder, it is important to have reliable numerical tools that can properly simulate disorder effects for various classes of quantum materials. To study the effect of disorder on quantum materials, we developed an effective medium quantum cluster method (CDMT) to simulate different types of disorder: binary, box, and Gaussian. These distributions represent different disorder scenarios in technologically important systems, such as alloys and semiconductors. In this project, we will show that our CDMT method captures the experimentally observed impact of disorder on a material's density of states, i.e. the broadening of the spectrum by disorder. We will also investigate the importance of non-local (beyond single impurity) scattering effects which we model by a finite cluster method.

66. Tanya Garain
Faculty Mentor: Dr. Souvik Banerjee
Chemistry – Doctoral

Design, Synthesis and Biological Evaluation of Novel Quinoline/ Dihydroquinoline Tubulin Polymerization Inhibitors

Microtubules (MT) are a crucial component of the cellular cytoskeleton and comprise alpha and beta heterodimers. Microtubules have a variety of cellular functions, like proliferation, intracellular trafficking, mitosis, etc. The MTs experience cyclical periods of polymerization (GTP-tubulin is added to the growing end of the β subunit) and depolymerization (hydrolysis of β-bound GTP to GDP), and this rate of polymerization and depolymerization leads to dynamic instability. For successful mitotic events, cell development, and cell division, dynamic instability is significant. Anti-tubulin drugs alter the dynamics of MTs, which are fundamentally necessary for DNA segregation and cell division during mitosis, hence eliminating cancerous cells. Although this class of drugs has been thoroughly investigated and shown to be effective against various cancer types, there are still major challenges to overcome, such as narrow therapeutic window and the emergence of drug resistance. Because of their benefits over other MT targeting drugs, colchicine-binding site inhibitors (CBSIs) are a subject of ongoing research, however, balancing their potency and toxicity is an issue that needs to be resolved. Crolibulin is one such tubulin polymerization inhibitor that is active against tumor angiogenesis and shows anti-cancer activity. It went up to Phase I/II clinical trials with cisplatin for anaplastic thyroid; however, due to its strong cardiovascular and neurotoxicity, it could not be used clinically. Taking inspiration from such known inhibitors, the goal of this project is to generate MT destabilizing agents that bind to the colchicine binding site (CBS). Our analysis from molecular modeling suggests that inhibitors with quinoline or dihydroquinoline as a core template can compensate for the interactions required between the ligand and the CBS and could have reduced toxicity. We aim to design, synthesize, and assess the biological efficacy and metabolic stability of more such unique scaffolds that could circumvent existing challenges and are highly potent.

39. Benjamin Garretson
Faculty Mentor: Dr. Saeed Foroudastan
Engineering Technology – Masters

Powering Up: MTSU and the Solar Splash Competition

Participating annually in Solar Splash, the world's premier solar-powered boat competition in association with the American Society of Mechanical Engineers, MTSU's Experimental Vehicles Program (EVP) exemplifies innovation in sustainable watercraft design. Committed to addressing the inefficiencies of fossil-fuel-dependent boats, the EVP has showcased solar-powered vessels that promise an eco-friendlier future for marine transportation since 2004. Central to their approach is the integration of cutting-edge technology and continuous improvement based on iterative design and competition experience. The diverse, interdisciplinary team of MTSU students leverages unique skills, classroom theory, and hands-on practice to advance their designs, mentored closely by graduate counterparts to enhance teamwork, leadership, and problem-solving abilities. This educational synergy cultivates not only academic excellence but also practical expertise, preparing participants for the professional environment. With a legacy of high performance, the team anticipates maintaining their competitive edge at the upcoming Solar Splash event, where their latest innovations will once again be put to the test.

68. Giovanni Ghattas
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Decoding Turbidity: Impact Assessment on Stream Biodiversity in the Stones River Watershed

Biodiversity is paramount in preserving the balance and vitality of Earth's ecosystems. Yet, this delicate balance is threatened by factors like climate change, invasive species, and pollution. Within the aquatic realm of the Stones River Watershed, one parameter of interest is turbidity - a measure of water's cloudiness due to suspended solids. Previous studies show that turbidity can affect aquatic life, altering predator-prey dynamics and impacting overall biodiversity. However, the extent of its influence in specific ecosystems, such as our local watershed, remains underexplored. This study aimed to bridge this gap by investigating the relationship between turbidity and biodiversity in the Stones River Watershed. We hypothesized that higher turbidity levels would correlate with decreased biodiversity. To test this, we collected water samples from eleven sites, analyzed them for turbidity using spectroscopy and biodiversity using environmental DNA (eDNA) metabarcoding. Turbidity varied significantly across the sites from 0.191 NTU at Southridge Trailhead to 19.64 NTU at Goochie Ford, and biodiversity also varied across sites from 3.43 at Goochie Ford to 45.36 at Thompson Lane Trailhead (Inverse Simpson). Although both varied, the turbidity's relationship to biodiversity was less straightforward than anticipated with a correlation value of $R2 = 0.006$. The most biodiverse site displayed relatively low turbidity, while areas with higher turbidity did not consistently show a reduced alpha diversity or even species numbers. This suggests that factors beyond turbidity, or a combination of other factors in addition to turbidity might play crucial roles in shaping local biodiversity patterns. To uncover the complexities of turbidity's impact on biodiversity within our watershed, future studies should extend over longer periods and account for seasonal variations, including periods of heavy rainfall that lead to more turbid waters, as well as combining parameters that may collectively influence biodiversity.

70. Karmina Ghobrial
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Exploring Coffee Silverskin Extract's Effects on Age-Related Gene DVE-1/SATB1 During UV-Induced Oxidative Stress

Aging is the gradual and progressive loss of function in the majority of living organisms, ultimately resulting in death. While many aging models have been proposed, no single model can explain aging fully, as both genes and the environment play roles. C. elegans, the small nematode, is a model organism often used in studying lifespan and aging. Based on an earlier study that used a RNAi screen to identify C. elegans genes affecting lifespan and were implicated in human aging, DVE-1 repression decreased lifespan. In addition to genes, environmental stressors such as oxidative stress accelerate aging. When there is an imbalance of reactive oxygen species (ROS) and antioxidants, the excess ROS chemically attacks cellular molecules causing dysfunction. Antioxidants chemically interact with ROS, making them inert. A natural product that contains antioxidant compounds is coffee silverskin (CS), the outer layer of coffee beans. Its high antioxidant capacity is of unknown character and has the potential to preserve health and increase longevity. For this project, we first examined the antioxidant capacity for three different CS extraction (CSE) solvents and procedures. All three extraction methods produced high antioxidant capacity equivalent to 10 mM gallic acid. Next, we are currently investigating the molecular effects of CSE treatment after UV-induced oxidative stress, on the regulated expression of age-related gene, DVE-1. We expect that UV treatment will induce alternative splicing in age-synchronized nematode adults to produce non-functional DVE-1 proteins and that CSE treatment will ameliorate this switch in gene expression towards producing RNAs that encode functional DVE-1 proteins in age-synchronized nematode adults. This study is significant in the context of averting age-related diseases and extending a healthy lifespan, utilizing nematodes as a model for human research.

41. Kendra Givens
Faculty Mentor: Dr. Joshua Phillips
Computer Science – Undergraduate

Collective Intelligence: Emergent Reasoning and Theory of Mind in Multi-Agent Systems

The challenges posed by multi-agent systems such as partially observable environments, communication overhead, and robustuness to communication failure demonstrate the need for using the paradigm of centralized training decentralized execution. However, the inherently decentralized nature of an agent's decision making can lead to a deterioration in coordination and collaboration between agents. Our method uses working memory to induce the capability of abstraction into agents. This abstraction enables agents to reason about the decision-making processes of others, facilitating the emergence of a theory of mind and choosing more optimal actions collectively rather than individually. We hypothesize that integrating working memory leads to improved coordination and an increased ability to generalize to various tasks.

43. Heather Green
Faculty Mentor: Dr. Greg Rushton
Biology – Doctoral

Analysis of Performance on the Praxis Biology Content Knowledge Test at the Category Level

The pipeline of prospective teachers from colleges and universities is a vital component of K12 teacher preparation. Qualified teachers are major contributors to student success. Teachers need a strong understanding of their subject area to teach effectively, especially in STEM subjects. Current research on prospective teacher content knowledge is scattered, lacking a comprehensive approach of evaluating the subcategories of biology content knowledge. In this study, we examined scores on the Praxis Biology Content Knowledge Test 5235 over the 10-year period between 2006-2015. This test assesses the candidates' knowledge of: the history and nature of science; molecular and cellular biology; genetics and evolution; diversity of life and organismal biology; ecology; and social perspectives. The purpose of this study was to better understand prospective teachers' biology content knowledge to answer the following questions: 1. In what categories of biology content knowledge are prospective teachers' strengths and weaknesses? 2. What patterns exist across biology subdomains that are associated with their reported demographic characteristics? We found the categories in which prospective teachers struggled the most were genetics and evolution, cell and molecular biology, and diversity of life. Ethnicity, undergraduate major, and undergraduate GPA affected the variance of the category scores more than other demographic characteristics.

45. Rose Gutierrez
Faculty Mentor: Dr. Daniel Erenso
Physics and Astronomy – Undergraduate

Electromagnetic Ionization and Radiation Creation in Neuroblastoma Cancer Cells

Neuroblastoma is a common childhood cancer that has one of the highest incidence rates for children less than one year with poor prognosis as children age. Although current radiotherapy treatments are efficient, many patients are left with unpleasant side effects. Laser trapping is a technique that traps dielectric objects as small as an atom and as big as 100 micrometers with a high-power laser. The laser trapping technique with the addition of magnetic beads was used in this study to initially provide a more efficient treatment for neuroblastoma. This study determined that the amount of radiation received in neuroblastoma cells through laser trapping was significantly reduced. However, throughout this study, it was discovered that these neuroblastoma cells could produce radiation emission, which lasted over six hours with a consistent amount of over 93% energy absorption of an infrared light (low energy) resulting in intense visible radiation (high energy light). Using infrared laser light with the neuroblastoma cells and magnetic beads has the potential to create a new source of energy of white light that has the blackbody radiation. The overall results of this study has the possibility of improving cancer treatment and solar energy harvesting.

47. Chance Hall
Faculty Mentor: Dr. Daniel Erenso
Physics and Astronomy – Undergraduate

The Creation of Min-Sun's from Blood: Taking Steps to Create a Sustainable Plasma from the Ionization of Turkey Blood Samples

As our technology advances and the population grows, so does our need for a source of energy. The research team in the biophysics lab at MTSU created a way to form plasma that generates electromagnetic radiation, which could store, harvest, and generate light energy. In previous years research it has been found that when ionizing a livestock blood sample mixed with magnetic beads, via an infrared Laser Trap (LT), a dense plasma is formed that radiates electromagnetic radiation even after the LT was turned off. The current goal is to determine the effects that storing the turkey blood for 6+ months in a refrigerator will have on creating a plasma and storing/producing light energy. Thus far my focus has been to realign the Ultraviolet Laser Trap (ULT) so that it can be utilized to study these effects. Once operational the ULT will allow us to determine if a higher energy input into the blood sample will create a more dense plasma that can also output more electromagnetic energy. Experimentally my concentration is on Turkey blood samples mixed with magnetic beads. Which will be contrasted with the other researcher's samples of sheep, goat, chicken, cow, horse, and pig to determine which forms a more dense plasma and efficiently produces the most electromagnetic radiation. There is immense potential in this research to eventually create a new means of energy generation for our growing energy needs, while also eliminating a wasteful/toxic biproducts of the livestock industry.

72. Sammi Hamdan
Faculty Mentor: Dr. Khem Poudel
Computer Science – Masters

Using a Stacking Autoencoder Architecture to Clean EEG Data

Preprocessing electroencephalogram (EEG) data effectively is vital for making accurate predictions from the data. Some of the most well-known diseases are detected through an EEG, such as epilepsy and Alzheimer's Disease. In addition, an EEG can suffer from various artifacts, such as eye-blinking, swallowing, and chewing. While there have been various methods proposed to tackle this issue, they have all suffered from being too specific in their tasks. They either focus on a few artifacts to clean, or they only use a specific dataset to train and test their method. This study attempts to overcome this problem and present a method that will be able to effectively clean multiple artifacts while also being flexible on the dataset used. A stacking ensemble of autoencoders will be trained and tested on three different datasets. Simulated artifacts will be used to ensure that the model is trained on a variety of different potential sources of noise. We anticipate that the model will be able to perform well on the three datasets, and would be capable of handling far more artifacts than other studies have done.

12. Tadros Hana
Faculty Mentor: Dr. Kiel Ormerod
Biology – Masters

Examining the Electrophysiological Impacts of Huntington's Disease at the Drosophila Neuromuscular Junction

Huntington's Disease (HD) is an inherited, monogenic disease affecting ~1 / 1,000 people yearly. Mutant Huntingtin protein contains a stretch of glutamine repeats that, when expanded, becomes unstable and forms inclusion bodies associated with the pathophysiology of the disease. Using Drosophila 3rd instar larvae as well as adults to model pathogenic huntingtin progression through development and into adulthood. We tracked huntingtin aggregate proliferation from eggs every 24 hours and determined a linear progression in the size and number of aggregates in the developing brain, motor axons, and at the neuromuscular junction. This trend of aggregate proliferation was also observed in the pathogenic huntingtin modeled in the adult wing. Interestingly, larval morphology and viability were not impacted. Using live imaging of fluorescently labeled huntingtin, we determined that axonal aggregates significantly impaired trafficking of organelles like synaptic vesicles, mitochondria, and dense core vesicles. To assess the downstream implications, we conducted electrophysiological recordings from muscles using intracellular voltage recordings and muscle force recordings and observed significant impacts on neuromuscular transduction. Larval crawling patterns were significantly impacted, showing impairments in movement speed and total distance traveled. These physiological deficits were also observed in adult flies, with impairments in motor function as well as behavioral manifestations. The lifespan of adults expressing pathogenic huntingtin was reduced by a third. Novel application of mTOR inhibitor Rapamycin shows a significant increase in lifespan, suggesting a mechanism by which autophagy can influence the pathology linked to huntingtin aggregates. Here we have shown significant molecular, cellular, physiological, and behavioral deficits associated with pathogenic human huntingtin expression in the nervous system of Drosophila. Our work serves as a robust model to assess the progression of HD, and as a rigorous tool for potential genetic and therapeutic treatments for HD disease progression.

49. Lillian Hardin
Faculty Mentor: Dr. Saeed Foroudastan
Engineering Technology – Masters

2024 MTSU NASA Human Exploration Rover Challenge

MTSU's Experimental Vehicles Program (EVP) annually competes in the NASA Human Exploration Rover Challenge (HERC) to increase member's ability to effectively complete the engineering design process and gain hands-on experience in the engineering field. The Rover challenge allows students to apply the knowledge acquired in the classroom from Science, Technology, Engineering, and Math in a real-world application. Beginning with the design phase, students have biweekly meetings where they learn to effectively communicate their ideas. They will learn to apply digital drafting and design skills to transform imagination into a concept to share with the team, to negotiate with others for a viable design concept, and to meet failures and develop strategies for an effective design solution. Then, fabrication begins in the machine shop to make the vehicle components from various materials, such as metal and plastic. During the fabrication process, students must rely heavily on NASA standards as there are safety restrictions. Finally, the team will load their vehicle up and travel to the Huntsville NASA Space and Rocket Center to compete with teams from around the nation. This is an excellent opportunity for students to showcase their creative passion in the real world, and to gain hands-on experience in the design and fabrication processes.

51. Lillian Hardin
Faculty Mentor: Dr. Saeed Foroudastan
Engineering Technology – Masters

Revving Up Ingenuity: MTSU's Hands-On Engineering Project

At MTSU's Experimental Vehicles Program (EVP), students rise to the challenge of the Baja SAE competition, an international collegiate event hosted by the Society of Automotive Engineers International. This competition mandates the creation of off-road vehicles that meet stringent safety and performance standards while adhering to a comprehensive SAE rulebook. Beyond engineering prowess, the event also demands fiscal prudence; teams must design cost-effective vehicles and present a convincing sales strategy, reflective of real-world market pathways. The EVP's participation in Baja SAE underscores its commitment to providing students with an authentic design experience that spans the full spectrum from ideation to potential market entry. Here, a diverse cohort of undergraduate and graduate students collaborates, drawing on their varied academic strengths to enhance the learning process. By incorporating lessons from past projects and competition outcomes, the EVP team consistently refines their designs, contributing to a legacy of award-winning performance. This hands-on approach not only bolsters their engineering expertise but also equips them with the practical skills necessary for future industry success.

53. Rand Hasan
Faculty Mentor: Dr. Kevin Bicker
Chemistry – Undergraduate

Synthesis and Evaluation of Polyaspartate Peptoid Polymers

Polyaspartic acid and its derivatives, such as peptoid polymers, have garnered attention for their potential as antimicrobial agents due to their biocompatibility and structural versatility. This research project delves into the synthesis and evaluation of novel polyaspartate peptoid polymers, aiming to unveil their antimicrobial potential and shed light on their structure-activity relationships. The primary objective is to explore the impact of these novel polyaspartate peptoid polymers on Pseudomonas aeruginosa biofilms, investigating their potential as disruptors or inhibitors of biofilm formation. Furthermore, an examination of their susceptibility to proteases aims to determine their stability and potential application as protease substrates. Central to this investigation is the comparison between peptide versions of polyaspartic acid and the peptoid versions being synthesized. Elucidating the differences in their structures and properties will provide valuable insights into the tailored design of antimicrobial materials. The study's methodology involves synthesizing polyaspartate peptoid polymers of varying lengths to evaluate their efficacy against microbial growth and biofilm formation. By systematically varying the length of these polymers, the aim is to discern the relationship between polymer structure and antimicrobial activity, thereby contributing to the understanding of structure-function correlations in these materials. The discussion will contextualize these findings within the realm of antimicrobial materials, elucidating their potential implications for combating microbial infections and devising novel strategies for antimicrobial applications. This research endeavors to advance the understanding of polyaspartate peptoid polymers as potential antimicrobial agents, unveiling their structural intricacies and evaluating their efficacy against microbial biofilms, ultimately paving the way for the development of innovative antimicrobial materials.

55. Md Nahid Hasan
Faculty Mentor: Dr. Khem Poudel
Computational and Data Science – Doctoral

Stress Identification from the Chest-Worn Sensor by Leveraging Machine Learning

Stress identification is crucial for society and individual well-being. We considered the publicly available WESAD dataset to identify stress. The WESAD dataset recorded physiological responses via a chest-worn device (RespiBAN) and a wrist-worn device (Empatica E4) while 15 participants were in stress, amusement, and non-stress. We leveraged different genres of machine learning models, such as random forest, support vector machine, and extreme gradient-boosting(XGBoost), for accurate classifications of stress vs. non-stress from the chest sensors only. We empirically evaluated the window size (e.g., 100 to 1000 ms with 100 ms step) that can provide the most accurate classification. Our analysis showed that the optimal window size of 500 ms can identify stress vs. nonstress with an accuracy of 99.71%. Our results demonstrate that stress identification improved by 3% compared to the previous research studies (96.5%). This work could be helpful for quick stress identification and understanding the cause of stress.

57. Amanda Lake Heath
Faculty Mentor: Dr. Sarah Bleiler-Baxter
Mathematics and Science Education – Doctoral

The MAJORWISE Survey Study: Why Students Leave and Stay in the Mathematics Major

An overwhelming 52% of declared mathematics majors nationwide change their major in the course of their college career (Leu, 2017). To better understand retention and attrition in the mathematics major, our research team launched the Mathematics Journeys of Retention: Why Individuals Shift Educational Paths (MAJORWISE) project. In this poster, we will address the question: Why do students choose to stay in and leave the mathematics major? During October 2023, we carried out a nationwide survey in the United States with free-response items of students who have been enrolled in a mathematics major during the years 2013-2023. In addition to demographic information, this survey solicited information such as reasons for enrolling in a mathematics major and timing of and reasons for deciding to either leave or stay in the mathematics major. We recruited participants through professional networks, social media, and snowball recruitment (requesting participants share the survey with others). We analyzed free-response survey items using a predetermined coding scheme framed by Self-Determination Theory (Ryan & Deci, 2000), with codes for autonomy, relatedness, and competency. We then conducted an inductive analysis of responses in each category to describe specific experiences relevant to choosing to leave or stay in the mathematics major. The MAJORWISE online survey received 147 applicable responses. In our poster, we will report detailed findings from our analysis. For example, out of 40 responses to the question, "Why did you consider leaving the mathematics major?," 22 (55%) were related to autonomy (or a lack thereof), 7 (17.5%) indicated a lack of relatedness, 15 (37.5%) concerned competence, and 13 (32.5%) cited sources of extrinsic motivation (e.g., job opportunities). These findings, along with our in-depth inductive analysis, provide insight into how relevant stakeholders can best promote the motivation and retention of mathematics majors.

74. Braedyn Hollingsworth
Faculty Mentor: Jeffrey Leblond
Biology – Undergraduate

Chemotaxonomy of the Dinoflagellate Togula Britannica as Based on Sterols and Galactolipids

Dinoflagellates are one of the largest groups of algae that encompass marine and freshwater, and photosynthetic and heterotrophic taxa, which are found in almost every water body on earth. On a monthly basis in phycological journals, newly identified taxa are reported, often after morphological and/or phylogenetic study. While the most longstanding method for identifying dinoflagellates (and other algae), identification of new species based only on morphology could be inaccurate and misleading because of convergent evolution of truly different dinoflagellate species toward a particular cellular shape. Previous identification of the dinoflagellate Togula britannica was accomplished using a combination of morphology and phylogeny, leading to its separation from the genus Amphidinium, which shares morphological features. However, there are other tools, namely chemotaxonomic characterization of various lipids such as chloroplast-associated galactolipids and membrane-associated sterols, that can serve as a valuable complementary method in identification of dinoflagellates. To this end, we have obtained an isolate of T. brittanica which has not been characterized phylogenetically nor chemotaxonomically and have performed chemotaxonomic characterization of these lipid classes. Identification of its sterols has shown compounds commonly associated with certain species of Amphidinium; these include 4α-methyl-5α-cholest-8(14)-en-3β-ol, 4α-methyl-5α-ergosta-8(14),24(28)-dien-3β-ol (amphisterol), and 4α-methyl-5α-ergosta-8,14,24(28)-trien-3β-ol. However, characterization of its galactolipids has shown C18/C18 (sn-1/sn-2) polyunsaturated fatty acid-containing major forms of mono- and digalactosyldiacylglycerol that are uncommon to Amphidinium, which generally possesses C20/C18 major forms. Phylogenetic characterization of this isolate is still ongoing. T. britannica is an alga that has had ambiguity surrounding the phylogenic and chemotaxonomic tree since its discovery. Our objective is to provide resolution for whether this particular isolate of T. britannica is chemotaxonomically separate from the genus Amphidinium.

59. Patrick Ibrahim
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Effects of Total Water Hardness on Biodiversity in the Stones River Watershed

Biodiversity studies focus on the variety of species living within an area and the way they interact with each other. Biodiversity can be affected by a range of water quality and environmental parameters. The focus of this study was to examine a possible relationship between a water quality parameter called total water hardness and biodiversity in our local watershed, the Stones River Watershed. Water hardness is a measure of the dissolved minerals in water. Given that high dissolved minerals are known to stress ecosystems, we hypothesized that sites with high water hardness would have lower biodiversity as compared to sites with normal concentrations of dissolved minerals. Water samples from eleven sites in the Stones River Watershed, tested for water hardness using Hach test strips, and used to collect environmental DNA (eDNA). DNA was sequenced and used to quantify species richness and alpha diversity at each site and beta diversity for the watershed. We found that all sites sampled exceeded the threshold for hard water (>175 mg/L) ranging from 250 to just over 400 mg/L. Alpha diversity as measured by the Shannon Index ranged from 2.30 at Southridge Trailhead to 4.33 at Thompson Lane Trailhead. These values are in the mid-upper ranges found in other real world biodiversity studies suggesting the Stones River Watershed has good levels of biodiversity. When water hardness was compared to alpha diversity, we found a R2 value of 0.1386, which does not support a correlation of biodiversity to hardness alone. Given these results, the next step would be to examine the relationship of a combination of water quality and environmental parameters to biodiversity as a single parameter may play only a small role in biodiversity in the Stones River Watershed.

61. Shahruza Jaffarkhonova
Faculty Mentor: Vishwas Bedekar
Engineering Technology – Undergraduate

Pioneering Piezoelectric Potential: Unveiling Innovative Energy Harvesting Designs

Piezoelectric energy harvesting has garnered significant attention as a promising avenue for sustainable energy generation. This poster provides an overview of recent advancements and key findings in the field of piezoelectric energy harvesting. We discuss the fundamental principles of piezoelectricity, exploring how mechanical vibrations induced stress generates electric charge in piezoelectric materials, thus allowing for the conversion of mechanical energy into electrical energy. Various materials and technologies employed in energy harvesting devices are discussed, highlighting their advantages and limitations. Additionally, recent progress in applications such as human wearable technology and IoT devices are examined. Based upon the literature review, authors believe that piezoelectric energy harvesting can provide a viable solution for powering autonomous electronic devices and contributing to the development of energy-efficient technologies.

63. Vardhan Jalluri
Faculty Mentor: Dr. Joshua Phillips
Computer Science – Masters

Brain Tumor Analysis Using Neural Networks

Detecting defects automatically in resonance (MR) images holds importance across various diagnostic and treatment scenarios. The abundance of data and indistinct boundaries, in MR images pose challenges for tumor segmentation and classification. This study presents an automated method for brain tumor detection aimed at enhancing accuracy, efficiency and reducing diagnosis time. The objective is to categorize tissues into three classes; benign and malignant. The vast amount of data in MR images makes manual interpretation and analysis impractical. In years brain tumor segmentation using magnetic resonance imaging (MRI) has emerged as an area of research in medical imaging systems. Precise identification of tumor size and location is crucial, for diagnosis. The diagnostic process involves four stages; preprocessing MR images extracting features and classification. After image histogram equalization features are extracted using Dual Tree Complex Wavelet Transformation (DTCWT). In the stage a Back Propagation Neural Network (BPN) is utilized to distinguish between abnormal brain structures effectively. A proficient algorithm is proposed for tumor detection based on Spatial Fuzzy C Means Clustering.

14. Gracie Johnson
Faculty Mentor: Dr. Mengliang Zhang and Dr. Greg Van Patten
Chemistry – Undergraduate

The Ligand Exchange of Iron Oxide Nanoparticles and Peptoids for the Advancement of MRI Technology

Currently, in the field of MRI technology, contrasting agents are plagued by varying levels of cytotoxicity. Organ and bone retention of the dyes can lead to possible complications long term, such as nephrogenic systemic fibrosis. Further, current contrasts could benefit from an even higher level of in vivo stability to ensure that the contrast is as effective as possible. A possible solution to these issues is peptoid coated iron oxide nanoparticles (IONPs). Nanoparticles (NPs) have emerged as candidates in the future of biomedical imaging technology due to their unique physical properties, versatility, and adaptability. IONPs are currently being used for some MRIs and have been extensively studied for their usage as a contrasting agent. IONPs are good candidates as contrasting agents because they have a large surface area to volume ratios which increase escape probabilities of particles influenced by radiation. In turn, this allows the radiation to garner a proper reading more efficiently within MRIs. Furthermore, the single-domain magnetization of NPs effectively enhances spin interactions with protons in surrounding water molecules that in turn enhance MRI contrast. Although IONPs exhibit one of the lowest toxicities of metal oxide nanoparticles, their toxicity is a concern when degrading. These issues can be assessed by utilizing their crystalline cores that carry a net positive charge which will allow a ligand coating their surface to adhere and help mitigate these issues. Our ligand of choice will be peptoids, which are N-substituted glycine peptidomimetics that have varying usages from drug delivery to antimicrobial agents. Peptoids will help lower the toxicity of the IONPs by forming a shell around the NPs and through their unique structure allow a more favorable in vivo interaction with cells. The major structural difference that will allow this is the side group functionalization which branches from the amide nitrogen, allowing proteolytic stability as well as exhibit a favorable amphiphilic interaction with the structure's surroundings. The success of ligand exchanges first using peptides provides us with a viable framework to guide our work and gives us confidence that the exchange with peptoids is possible. Once we have been able to successfully perform the ligand exchange with Peptoids onto IONPs, we will be able to use this work as the basis for carrying out similar exchanges on other NPs with interesting applications beyond bioimaging.

65. Emily Jolley
Faculty Mentor: Dr. Alyssa Logan
Agriculture – Undergraduate

Ability of Novice and Advanced Western Riders to Identify Induced Stirrup Asymmetry

The impact of asymmetry on both horse and rider have been evaluated in previous studies and has shown rider asymmetry can influence position and alignment, impacting rider effectiveness, thus raising concern for horse safety and welfare. This study hypothesized advanced riders could detect stirrup asymmetry in a greater frequency than novice riders. Ten riders were used, each riding a different horse. This study induced asymmetry by shortening one stirrup by 10 cm, while riding in a western saddle. Two data collection days were performed, both requiring the riders to perform the same pattern on the same horse, with stirrups being randomly assigned to be symmetrical during one ride, and asymmetrical during another. Riders were blinded to the objectives of the study, and the shortening of the stirrups. Surveys were given at the completion of each ride regarding awareness of stirrup and rein symmetry. Our study found 60% of advanced and 50% of novice riders identified their stirrup symmetry correctly. Results showed an improvement in pattern accuracy by the second ride, from 80% to 100% accuracy. However, decreased accuracy in stirrup identification was found, from 60% to 50% accuracy from the first ride to the second ride. Fifty percent of riders riding 1-2 or 2-3 hours per week, 0% of riders riding 3-4 hours per week, and 70% of riders riding more than 5 hours per week identified stirrup asymmetry correctly. Understanding of the rider's perception of asymmetry is important to the field of equitation science and needs further investigation, and frequency of riding during the week may contribute to recognition of induced asymmetry such as that utilized in this study.

16. Sevinch Kamaridinova
Faculty Mentor: Dr. Kiel Ormerod
Biology – Undergraduate

Targeted RNA Interference Screen to Identify Novel Modifiers of Huntington's Disease Impact on Adult Viability in Drosophila

Huntington's Disease (HD) is an inherited neurodegenerative disorder highlighted by a progressive breakdown in neurons leading to progressive loss of motor control. Unlike other neurodegenerative disorders, HD research has focused mostly on one gene, the: Huntingtin gene (HTT). The disease is attributable to an abnormal expansion in CAG codon repeats in the gene, causing the protein product, huntingtin protein (htt), to have an expanded region of glutamine repeats (PolyQ region) which is linked to misfolding and aggregation of the protein within nerve cells. The severity of the disease and the age of onset have been shown to correlate with the degree of expansion within the PolyQ region of htt where an increase in glutamine repeats increases the pathogenicity and reduces age of onset. A Drosophila model of HD was previously created in the Littleton lab, where the first Exon of human htt was altered to include either 15 or 138 glutamine repeats in the PolyQ region (htt-Q15, and htt-Q138). These transgenic lines also included an RFP-tag for fluorescent imaging. Using the UAS/Gal4 system to express these transgenes in motor neurons (ElavC155,) we demonstrated that htt-positive aggregates accumulate in the axons and at the neuromuscular junction (NMJ) in third-instar larvae which significantly reduces the intracellular trafficking of organelles like synaptic vesicles, mitochondria, and dense core vesicles. We also repeated the observation that expression of htt-Q138 in motor neurons (ElavC155) significantly reduces adult viability. Here we target 50 different genes associated with HD pathology or huntingtin protein function using RNA interference (RNAi) and screened for changes in adult viability. Positive hits were then examined for molecular changes, like axonal and NMJ aggregation, to elucidate putative pathways altered in HD pathology or htt biological function. The results from our genetic screen may help to identify novel therapeutic targets for treatments of HD.

18. Abigail Kelly
Faculty Mentor: Dr. Arpan Sainju
Computer Science – Doctoral

Identifying Region-Based Spatial Neighborhood Relationship Constraints for Colocation Mining

A spatial colocation pattern refers to spatial features commonly found near each other within a geographical area. Colocation pattern mining plays crucial roles in fields like epidemiology, for identifying relationships between diseases and environmental factors, and crime analysis, for finding links between crime event types and potential crime generators. Existing work in colocation mining primarily focuses on addressing computational challenges, such as the exponential growth in candidate patterns with the increasing number of spatial features and the computational expense of spatial neighborhood relationship checks for large feature instances. However, very few research works address the challenge of varying interestingness of a colocation pattern across different regions. Interesting colocation patterns are context-dependent and can be influenced by various factors, including local context, cultural differences, and so on. For instance, a candidate colocation pattern that is interesting in Japan may not be interesting in the USA. In this paper, we address the challenge of identifying spatial neighborhood relationship constraints across different regions. Due to the variations in data behavior, it is necessary to be able to have a dynamic neighborhood relationship constraint that can adapt to each region. To address this, we propose a novel approach that analyzes the data in each region to determine the best estimate of optimal spatial neighborhood relationship constraints. We evaluate our proposed approach on the Global Terrorism Data set, which includes various terrorist attack events around the world. Using case studies, we demonstrate that proximity alone does not ensure consistent spatial neighborhood relationship constraints across neighboring regions. Finally, by using the constraints identified by our proposed approaches, we extract the interesting patterns in countries included in the case studies: Jordan, Saudi Arabia, Yemen, Afghanistan, and Pakistan.

67. Paul Klockenkemper
Faculty Mentor: Dr. Rachel Leander
Mathematics – Masters

Exploration of the Impact of Complex Host Dynamics on a West-Nile Virus Epidemic

In this paper we use mathematical modeling and optimal control to study the implications of variable host competency and host demographics on a West Nile virus epidemic and optimal control. The model uses ordinary differential equations to describe the transmission of the virus between birds and mosquitoes, vertical transmission in mosquitoes, horizontal transmission in birds, the mosquito life cycle, and bird demographics. Previous work, which focused on mosquito dynamics, demonstrated the choice of objective functional can significantly impact the optimal control and its impact on the mosquito population. However, these results are only relevant to the late summer and early fall, due to the simplistic treatment of the bird demographics. Moreover, previous work did not consider the impact of variable host competency on the epidemic and its control. In this paper, we formulate and parameterize a model including bird recruitment and two bird types which are thought to be important for West Nile virus maintenance and transmission: Corvids and Passerines. We investigate how the incorporation of multiple bird types impacts the model reproduction number using the Next-Generation-Matrix method. The existence of endemic steady states is numerically verified. Futurely, we will consider optimal control of the new model. Specific questions of interest include: How does horizontal transmission in birds and variable bird competency impact the model reproduction number and endemic steady-sates(s). Does the inclusion of more detailed bird dynamics impact the timing or magnitude of the optimal control? How are model dynamics and optimal control features impacted by the frequency of birds in each category?

76. Lori Klukowski
Faculty Mentor: Dr. Seth Jones
Mathematics and Science Education – Doctoral

A Conceptual Framework of Integrated STEM to Explore Student Sensemaking

Many integrated STEM frameworks focus on the disciplinary ideas that students learn as they experience integrated STEM activities. Framing integrated STEM in this way may hide ways in which students experience and coordinate disciplinary ideas and practices in schools as they make sense of STEM problems. In this poster, I share a theoretical framework that conceptualizes integrated STEM from a perspective of student sensemaking as students experience disciplinary thinking at different time scales. I then use this lens to describe how middle school mathematics and science teachers ask questions to support their students' sensemaking during integrated STEM investigations.

69. Harshit Kumar
Faculty Mentor: Dr. Kritagya Upadhyay
Computer Science – Masters

Stablecoins: Building Bridges in the Crypto Market

The project "Stablecoins: Building Bridges in the Crypto Market" focuses on creating a stablecoin pegged to the Indian National Rupee (INR) to provide a stable, secure, and scalable medium of exchange within the volatile cryptocurrency market. The project aims to conduct a comprehensive analysis of existing USD stablecoins, identifying sustainable economic and technical parameters that contribute to their stability. This involves examining collateralization ratios, token burning mechanisms, interest rates, and their correlations with market dynamics. The goal is to develop a framework ensuring the INR-pegged stablecoin's stability through various mechanisms, including collateralization and interest rate adjustments. The research addresses gaps in the current understanding of stablecoins, particularly their long-term viability, resilience to economic shocks, and interplay with the global financial system.

78. Bavly Labib
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Relationship of Free Chloride to Biodiversity in The Stones River Watershed

Biodiversity is the complex web of the interconnected relationships of all organisms in an area. All living organisms require several different nutrients and ions to carry out basic daily functions. When levels of these nutrients and ions are insufficient or in excess, organisms and biodiversity can suffer. One of these ions is chloride, which plays a major role in maintaining pH balance and activating action potentials in neurons. Given its role, I hypothesized that high free chloride levels will have a significant impact on biodiversity in the local watershed, the Stones River Watershed. To test this hypothesis, we collected water samples from eleven sites in the watershed. To quantify biodiversity, we isolated environmental DNA (eDNA), amplified the mitochondrial COI region, sequenced the DNA fragments, and identified the taxonomy of the species present. We found that alpha diversity, as measured by Inverse Simpson, ranged from 3.44 at Lascassas Drug to 45.36 at Thompson Lane Trailhead. We next measured free chloride levels using Hach Chemical Test strips. Surprisingly, every location had no detectible levels of free chlorine (0 mg/L). So, when we compared chlorine levels to biodiversity, the correlation R2 value was 0. These data indicate that chloride levels are unable to explain the more than 10-fold differences in biodiversity we observed at the Stones River Watershed sites. However, due to the absence of variation in the chloride data, these data cannot answer whether chloride does have some effect on biodiversity. In order to test this hypothesis, a water system with variable chloride levels should be tested.

80. Brooke Lafferty
Faculty Mentor: Dr. Warner Cribb
Geosciences – Undergraduate

A Mineralogical and Geochemical Study of the Copper Basin Anticlinorium

The mineralogical and geochemical significance of the Copper Basin Anticlinorium regarding ore deposition is relatively unknown, as very few studies have been conducted in this region of the Southern Appalachians. Moreover, the few that are available were published in the 1930s, when sulfide mining operations in the Copper Basin were at their peak. Given the region's history regarding mineral resources, this research investigates the geologic history of the Copper Basin anticlinorium to expand upon existing information and hypotheses on the origin of its sulfide ore deposits. The primary ore bodies occur in the center of the anticlinorium, while supposedly very little form on the east and west limbs. To better understand why these ores were deposited largely in the center as opposed to the limbs, samples were collected from 9 road cuts along US 64 in East Tennessee, starting at the west limb and ending near the east limb. Each location represents the lithology of different geologic units that make up the anticlinorium, and samples from western-lying and eastern-lying units were compared to samples from the unit that lies in the center. The samples were processed into pressed pellets and glass disks for XRF analysis for major and trace elements. Additionally, at least one sample from each location was thin sectioned for petrographic analysis. Trace element analyses provide essential information on trace constituents of sulfide ores to determine their distribution across the anticlinorium. Trace elements, such as Cu and Ti, in ore samples were compared to results from the east and west limbs. Our results suggest that mineralization occurs primarily in the center of the anticlinorium, and slightly increases to the east. Further geochemical and petrographic analysis will aid in determining the petrogenesis of the ore bodies.

82. Brooks Leyhew
Faculty Mentor: Dr. Cole Easson
Biology – Undergraduate

Population Genetics Structure of Eunapis Fragilis Across Middle Tennessee

Sponges (Phylum Porifera) are found all over the world and are one of the most diverse animals in marine benthic ecosystems. Freshwater sponges, when compared to marine sponges, make up a small portion of the total sponge diversity. Eunapius fragilis is a cosmopolitan freshwater sponge species found across Middle Tennessee, and it was the focus of our research. E. fragilis samples were taken from several watersheds, including Burgess Falls, the Stones River, and the Duck River. Sponges are essentially immobile when not in their larval form, so E. fragilis being in many disconnected ecosystems made us curious about its distribution patterns. This study used population genetics as a tool to understand distribution patterns of E. fragilis across Tennessee through comparing data from microsatellites and next-generation sequencing. Polymerase chain reaction (PCR) and gel electrophoresis techniques were used to obtain microsatellite data, and MiSeq was used to obtain sequencing data. Primers for PCR amplification of microsatellite regions in E. fragilis were designed using the genome of Ephydatia muelleri, which could have been a limiting factor in microsatellite data collection. Our MiSeq data from 6 samples of E. fragilis showed a high population structure across Middle Tennessee, possibly indicative of its distribution mechanism across Tennessee. Future research of E. fragilis using next-generation sequencing technology could prove beneficial in further understanding its distribution in Tennessee.

71. Jonathan Magdy
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Phosphorus Effects on Stream Biodiversity in the Stones River Watershed

Biodiversity is an integral part of life on Earth. It is not limited to one aspect of the environment, but rather is essential at all levels through 10-100 million different species. Phosphorus plays a significant role in the amount of diversity within an ecosystem. While beneficial in moderation, high levels of phosphorus can lead to habitat degradation, low dissolved oxygen, bacterial growth, and eutrophication. Within the Stones River Watershed specifically, this project was geared towards examining the relationship of phosphorus and biodiversity levels. Eleven sites within the watershed were analyzed for biodiversity using environmental DNA sequencing and for phosphorus levels using a Hach test. We found that Thompson Lane Trailhead had the highest number of species (149), while Broad StreetTrailhead had the lowest number (44). Alpha diversity was calculated using Shannon which showed Thompson Lane having the highest biodiversity (4.3) and Southridge Trailhead having the lowest (2.3). Beta diversity showed Manson Pike Greenway Trailhead and Broad Street Greenway Trailhead as the most similar sites. The two most abundant phyla across the samples from Manson Pike were Synurophyceae (heterokant algae) and Bacillariophyta (diatoms). As for phosphorus levels, Nice Mill Dam and Southridge Trailhead had the highest levels (4.16 mg/L and 3.304 mg/L). All of the other sites had less than 0.5 mg/L, including Elam Mill which had lowest levels (0.015 mg/L). We next calculated a correlation coefficient for alpha diversity and phosphorus level and found that phosphorus alone was not correlated to biodiversity within the watershed ($r2 = 0.0105$). These data, therefore, do not support phosphorus playing a singular role in biodiversity, although it may contribute to biodiversity as part of a combination of water quality factors.

73. Elena Ivonne Mancera Andrade
Faculty Mentor: Dr. Kevin Bicker
Chemistry – Doctoral

Using the Peptoid Library Agar Diffusion (PLAD) Assay to Discover New Antimicrobial Peptoids Against Pseudomonas Aeruginosa

Peptidomimetics have emerged to mimic peptides' structure and biological activity, which play key roles in physiological and biochemical processes. Specifically, peptidomimetic compounds, like peptoids, have been used as an alternative therapeutic agent to overcome some drawbacks that antimicrobial peptides have, such as low bioavailability and low diffusion into organs due to their degradation by proteases. Peptoids are N-substituted glycine oligomers that differ from peptides by having the side chains on the nitrogen-amide instead of the alpha-carbon, providing stability against proteases. The development of the submonomer approach and the one-bead-one compound combinatorial library techniques have allowed the synthesis of many structurally diverse peptoids. However, using traditional screening and optimization techniques of novel compounds is resource- and time-consuming. The objective of this project is to utilize the Peptoid Library Agar Diffusion (PLAD) assay, a high-throughput screening technique capable of testing thousands of compounds at the same time, to discover antimicrobial compounds against Pseudomonas aeruginosa, an opportunistic multi-drug resistant pathogen. This objective will be accomplished in three phases. Phase 1 will be to design and synthesize combinatorial peptoid libraries to target the negatively charged membrane of P. aeruginosa. Phase 2 will be to screen and select antimicrobial peptoids from the libraries. Finally, phase 3 will be to characterize the selectivity of peptoids toward the pathogen over mammalian cells based on quantitative assays. Results of each phase and promising peptoids will be discussed.

75. Brian Matthews
Faculty Mentor: Dr. Neda Naseri
Physics and Astronomy – Undergraduate

Particle-Dipole Interactions in Relativistic Collisionless Shocks

Evidence suggests that particle-dipole interactions in the upstream of unmagnetized plasma holds a key importance for energy gaining and sustaining particles. In particular, we study the particle-dipole interactions in the upstream region of relativistic collisionless shocks. We use a two-dimensional particle simulation to study the effects of the particle-dipole interactions. Each particle in our simulation begins with an energy of $\gamma = 15$ where γ is the Lorentz factor, which is used for quantities when the speed of an object becomes comparable to the speed of light. The upstream region consists of numerous dipoles that deflect a particle's path. The dipole deflections result in an overall change to the particles energy. A similar process is that of Fermi acceleration. A key difference between our results and energy gaining via Fermi acceleration is that our results show significantly faster growths in the energy then that of Fermi acceleration. In the certain cases of interest, we find that particles can gain a large amount of energy and end up keeping that energy. We study the particle-dipole cases in which the particle interacts with multiple dipoles in the upstream. The overall energy gain of the particles can cause the particles to accelerate. When comparing our results with the results of energy gaining via Fermi acceleration, we find that the two results differ significantly.

77. Shelby Mayhut
Faculty Mentor: Dr. Daniel Erenso
Physics and Astronomy – Undergraduate

Livestock RBC Ionization and Radiation for the Purpose of Clean Energy

This project aims to advance the method of converting biomass waste into a source of renewable energy by utilizing plasma, derived from red blood cells of livestock, for the storage and emission of electromagnetic radiation (light). The livestock industry generates 1.4 billion pounds of biomass waste each year, resulting in copious water and air pollution [1]. A preliminary study conducted by MTSU physics professor Dr. Daniel Erenso and undergraduate biology major Lindsey Tran demonstrates the unique capability of plasma to absorb 90% of electromagnetic radiation emitted from a 1064 nanometer infrared laser in a study titled "Harvesting and Storing Electromagnetic Radiation using RBCs in Animal Blood and Micromagnetic Beads" [2]. This study also demonstrates the capability of plasma to serve as a source of self-sustaining energy, as evidenced by a newly discovered "Star-like" formation that continued to emit radiation after the laser was turned off [2]. These findings imply two things:
1.) Animal blood from livestock waste may serve as a viable source of electromagnetic energy storage and emission.
2.) The "Star-like" formation created during ionization of the plasma provides an exciting opportunity to simulate hands-on, experimental research on a star that would otherwise only be studied through observation.
Drawing on the studies discussed above and my previous research experience in the optics lab, I propose that testing larger volumes of plasma (10 ml, 100 ml, and 1000 ml) and incorporating new variables (such as using an ultraviolet laser to simulate natural sunlight) is necessary to develop practical applications for this new method of energy harvesting. The objectives of this study include measuring key characteristics of radiation emission from varying volumes of plasma samples, including incident and transmitted power, temperature, and duration of time.

79. Elizabeth McQueen
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Ultraviolet Levels Does Not Correlate with Species Biodiversity in the Stones River Watershed

Biodiversity is crucial for sustaining ecosystems by providing essential services to each unique environment. However, environmental stressors impact ecosystem, including Ultraviolet (UV) radiation. The UV Radiation Index quantifies the amount of radiation an area receives from the sun on a scale of 0-11+. The goal of this study was to examine the relationship between UV index levels and biodiversity at eleven different sites across three years within the Stones River Watershed. UV levels for the sites were gathered from the nearest weather station at Weather Underground by taking the average days above UV 8 for June, July, and August of each year. Biodiversity was quantified using environmental DNA (eDNA) collected from running water at each site. DNA was sequenced and taxonomically identified using the Midori database in combination with the Phyloseq R package. We hypothesized that we would find an increase in UV index, and as UV index increased, we would see a decrease in biodiversity. However, the study found that species richness and alpha diversity was variable throughout all sites and the correlation between biodiversity and UV index was minimal for all years; R2 values were 0.0158, 0.0947, and 0.0105 for 2021, 2022, and 2023, respectively. The UV index for each site was fairly consistent across the years with Lascassas Drug having the highest UV levels of all sites and Southridge Trailhead having the lowest UV levels. The next step for this project will be continuing data collection for each of the following years, pursuing combinations of variables that may influence biodiversity levels. In addition, setting up accurately placed weather stations per site would enhance the precision of UV index measurements and allow more accurate measures. This research speaks to the importance of complex interactions between environmental factors and biodiversity levels and will continue to inform future conservation efforts.

81. Joseph Mego
Faculty Mentor: Dr. William Robertson
Physics and Astronomy – Undergraduate

Quantitative Data from Impulse Response of Acoustic Instrument

The goal of this research is to create a mechanical striker and audio signal capture system to create, measure, and characterize the impulse response of acoustic guitars. The aim is to replace the largely qualitative way in which acoustic instruments are assessed during the modern manufacturing process with a quantitative measurement. A solenoid striker is arranged to have a consistent set of parameters for impact location, height, and force. After the guitar bridge is hit by the solenoid striker, audio data is acquired via a microphone suspended over the instrument. The data are analyzed in both the time and frequency domains and transformed into a forms that can be used to compare the acoustic responses to instruments of differing material, design, assembly, and care techniques. The goal is to obtain data that can then be used to refine the manufacturing processes, assist in quality control during instrument manufacturing, provide new insights into proper storage and care techniques, and give quantitative details about instrument performance to prospective instrument buyers. Some calculated responses measured as part of this research are range and intensity of different frequencies (produced using Fourier transforms of the time data), sustain time of the different frequency ranges , overall sustain time of sound produced, total loudness of sound produced, loudness of different frequency ranges, as well as any abnormalities in the sound produced by the instrument. This data will essentially make it possible to understand the audio profile of an instrument before it is even picked up for the first time, as well as shedding light on why certain instruments produce characteristic sounds, why those sounds are different, and how they can be either mitigated, modified, or reproduced.

84. Andrew Michael
Faculty Mentor: Dr. Kiel Ormerod
Biology – Undergraduate

Cell-Specific Genetic Manipulation of Drosophila Sallimus Severely Impacts Muscle and Motor-Neuron Morphology and Physiology

Skeletal muscle allows animals to produce movement, facilitating a robust set of behaviors and interaction with our environment. The ability of skeletal muscles to contract is derived from the unique genes and proteins that are expressed within muscles, most notably thick and thin filaments, and elastic proteins. Within in vivo systems investigations of these proteins are particularly difficult as they often lead to gross phenotypic changes, compensatory mechanisms, or lethality. To circumvent this limitation, Drosophila biologists exploit the Gal4/UAS system to selectively express transgenic manipulations in a subset of cells. Here we investigate the role of the sallimus (sls) protein, which encodes a homologue of titin, in muscle development and function at the larval neuromuscular junction. RNA interference (RNAi) of sls using a ubiquitously expressed muscle driver caused embryonic lethality. We next screened for muscle drivers that express in subsets of larval body wall muscles and identified a driver which expresses Gal4 only in muscle fiber 12 (MF12). Knocking down sls using MF12-Gal4 did not impact larval viability. Immunostaining for elements of the sarcomere revealed significant changes in the structure of MF12. Surprisingly, muscle-specific knockdown of sls in MF12 also resulted in drastic changes in synaptic morphology. We also reveal dramatic changes in the size and number of nuclei in the affected muscles. Using our muscle force transducer system, no obvious changes in whole larval force production were observed. Changes in larval crawling are currently being explored. Mutations in human titin are known to cause cardiomyopathies. Dilated cardiomyopathy is associated with mutations in genes encoding sarcomere proteins, with mutations in titin being the most frequent. This disease is found in ~ 1/ 20 000 individuals but causes 10,000 deaths and 46,000 hospitalizations yearly in the United States. Dilated cardiomyopathy is the most common reason for heart transplantation and the third most common reason for heart failure. Despite the prominence and impacts of these diseases, in vivo model organism studies of these elastic protein defects are minimal due to the associated lethality. This work in Drosophila provides a potential in vivo model for investigations of titin, other elastic proteins, and of muscle proteins generally.

86. Kyla Mooneyham
Faculty Mentor: Brittany Price
Geosciences – Undergraduate

Geomorphic Analysis of Short Springs Natural Area

Short Springs Natural Area lies on the border of the Central Basin and the Eastern Highland Rim, and provides examples of the geologic forces and surficial processes that have shaped South-Central Tennessee. Located in northern Tullahoma, Short Springs directly overlies the Chattanooga Shale, a black carbonaceous shale of Mississippian age. Locally, outcrops of Mississippian bedded cherts and limestones can be observed, as well as Ordovician limestones characteristic of the Central Basin. Here, Bobo Creek, a tributary of the Tennessee River carves through the landscape. Overtime this flowing water has resulted in the development of unique landforms and features, formed in part from the abundance of easily dissolved biochemical sedimentary rocks. This has resulted in the development of Short Spring and other local waterfalls such as Machine Falls and Busby Falls, where the distinct geology of the Eastern Highland Rim is easily visible. Several methods were used to decipher the geomorphic history of this area. Field work was conducted to visually identify geomorphic landforms and features indicative of differential weathering and erosion, and local stratigraphy was mapped. LiDAR imaging, as well as topographic and physiographic maps were used to provide additional information on the greater regional geology, adding needed context to the field data. These findings and observations were compared alongside other geomorphic and stratigraphic analyses from previous studies conducted throughout the Eastern Highland Rim. A more thorough understanding of the local geology and geomorphology of Short Springs Natural Area will better inform local communities and conservation efforts to promote preservation of this natural area. While this area was shaped over hundreds of thousands of years, interference from humans can quickly change this fragile environment. By identifying the agents that promote change to the surficial geology, conservators can identify and prevent unnatural and harmful elements from infiltrating and damaging this ecosystem.

88. Veronika Mousa
Faculty Mentor: Dr. Kiel Ormerod
Biology – Undergraduate

Sorting of Neuropeptides into Dense Core Vesicles

Neuromodulation through the release of neuropeptides stored within dense core vesicles (DCVs) plays an essential role in regulating behavior. Given the diversity of neuropeptides encoded in animal genomes and their distinct effects on behavior, it is critical to define how different neuropeptides are sorted, packaged, and released. Here, we use fluorescent-tagging of multiple independent neuropeptides in Drosophila motor neurons to follow their sorting and transport. We find unique neuropeptides co-expressed within the same neuron largely sort into separate DCVs that do not intermix during their lifecycle. In addition, the same neuropeptide encoded from different mRNAs also sort to unique DCV populations, while multiple neuropeptides encoded in the same mRNA transcript are usually sorted, packaged, and transported together. Altering the expression of key enzymes involved in neuropeptide processing did not disrupt their sorting or transport, but caused an accumulation of DCVs at synapses, providing a link between neuropeptide processing and their subsequent release. These data indicate cargo of single DCVs can be associated with neuropeptides generated from one mRNA population that do not intermix during biogenesis or transport, allowing DCV release to activate specific downstream signaling pathways associated with their individual neuropeptide content.

83. Fadumo Muhumad
Faculty Mentor: Dr. Rebecca Seipelt-Thiemann
Biology – Undergraduate

Alternative Splicing of SRP-6 Exon 3 in Response to Hypoxia Stress in Nematodes

Aging is a deterioration of physiological function that affects living organisms. Hallmarks of aging include genomic instability, proteostasis loss, and mitochondrial dysfunction. To create therapies to increase lifespan and postpone age-related disorders, understanding the molecular mechanisms underlying aging is essential. Hundreds of genes affecting longevity have been found in C. elegans through genetic screens and many of them are also found in humans, including one such gene called Serpin domain-containing protein 6, SRP-6, or SERPINB4 in humans. This gene has been implicated in stress-induced cell death, proteolysis, and cancer. Stress, which influences many levels of gene expression, is also known to decrease lifespan. This experiment examined whether a specific form of gene regulation called alternative splicing was altered for SRP-6 when nematodes underwent hypoxic stress compared to unstressed nematodes. Alternative splicing was measured by RT-PCR using RNAs from nematodes exposed to hypoxia or not. Nematodes grown in oxygen showed only RNA including exon 3. Analysis of RNAs produced under the hypoxic condition is currently being performed. In the meanwhile, we explored the potential change in protein function encoded by RNAs that included or skipped exon 3 or retained the introns surrounding exon 3. Multiple alignment showed that skipping exon 3 or retaining introns 2 and 3 would truncate the protein at amino acid 111 and 121, respectively, compared to the 375 amino acid reference sequence protein. Domain analysis showed that while the reference sequence would retain the full serpin domain and likely function, both other isoforms would retain serpin domains and at least partially function. To complete this investigation, RNAs from hypoxic conditions are being examined to determine whether exon 3 skipping does occur. Future studies might investigate whether proteins resulting from exon 3 skipping or intron retention function similarly to those encoded by the reference sequence.

90. Skye Neal
Faculty Mentor: Dr. Preston MacDougall
Chemistry – Undergraduate

Computational Analysis of a Chromosome Structure in the Context of QTAIM

One important feature in the structure of human DNA is the telomere, which appears at the ends of linear chromosomes. The telomere does not encode genetic information, instead serving to preserve the integrity of the chromosome during cell division. In humans, the telomere is made of a repetitive sequence of DNA which includes an especially high quantity of the nucleotide guanine. These concentrated areas of guanine naturally form a special structure called the guanine quadruplex, which consists of one or more (stacked) tetrads of guanine molecules. In this study, the structure of a guanine quadruplex was computationally analyzed in the context of the Quantum Theory of Atoms in Molecules (QTAIM). This theory describes the atoms and bonds within molecules and supramolecular complexes in terms of topological properties of electron density. Analyzing the guanine quadruplex in the context of QTAIM allows for a unique perspective on the molecular properties of the structure. The goal of this project is to improve the broader understanding of this essential chromosomal feature by investigating it in a novel way. This investigation has already shown that both oxygen and hydrogen are each simultaneously involved in two hydrogen bonds. Further investigation will be done on the effects of a potassium cation on the structure, which has been found in x-ray analysis of crystal structures near the center of the quadruplex.

20. Thuan Nhan
Faculty Mentor: Dr. Khem Poudel and Dr. Kritagya Upadhyay
Data Science – Doctoral

Blockchain-Based Electronic Health Records: A Patient-Centric Approach

This paper explores the practical implementation of blockchain technology in Electronic Health Record (EHR) systems to address centralization, standardization, and security challenges. We showcase the feasibility of adopting blockchain-based EHR systems on active networks while acknowledging inherent limitations, such as slower operational speeds. Our research highlights the importance of patient-centric design in ensuring privacy and control over healthcare data. We identify challenges related to patient access and transaction times, emphasizing the need for further research to optimize blockchain's practical use in healthcare.

22. Damilare Ogungbesan
Faculty Mentor: Dr. Misagh Faezipour
Engineering Technology – Masters

Understanding Public Policy Effects on Alcohol-Related Behaviors and Outcomes Using System Dynamics

Public policies, such as alcohol taxation policy, age restriction policy, production and sales regulation policy, advertising restriction, and rehabilitation, significantly impact alcohol consumption which is a complex social issue with wide-ranging implications for public health and safety. This study employs system dynamics methodology to explore the intricate relationships among crucial factors, policies, and their effects on behaviors and outcomes resulting from alcohol consumption. The research identifies various influential factors, including socioeconomic conditions, cultural norms, rehabilitation policies, alcohol pricing, healthcare costs, and societal consequences. These elements are integrated into a dynamic model that captures feedback loops and causal links guiding changes in alcohol consumption, accidents, and long-term effects. Through causal loop analysis, diverse policy scenarios are evaluated for their potential impacts, revealing the intricate influences surrounding alcohol use and the multifaceted repercussions of policy interventions. This research offers a comprehensive perspective on public policy’s role in shaping alcohol-related behaviors and outcomes.

85. Emily Olson
Faculty Mentor: Dr. Daniel Erenso
Physics and Astronomy – Undergraduate

The Effect of Aging and Refrigeration in Animal Blood in Plasma Formation and Radiation Emission by Infrared Laser Trap

The livestock industry is continuously growing, and as it grows the pollution caused by waste products from the livestock industry also grows. A notable waste product is that of animal blood, and it would be beneficial to find a productive use for this blood. This study investigates a phenomenon observed in the biophysics lab at MTSU, involving a combination of animal blood, micro-sized magnetic beads, and an infrared laser trap. The phenomenon exhibited intense blackbody radiation from the different animal blood samples recorded during measurements conducted on 06/01/2023 (goat), 07/05/2023 (bovine), and 10/09/2023 (horse). The blood samples were mixed with micromagnets that had been refrigerated at 8 degrees Celsius since the last measurement. To explore the impact of aging and extended refrigeration duration on the observed phenomenon, we conducted measurements on bovine (02/14/2024) and goat blood samples (02/20/24). The results indicate that aging and longer duration of refrigeration leads to faster plasma formation and enhanced radiation emission in individual bovine and goat blood samples. Additionally, a separate experiment involved a higher volume (400 microliters) mixture of bovine and horse blood (02/17/24). Moreover, the mixed blood with a larger volume exhibited exceptionally intense radiation, illuminating the experimental room. Further exploration with these findings might present a novel solar energy harvesting technique and provide a new use for animal blood.

92. Chance Perkins
Faculty Mentor: Dr. Mina Mohebbi
Engineering Technology – Masters

The Effects of Microplastic Contamination on the Biogas Produced By the Anaerobic Digestion of Food Waste

Solid food waste being landfilled is a growing cause for concern in the United States with over 63 million tons being landfilled in 2018. Landfilled food waste is problematic because it is a growing source of methane emissions. A technology that can be utilized to divert solid food waste being sent to landfills and reduce the amount of methane emissions is Anaerobic Digestion (AD). One factor that affects the efficacy of AD systems is the presence of microplastics (MPs), particles between 1nm and 5mm, within the food waste. Microplastics may physically or chemically alter the performance of an AD system by reducing the contact area of microbial cells to food waste and by chemicals (e.g., di-n-butyl phthalate (DBP)) leaching into the food waste. In this study, we assessed the effects of Polyethylene (PE) microplastic particles between 2.36mm and 4.75 mm on the biogas produced by anaerobic digestion of food waste and cow manure as the co-digestor. The food waste composition was designed to resemble the American diet with 21% protein, 24% fat, and 55% carbohydrate. The microplastic contamination tested at two levels of 0.34g and 1.35g MP/kg food waste. The digesters were run in two phases of 55 C and 37 C, and the pH was controlled using 4 molar NaOH. Biogas samples were collected from the control vessels and vessels including MP particles and analyzed using Fourier Transformed Infrared Spectroscopy (FTIR). The effects of the addition of MPs included changes in the composition of the biogas, mainly a decrease in the methane fraction of the biogas and a decrease in pH activity, which can indicate a change in microbial activity. We will continue this study with evaluating the effect of the amount, particle size distribution, and type of microplastic polymers on AD systems.

87. Shruthi Perna
Faculty Mentor: Dr. Mengliang Zhang
Biology – Doctoral

Extraction and Analysis of Ignitable Liquid Residues by Solid Phase Micro Extraction Coupled Direct Analysis in Real-Time Mass Spectrometry (SPME-DART-MS)

The presence of ignitable liquid residues (ILR) in the fire debris could indicate the occurrence of arson. Accurately identifying ignitable liquids (IL) from the fire debris is a critical step in the crime investigation. GC/MS is the most commonly used method for analyzing the volatile components in ILR. Simultaneously, DART-MS has the potential to analyze both volatile and non-volatile chemical components and identifying them could yield corroborating evidence in the identification of specific IL used. Due to the interferences caused by the substrates and matrix, ILR analysis has become challenging. In this study, SPME was coupled to DART-MS to examine the matrix effects and extraction parameters to reduce the interference in the analysis. The SPME-DART-MS method was investigated on paint thinner and gasoline samples. Two-factor composite design was used to evaluate the SPME factors, such as extraction temperature and time. The full second-order polynomial model was constructed to fit the data, based on the modeled response surface, optimum conditions were reported. The ILR on wood, paper, fabric, sand and debris samples were studied to better understand their impact on extraction efficiency and analytical interference. The less volatile marker compounds associated with paint thinner and gasoline were successfully extracted from the substrates and fire debris by SPME followed by its analysis on DART-MS. As demonstrated, SPME-DART-MS has shown promising results in the detection of ILR, suggesting this method can serve as a complementary tool. The chemical information obtained from this method is very unique unlike the traditional GC/MS method. Since DART-MS is becoming more available in forensic labs and SPME is a widely used standard extraction method. The SPME-DART-MS setup can be easily implemented in the lab for ILR analysis.

89. Raga Amrutha Pogadapula
Faculty Mentor: Dr. Ngee Chong
Chemistry – Masters

Characterization of Toxicants Released from Recycled Tire Rubber Materials

Waste tires could pose undesirable environmental consequences through the release of contaminants and microplastics, which are defined specifically as plastic particles less than five millimeters in diameters. This study investigates the release of volatile organic compounds (VOCs) from recycled tire materials commonly utilized in various applications such as fuel for industrial facilities, lightweight embankment fill, playground groundcover, and athletic track surfaces. Contaminants released from the tire rubber via combustion, thermal desorption, and leaching were characterized by gas chromatography coupled to mass spectrometry (GC-MS) and infrared (IR) spectrometry. GC-MS is used to study the desorption of volatile organic compounds (VOCs) at 40-50 °C due to the heat absorption of the recycled products in summer and equatorial climate. Thermal desorption is also conducted at 200-350 °C to investigate the release of VOCs during the injection molding process for producing recycled products. The VOCs include alkanes, ethanol, acetone, acetaldehyde, cyclohexanone, methyl isobutyl ketone, xylenes, nonyl pentyl sulfite, and cyclic siloxanes. Combustion analysis of TDF particles by IR showed the emission of CO, SO2, ethylene, acetylene, methanol, and 1,3-butadiene. The leachates of tire rubber in contact with rainwater contained alkanes, aromatics, aniline, tetramethyl silicate, dimethyl silanediol, triethylamine, benzothiazole, benzaldehyde, benzyl alcohol, alkyl substituted 1,4-dibenzeneamines, D4 and D5 cyclic siloxanes, N-cyclohexylformamide, N-cyclohexyl acetamide, (bicyclohexyl)2-amine, phthalimide, 2(3H)-benzothiazolone, and alkylphenols. The benzothiazole derivatives have been reported to be dermal sensitizers, respiratory tract irritants, endocrine disruptors, carcinogens, and genotoxicants. Knowing the toxicant profiles is crucial to the development of sustainable technologies for recycling waste tires. Thermal desorption, selective degradation via ozone and ClO2, and solvent extraction were evaluated for their toxicant removal efficiencies. In addition to GC-MS, both infrared and Raman spectroscopic techniques are also used to characterize the tire wear particles.

91. Samir Poudel
Faculty Mentor: Dr. Khem Poudel
Computer Science – Masters

Impact of GAN-Generated Visual Aids on Learning Retention in Educational Materials

This research explores the integration of Generative Adversarial Networks (GANs) into educational materials to enhance learning outcomes. While human problem-solving abilities are profound, GANs offer unique advantages, particularly in automating content generation and fostering creativity. In scenarios where a human could easily tackle a problem, GANs present opportunities to automate tedious tasks, augment datasets for machine learning models, and introduce novel perspectives. The study focuses on a specific educational module, investigating the impact of GAN-generated visual aids on students' learning retention compared to traditional visuals. Although results are pending, we anticipate positive outcomes based on GANs' ability to generate diverse and contextually relevant content. GANs hold potential in providing scalable solutions for educational materials, addressing challenges related to data augmentation, and promoting creativity in content creation. Additionally, GANs can play a crucial role in subjective tasks, catering to various preferences and reducing human bias in datasets. The exploration of GANs' capabilities in educational contexts aligns with the broader goal of optimizing learning experiences through innovative technologies.While awaiting conclusive results, the study aims to contribute valuable insights into the efficiency and effectiveness of GANs in educational settings. The integration of GAN-generated visuals may not replace human problem-solving, but it has the potential to complement and enhance educational materials, creating a synergy between human expertise and automated content generation. This research underscores the importance of exploring emerging technologies like GANs to unlock new possibilities in education, fostering a dynamic and engaging learning environment. Future developments may reveal additional applications and further refine the integration of GANs to maximize their positive impact on learning outcomes.

93. Rachael Quinby
Faculty Mentor: Professor Jessie Runnoe and Dr. Aaron Stemo
Physics and Astronomy – Undergraduate

Measuring the Eddington Ratio of Single and Dual Active Galactic Nuclei in Mergers

As enough gas and dust is funneled onto the supermassive black holes at the centers of galaxies, it experiences significant friction, causing this gas and dust to emit tremendous amounts of heat and light. We observe these objects as active galactic nuclei or AGN. Our current methods of detecting these objects can find the biggest and brightest of these objects; however, if an AGN has low luminosity, it can be mistaken for a non-accreting galaxy. Therefore, it is thought that the true number of AGN, capable of being observed, is being undercounted. Using data from the Advanced Camera for Surveys AGN (ACS-AGN) Merger Catalog, a sample of 80 single AGN systems and 8 dual AGN in ongoing galaxy merger systems, we attempted to better understand AGN selection biases through an examination of the Eddington ratios of this sample. The ACS-AGN Merger Catalog contained total system mass, AGN luminosity, as well as merger ratio, so the Eddington ratios were able to be calculated for each black hole. The Eddington ratios as a function of mass ratio showed that at high mass ratios, the secondary AGN takes over as the more efficient in both dual and offset systems. The difference in Eddington ratios between the secondary and primary AGN confirms this trend. This reveals that when choosing AGN candidates based solely on luminosity, an absolute measure, candidates with the same relative accretion rate compared to their counterparts in a merger, could be cast aside entirely, introducing an implicit bias. Addressing this and attempting to correct for it in the future is crucial for understanding the true nature of AGN activation and will provide more complete data sets for future study.

94. Prateek Rai
Faculty Mentor: Dr. Souvik Banerjee
Chemistry – Doctoral

A Computational Exploration of Small Molecule Inhibitors Targeting the Autotaxin-LPAR1 Signaling Axis to Overcome Cancer Therapeutic Resistance

The emergence of therapeutic resistance poses a significant challenge in cancer treatment, underscoring the urgent need for innovative strategies to combat drug resistance mechanisms. Remarkedly, the ENPP2 gene, which encodes the enzyme Autotaxin (ATX), was found to serve as one of 90 drug-resistance genes. ATX functions as an extracellular enzyme, catalyzing the hydrolysis of lysophosphatidylcholine (LPC) to yield the lipid signaling molecule, lysophosphatidic acid (LPA). Upon its formation, LPA exerts diverse physiological effects, including cell proliferation, survival, and motility, among others, by interacting with a family of six G-protein-coupled receptors (GPCRs) referred to as LPAR1–6. The dysregulation of the autotaxin-lysophosphatidic acid receptor 1 (ATX-LPA-LPAR1) signaling axis has been implicated in promoting cancer progression and therapeutic resistance. Significantly, cytotoxic cancer therapy and ionizing radiation essentially produce an injury to the tumor. In the process of self-repair, cancer cells exploit the ATX-LPA-LPAR1 signaling axis to upregulate survival pathways, diminishing the efficacy of subsequent therapies. Therefore, directing efforts to target the signaling axis has emerged as a central strategy for overcoming resistance in cancer. In light of these factors, we employed a hybrid approach combining structure-based and ligand-based drug design methodologies to identify novel autotaxin and LPAR1 inhibitors. Virtual screening and pharmacophore-based approaches were employed to identify lead compounds from diverse chemical libraries. Molecular dynamics (MD) simulations, density functional theory (DFT), and quantitative structure-activity relationship (QSAR) analyses were subsequently utilized to refine the selected compounds, enhancing their potency, selectivity, and pharmacokinetic properties. The potential candidates underwent further validation via experimental assays, such as enzyme inhibition and combination therapy studies. This approach unveiled two compounds, exhibiting IC50 values of 494 nM and 1.6 μM, respectively, with further synthetic hit-to-lead modifications soon to follow. Preliminary results indicate that the hit compounds exhibit promising dual inhibitory activity against ATX and LPAR1.

96. Sydney Robbins
Faculty Mentor: Dr. Chusuei
Chemistry – Undergraduate

Electrochemical Detection of Fenthion for Forensic Analysis

Fenthion is an insecticide that has been widely used to protect crops against pests, however its toxicity has led to environmental and health concerns. Because of the harms fenthion presents, the ability to rapidly and accurately assay this pesticide is essential for forensic investigations of suicides, environmental violations, and poisonings. Electroanalytical techniques have been shown to be advantageous in detecting pesticides. Cyclic voltammetry is an electrochemical technique used to determine the reduction and oxidation of analytes in order to identify unknown compounds. The efficiency of cyclic voltammetry to detect trace amounts of fenthion is reportedly increased with the use of nanoparticles to modify the electrode used. The electrocatalytic capabilities of various nanomaterials drop-casted onto glassy carbon electrodes for fenthion detection will be presented to provide a non-destructive, cost efficient, time sensitive, and reliable method of fenthion detection that can be applied to forensic investigation, environmental protection, and public health efforts.

98. Sterling Rogers
Faculty Mentor: Dr. Keely Obrien
Agriculture – Undergraduate

Novel Use of a Sustainable, Perennial Sorghum Hybrid for Tennessee Whiskey

A perennial sorghum hybrid, derived from Sorghum bicolor and Sorghum halpanese, has been developed at the University of Georgia to decrease and even reverse soil degradation in agriculture. Other benefits of growing this perennial sorghum include a higher grain yield as it grows back each year, healthier soil, and not having to be resown yearly. Sorghum is comparable in price per bushel to other well-known grains like corn, rye, wheat, and barley, but lacks the demand shared by those other grains. Sorghum cultivation has been around for centuries, but research on perennial strains is still in its nascency. For this sorghum hybrid to find a place in mainstream markets, it needs a strong demand to drive its cultivation. The goal of this research is to seek out a viable way for the new sorghum hybrid to be used in Tennessee whiskey or bourbon and explore the effects of rapid aging techniques when compared to traditional aging methods. Should this research prove fruitful, it would expand sorghum's utility beyond animal feed and biofuel and provide the economic incentive for farmers to grow this ecologically and environmentally beneficial crop.

95. Claudia Roselio
Faculty Mentor: Dr. Andrienne Friedli
Chemistry – Undergraduate

Copper or Acid/Base Complexes with Pyridines for Self-Organizing Materials

Blatter radicals (BR) are a group of 1,4-dihydrobenzo[e][1,2,4]triazin-4-yl systems that have exhibited unique stability and have potential application as magnetic or optoelectronic materials. A derivative of BR containing a pyridine ring could not be characterized by single crystal X-ray diffraction (SCXRD) due to insolubility in less polar solvents and the tendency to precipitate as a powder from polar solvents. Attempts to induce self-organization through complexes with a wide variety of mono-, di-, and triacids also resulted in powders. Model bis complexes using cupric acetate, 2,6-pyridine dicarboxylic acid, and bipyridyl or 1,4-dipyridylbenzene were prepared with a modified literature hydrothermal synthesis and a novel SCXRD structure was obtained. This method was promising for formation of mono Cu complexes with other model compounds relevant to BR, but cobalt II complexes, and for other synthetic methods did not result in single crystals. Other characterization of products includes IR and NMR spectroscopy, mass spectrometry, and thermal and elemental analysis.

100. Myra Sabir
Faculty Mentor: Dr. Mary Farone
Biology – Undergraduate

Interactions Between the Novel Obligate Intracellular 'Candidatus Berkiella Cookevillensis' and Human Neutrophil-Like Cells

'Candidatus Berkiella cookevillensis' (CC99) is an obligate intracellular bacterium that can infect and replicate within host cell nuclei. The bacterium is closely related to other intracellular bacteria such as Coxiella burnetii, and Legionella pneumophila, both of which are human pathogens. Although CC99 has been shown to infect a variety of different cell types, the interactions between CC99 and neutrophils have yet to be characterized. Neutrophils are essential in the clearance of bacterial pathogens in the body, but susceptibility to infection by intracellular bacteria may play a role in the progression of disease. In this study, HL-60 cells were differentiated using 1.3% DMSO, and treated with CC99. Immunofluorescent microscopy was used to determine the level of differentiation of the HL-60 cells into neutrophil-like cells and to see CC99 can infect these neutrophil-like HL-60 cells. Results show that CC99 can infect differentiated HL-60 cells that express CD11b, suggesting that CC99 can potentially infect human neutrophils.

97. Marco Said
Faculty Mentor: Dr. Grant Gardner
Biology – Undergraduate

Graduate Teaching Assistants' Perceptions of Autonomy, Pedagogical Discontentment, and Self-Efficacy: A Quantitative Analysis

Prior research has suggested the importance of considering an instructor's self-efficacy (confidence for teaching) in conjunction with their perceptions of pedagogical discontentment (dissatisfaction with one's teaching practices). When pedagogical discontentment is experienced in instructors with high self-efficacy, they may attempt new instructional practices, but when low self-efficacy instructors experience pedagogical discontentment, they may engage in avoidance behaviors related to instructional change. Without autonomy over teaching goals and/or teaching practices, the development of pedagogical discontentment might not occur. In this study, we were interested in exploring graduate teaching assistants' (GTAs) perceptions of teaching autonomy, pedagogical discontentment, and self-efficacy in the STEM disciplines. Specifically, our research questions for this study were: 1) What are STEM GTAs' perceived teaching autonomy, pedagogical discontentment, and self-efficacy? 2) How and to what extent do perceived teaching autonomy and pedagogical discontentment differ among STEM disciplines? To answer our research questions, we administered cross-sectional surveys to a sample of GTAs in the disciplines of biology, geology, chemistry, and mathematics (n = 50). Results in relation to Research Question 1 revealed moderate Likert scale averages of autonomy, pedagogical discontentment, and self-efficacy. In support of Research Question 2, there was evidence of a difference in the teaching autonomy of GTAs based on their discipline. The biology and chemistry GTAs reported lower perceptions of autonomy compared to the geology and mathematics GTAs. There was no evidence of a difference in the GTAs' perceptions of pedagogical discontentment among the disciplines. However, there was evidence of a difference in the GTAs' reported perceptions of self-efficacy. Biology and mathematics GTAs reported higher perceptions of self-efficacy compared to the chemistry and geology GTAs. This study has implications for how GTAs' perceptions could influence their readiness to learn and try new instructional practices.

102. Sean Sanders
Faculty Mentor: Dr. Ngee Chong
Chemistry – Masters

Protocol for Quantitative Determination of Ammonia in Ambient Air Samples

The direct analysis of ammonia (NH3) in air samples by infrared spectroscopy with the use of a 10-meter gas cell can allow measurement in the range of 0.2-100 ppm. To achieve a detection limit as low as 2 ppb or 1.40 ng/L ammonia, a new passive sampling method for an extended period of 48-72 hours is necessary to provide analyte preconcentration for achieving a detection limit capable of distinguishing between the ambient air concentrations of ammonia near farming operations and the background levels of ammonia in at about 1-3 ppb. The passive sampling media will be based on (i) a spherically-shaped glass wool and (ii) a porous bubbling stone. The glass wool and bubbling stone are soaked in 0.1 molar sulfuric acid for at least 4 hours and air dried overnight before being used for field sampling of ammonia. Analyte molecules of NH3 will react with the sulfuric acid to yield ammonium sulfate at the sampling sites. These compact passive samplers will be analyzed for ammonia by the conversion of ammonium sulfate via the addition of 1.0 molar NaOH to the H2SO4-acidified media to release ammonia for gas phase determination using a 10-meter heated gas cell. For each sampling site, 3-5 samples obtained at the downwind locations will be composited for ammonia analysis to achieve a more representative sampling of ammonia concentrations that may fluctuate according to wind speed, wind direction, and air moisture. Secondly, the relatively lengthy procedure of sample preparation, spectral acquisition, and data analysis can be efficiently managed by combining facility-specific samples to ensure timely project completion. Last but not least, compositing the samples can potentially allow the lower detection limit of 0.5 ppb or 0.35 ng/L to be achieved. The performance of the passive samplers is evaluated for ammonia monitoring at the MTSU farm.

24. Natalie Schroth
Faculty Mentor: Jessica Arbour
Biology – Masters

Examining the Relationship Between Habitat and Color Diversification in Darter Fishes

Coloration serves many important functions among clades, including mate selection, kin recognition, and predator avoidance. Although ecological pressures act upon the color pattern evolution within groups, the impact these pressures have on said evolution is poorly understood. Within family Percidae, the often brightly colored subfamily Etheostomatinae (lotic “darter” fishes) serves as an excellent study group with more than 200 species. To better understand the macroevolutionary relationships between darter coloration and habitat, we used adjacency analysis to quantify color variation from photographs of wild caught specimens. We gathered habitat data for each species in the dataset from GIS databases and species accounts. Using the R package phytools, phylogenetic canonical correlation analysis was used to identify and measure any relationships between habitat and coloration characteristics. Cluster analysis was used to group major habitat types, and Multivariate BM models were used to test for heterogeneity in color diversification rates between macro- and micro-habitat types. We found a weak but significant relationship between habitat types and coloration. Evolutionary modelling revealed rapid diversification in rivers with large drainages, high discharge, low slope, and soft substrates. However evolutionary rate variation associated with micro-habitat data (i.e., riffles vs pools) showed the greatest support and demonstrated faster diversification in riffle-associated species. Our results suggest that although habitat is not strongly associated with specific coloration, it is a driver of diversification in Etheostomatinae.

104. Dipesh Shrestha
Faculty Mentor: Dr. Arpan Sainju
Computer Science – Doctoral

A Deep Learning Approach for Decision Support in Efficient 3D Object Manufacturing Method Selection

The global Auto Parts Manufacturing Market is expected to expand at a CAGR (Compound Annual Growth Rate) of 7.2% between 2023 and 2030, reaching a value of around $1200 Billion by 2030. Diverse manufacturing methods, including Injection Molding, Waterjet Cutting, Laser Cutting, CNC Machining, and 3D Printing, are employed across industries. Certain objects may be produced with greater efficiency using a particular manufacturing process, whereas others might require different techniques. The choice of a production method for a new 3D object is influenced by several factors, including its shape and the materials used. In current practices, manufacturers consider existing similar objects during the decision-making process to select the best manufacturing method. However, manually identifying existing similar objects can be time-consuming due to the large variety of data classes. To address this problem, we propose a deep learning-based clustering framework that includes a feature extractor based on a Multiview Multi-Slice CNN (Convolutional Neural Network) network and a robust clustering algorithm. The proposed feature extractor identifies key features from multiple slices captured from different viewpoints of the 3D object. To enable effective clustering of these features, we shall use the well-established DBSCAN (Density-Based Spatial Clustering of Applications with Noise) clustering algorithm. The DBSCAN clustering algorithm adapts to varying data densities, eliminating the need to specify a fixed number of clusters to address the uncertainty on the potential number of clusters. We believe this research will significantly contribute to improving design-to-manufacturing workflows and fostering long-term success in the industry.

99. Ty Stallings
Faculty Mentor: Dr. Mina Mohebbi
Agriculture – Undergraduate

Anaerobic Digesters, Food Waste, and Their Ideal Parameters

Food waste in America goes into landfills and produces high volumes of greenhouse gas emissions, predominately methane. According to the EPA, 58% of all emissions from landfills come from food waste while only taking up 24% of the total mass of what is disposed of. To curb this waste while recouping valuable materials, anaerobic digesters are being studied to diverge food waste. Our team wanted to know how best to utilize anaerobic digesters before testing the impact of microplastic on the digesters, so we sought out the ideal ratio of foods based on their factors in the anaerobic digestion process, namely the carbon-to-nitrogen ratio (C/N), pH, moisture, volatile and total solids (VS, TS), and the biochemical methane potential (BMP). We would then mix the food waste with cow manure at a ratio of 1:1 and moisture was added by using deionized water until the material was able to be made into patties. This mixture of food was then adjusted to better reflect the food waste that ends up in the landfills in America with a ratio of fat 24%, protein 21%, and carbohydrates 55%, and helped provide a more neutral pH, which the anaerobic digesters prefer. The mixture was then kept in an anaerobic environment, treated with a base (NaOH) to keep the pH neutral, and kept at originally at a temp of 37 C before changing it to 55 C later in the experiment. Potassium Metabisulfite (KMBS) was used in later experiments to curb the digester growth curve and ensure steady, manageable growth. Gas was collected into bags via plastic tubes, and was analyzed by Fourier Transform Infrared (FTIR) and Gas Chromatography (GC) techniques. It revealed the main byproducts were methane, carbon dioxide, and ethanol, showing we were able to recoup something from the wasted materials.

106. Ermias Takele
Faculty Mentor: Dr. Abdul Khaliq
Mathematics – Undergraduate

Energy Conservation of Solitary Waves; Nonlinear Schrödinger Equation (NLSE)

This research dives into the unique properties and behaviors of solitary waves, with a primary focus on their propagation, interaction dynamics, and potential applications, particularly in the context of energy conservation. The research centers on exploring the conservation of energy and mass for solitary waves, utilizing the Nonlinear Schrödinger Equation (NLSE) as a fundamental model. The NLSE framework offers a comprehensive approach to unraveling the nonlinear effects governing solitary wave behavior. While the research is ongoing, initial findings indicate the remarkable resilience of solitary waves when subjected to collisions, showcasing their ability to persist without breaking. This study contributes to the current field by providing valuable insights into the fundamental nature of solitary waves and their practical applications. Aligning with recent advancements that have opened exciting possibilities in understanding and harnessing these phenomena for various purposes. Such as in application of fiber optics and plasma physics. Solitary waves play a pivotal role in these fields, offering unique advantages such as maintaining shape over long distances without distortion in optical fiber communication systems and contributing to a deeper understanding of complex plasma behaviors.

101. Ian Tatum
Faculty Mentor: Dr. Arpan Sainju
Computer Science – Doctoral

Macro-Driven Virtualization of Rust Binaries

Unauthorized licensing, modification, and pirating of software has become a rising concern for individual programmers and software companies. In response to these concerns, software obfuscation has emerged as a crucial technology to safeguard intellectual property and deter potential attackers. However, commercial and academic state-of-the-art obfuscation approaches rely on specific build tools, limiting their usability and adoption among their intended users. In this work, we introduce an obfuscation library for the Rust programming language. Leveraging built-in language features, our approach utilizes macros to achieve obfuscation, mirroring virtualization-based techniques without the need for external or specialized build tools. This enables simple and effortless protection for any Rust program, allowing for widespread adoption within the community.

26. Pratanna Thamsorn
Faculty Mentor: Sumane Neupane
Physics and Astronomy – Undergraduate

Enhanced Magnetic Properties of Nickel-Catalyzed Carbon Nanotube-Alumina Composite

This research is centered on the synthesis and the study of new materials called carbon nanotube (CNT) embedded with alumina nanocomposites. We synthesized CNT/alumina nanocomposites using chemical vapor deposition process and investigated their structure, shape, and magnetic properties. The direct synthesis allows for the homogenous dispersion of CNTs within alumina matrix at the molecular level. The final composite had 6.4% carbon nanotubes by weight, and the carbon nanotubes were less than 50 nanometers wide. We measured the magnetic properties using vibrating sample magnetization and obtained an enhanced saturation magnetization on the composites. CNT/alumina nanocomposites can find application in magnetic sensors and memory devices.

103.Jacob Thomas
Faculty Mentor: Dr. Scott Handy
Chemistry – Masters

Fluorescence of Novel Pyrazoles

Aurones are naturally occurring molecules that have intriguing biological and photophysical properties and have become enticing synthetic precursors due to the reactivity of the exocyclic alkene. While several pyrazoles have been made through dipolar cycloaddition using that alkene, their photophysical properties have been poorly explored. To better understand these properties, we have prepared a series of pyrazoles derived from cycloaddition/ring opening of aurones with ethyl diazoacetate. We then examined their absorption and emission behavior in solvents with a range of polarities and protic natures. This showed that the presence of an electron donating group substituent increases the fluorescence response as polarity of the solvent increases. This leads to a significant increase in water, a solvent that typically quenches fluorescent activity. Halogen substituents were also found to have a similar effect in halogenated solvents. Correlations between the structure of each pyrazole and its fluorescence in a variety of solvents have been noted, and a plausible rationale has been proposed.

105.Wisdom Thompson
Faculty Mentor: Dr. Jing Kong
Chemistry – Undergraduate

Unjust Response or Rightful Reproof?

In 2009, a team of physicists (N. Helbig, I.V. Tokatly, and Angel Rubio) published a paper concerning the limitations of Density Functional Theory (DFT), a method employed to model the atomic structure of many-body systems computationally. The limitation in question was the fact that DFT is unable to properly describe the dissociation of molecules on the quantum level; thus, these researchers argued that the Kohn-Sham Potential (KSP)---A set of equations used to simplify the description of electrons' behavior in the atom—should be employed to account for this deficiency of DFT. The publication concluded that this was indeed the correct approach for computing molecular dissociation and as evidence produced a nontrivial form of the Kohn-Sham potential to model the dissociation of a single molecular bond, however their findings were not well received by the scientific community who remarked that the differential equations used in their models were not calculated accurately and so therefore their conclusion was made on unstable ground. This project solved the equations in the publication to determine in truth whether the response of the scientific community was justified or whether these scientists indeed were correct in their findings. The differential equations used in the publication were re-calculated to determine the validity of the physicists' conclusions.

107.Aubrey Tidwell
Faculty Mentor: Dr. Daniel Erenso
Physics and Astronomy – Undergraduate

A Computer Code for Measurement of Radiation Intensity from Animal Blood

This research project establishes a robust foundation by incorporating calibration data that I recorded from the equipment employed in the measurement of the animal blood cells by video clips. This meticulous calibration process ensures accuracy and reliability of estimations, serving as a cornerstone for the subsequent analytical procedures. A distinctive feature of our approach lies in the utilization of recorded video clips at varying brightness levels. Meticulously recorded calibration data ensures accurate measurements, encompassing intensity per unit area and temporal information for intensity per unit time in seconds. The resulting system provides a precise and versatile tool for radiation intensity measurements. harness the synergy of advanced computational techniques and laser trapping to create a dynamic and precise tool for calculating radiation intensity by using the programming language Python. The focus is on transforming power per pixel measurements into standardized units of W/m^2 .

28.Mary Tran
Faculty Mentor: Dr. Kevin Bicker
Chemistry – Doctoral

Revealing and Refining Antifungal Peptoids: From iPLAD Assay Discovery to SAR Optimization

The escalating global challenge of antibiotic resistance necessitates the exploration of innovative therapeutic alternatives. N-alkylated peptidomimetics, specifically peptoids, have emerged as promising candidates due to their broad-spectrum activity against bacteria and fungi, coupled with a non-specific mode of action. In this study, we introduce peptoids as an alternative solution to conventional antibiotics, leveraging a high-throughput iPLAD assay for rapid discovery and employing a structure-activity relationship (SAR) approach for compound optimization. The peptoid scaffold offers flexibility for systematic modification, allowing the exploration of diverse side-chain functionalities, lengths, and charges. Through an iterative SAR study, we aim to optimize the antimicrobial efficacy of peptoids while minimizing cytotoxicity. The integration of high-throughput assays and SAR analysis holds the potential to expedite the discovery of potent N-alkylated peptidomimetics, addressing the critical need for effective antimicrobial agents in the face of growing antibiotic resistance.

109.Lindsey Tran
Faculty Mentor: Dr. Daniel Erenso
Physics and Astronomy – Undergraduate

Revolutionizing Energy Harvesting: Creating Artificial Stars from Livestock Blood and Micromagnetic Beads to Generate Electromagnetic Radiation

Electromagnetic (EM) radiation, omnipresent in our surroundings, serves diverse purposes from simple cellular communication to advanced medical treatments and space exploration! Our research explores an innovative way to revolutionize EM harvesting and storage through laser-trapping technology, micromagnetic beads, and livestock blood. The livestock industry annually generates an excessive 1.4 billion pounds of waste, primarily animal blood, representing a significant environmental concern. By utilizing blood samples from key livestock animals (sheep, goat, chicken, bovine, turkey, horse, and porcine), our study produces long-lasting and self-sustaining EM radiation. To accomplish this, the experiment involves a 3:1 micro-level mixture of animal blood and micromagnetic beads on a depression slide within an infrared laser trap, progressing through two distinctive phases: Plasma formation and Star-like radiation. In Plasma formation, exposure to the laser trap induces electric breakdown, which ionizes the sample mixture and forms a dense plasma. Subsequently, the Star-like radiation phase begins when the laser is reactivated onto the dense plasma. This accelerates the plasma and generates intense blackbody radiation. This radiation is seen as a yellow, glowing illumination that grows as more energy is absorbed, showing similarities to stars, such as the natural Sun. Hence, we named this phenomenon, “Star-like formation.” The study attains 90-95% radiation energy absorption over 1.5 to 7.5 hours, marking a micro-level advancement in EM harvesting with animal blood. To expand on this, further measurements are now being conducted using greater sample mixture volumes. We envision this study to be a foundational step for macro-level applications, such as leading to the creation of artificial stars.

108.Jiblal Upadhya
Faculty Mentor: Dr. Jaishree Ranganathan
Computer Science – Doctoral

A Novel Approach in Multi-Modal Representation Learning: Applications in Healthcare and Blockchain Security

This research presents multimodal representation learning within heterogeneous data and explore the integration of these modalities using advanced data fusion techniques. The study is motivated by two distinct application fields, each presenting unique challenges and opportunities. In the domain of medical imaging, the focus lies on leveraging multimodal data, MIMIC-CXR dataset, where class imbalance poses a significant hurdle. The two primary modalities under consideration are chest X-ray image and radiological reports. To address the class imbalance effectively, our methodology embraces a multi-modal fusion approach, integrating radiological reports and chest X-ray images to enhance diagnostic accuracy and facilitate decision-making processes in medical settings. This dual perspective not only bridges the modality gap but also provides a comprehensive understanding of the underlying medical conditions. By employing early and late fusion techniques, we have substantially able to leverage the distinct and complementary information, thus enhancing the model's ability to recognize and classify rare conditions accurately. Our results demonstrate that the late fusion multi-modal architecture significantly achieving accuracy of 94.2% which is a promising strategy to help and diagnose in Chest X-ray medical imaging. In the realm of blockchain technology, particularly in smart contract security vulnerabilities, the research endeavors to understand and learn multimodal representations across four key modalities: Solidity source code, Bytecode, Opcode, and Intermediate representations. By comprehensively analyzing, the study aims to identify and mitigate potential vulnerabilities in smart contracts, thereby enhancing the security and reliability of blockchain-based systems. We developed a novel Multi-Modal Transformer architecture called Quadra Code AI, using the four unique modalities. Through our pioneering work, 12 different combinations of Multi-modal framework are devised using Cross-Attention and Concatenations as a robust data fusion algorithm. Out of the 12 diverse multimodal frameworks, the combination incorporating solidity source code and byte code standout, giving an impressive classification accuracy of 93%.

111.Jahnavi Vankayalapati
Faculty Mentor: Dr. Joshua Phillips
Computer Science – Masters

Comparative Analysis of Elbow Method and K-Means Algorithm for Customer Segmentation

In today's fiercely competitive business landscape, understanding and catering to the diverse needs and preferences of clients is imperative for organizational success. Targeted marketing strategies revolve around customer segmentation, which involves breaking down a heterogeneous client base into distinct groups based on common attributes. By doing so, businesses can effectively tailor their products, services, and marketing campaigns to resonate with specific customer segments. Effective decision-making hinges on interpreting client segments derived through clustering methods. It's crucial for businesses not only to identify discrete consumer segments but also to understand the key attributes characterizing each one. This study aims to provide practical recommendations by analyzing the spending patterns and demographics of each cluster's customers. In this research, we explore the application of machine learning techniques, particularly the K-Means clustering algorithm, in customer segmentation. The rise of big data and advancements in computing power have made machine learning algorithms indispensable for extracting meaningful insights from vast volumes of customer data. The literature review highlights significant challenges in consumer segmentation, including the need to determine the optimal number of clusters for K-Means clustering. To address this challenge, we investigate the elbow technique, which utilizes within-cluster sum of squares (WCSS) analysis to identify the ideal number of clusters. We examine comparative analysis of K-means and K-Means with Elbow approach in terms of accuracy and interpretability of consumer groups. The dataset utilized in this study comprises demographic information and spending scores of 200 customers from a mall. By leveraging machine learning algorithms and innovative techniques for cluster analysis, businesses can gain deeper insights into their customer base and make informed decisions to better serve their clientele. This study contributes to advancing the understanding and implementation of customer segmentation strategies in today's dynamic market environment.

113.Juan Vargas
Faculty Mentor: Dr. William Robertson
Physics and Astronomy – Undergraduate

Audio Steganography Using Python

In this presentation, we are attempting to develop and demonstrate the use of python encoding tool for audio steganography. The methods, employs a maximal length sequence (MLS) for embedding inaudible hidden information within audio signals. This method would have applications in digital watermarking for copyright protection, well as, uses in hidden messaging. We begin by generating an MLS sequence based on user input, such as the order of the sequence, which will then be used as the digital key for encoding and decoding. Using standard python libraries, we read in the audio signals, and generate the MLS. The MLS is then combined additively with the original audio waveform, ensuring the embedded information remains sufficiently small such that it is indistinguishable from the original audio file to the listener. Through the numerical signal processing technique of correlation, we show how using the original MLS sequence as a cryptographic key, the hidden information can be extracted from the combined audio. This analysis demonstrates the presence of the MLS within the audio signal, allowing extraction of the embedded data without noticeably altering the audio quality.

115.Katie Velasquez-Ruiz
Faculty Mentor: Dr Seth Jones
Geosciences – Undergraduate

What Do You Know About Volcanoes?

I conducted a clinical interview for my Knowing and Learning course this semester. I interviewed one novice and one expert on the topic about volcanoes. This interview was conducted on the purpose of seeing the different knowledge between each individual. They were asked the same exact questions. This project focuses on the ability of being able to remember details about certain topic we think we may know well.

30.Kiriti Vundavilli
Faculty Mentor: Dr. Joshua Phillips
Computer Science – Masters

Essence of Taste: Authentic Recommendation Model for Organic Word-of-Mouth and Temporal Information Networks

Research in recommendation systems in various domains like e-commerce, social media, and content consumption has probed for improvements in system performance primarily by changing two aspects of the way the problem of recommendation is defined. First, the data structure which is used to represent the relationships between what may be the users, the providers, the products, etc, and might also include ancillary information like the inter-relationships between providers, products or users. The second is the way this data structure is represented, learned, and then predicted by a model. This study will propose a different way to frame the problem of recommendation by using novel changes in both the data structure aspect as well as its representation and learning. The proposed model will focus its application on the domain of film. In this domain, and this study, the entities will be categorized as viewers (a viewer views a film), filmmakers (makes a film), and films (can be viewed or made). One additional novel relationship is "mentioned" (Viewer1 mentioned The Godfather). Many models proposed in this domain see additional relationships, such as acted in, composed for, written by etc. However, this study will focus on authorial recommendations, i.e., those that depend on preferences dictated by sole authorship of the film as a whole rather than aspects of it. Therefore the problem scope is constrained while also potentially showing that there is untapped performance even with two entities, which many existing models do not capitalize. The data structure, an information network and knowledge graph will be used as such: the study will model real world Word-of-Mouth (WoM) recommendations by using simultaneous multi-context ternary information networks, and also incorporate temporal-causal relationships to these networks for higher accuracy personalized recommendations as well as to model the web of influences over time; and this performance compared.

110.Satish Wagle
Faculty Mentor: Dr. Khem Poudel
Computer Science – Doctoral

Leveraging U-Net Architecture in GANs for Advanced Brain Tumor Image Synthesis and Segmentation

Brain tumor diagnosis and treatment have benefitted from advancements in medical imaging and computational methods, but significant challenges persist, including data scarcity and the need for precise tumor segmentation to support comprehensive treatment strategies. This study presents an approach for creating artificial brain tumor images and the segmentation masks that go along with them by combining Generative Adversarial Networks (GANs) with U-Net architecture. Our approach overcomes privacy concerns and the scarcity of specific tumor types by adding high-quality, diverse synthetic images to datasets, thereby addressing important issues in medical imaging research. We describe our GAN-based framework's development and validation in detail, highlighting its ability to generate realistic images for three different tumor categories. The incorporation of U-Net, a model well-known for its efficacy in medical image segmentation tasks, improves the segmentation accuracy of the generated images. Our findings show that these synthetic datasets have the potential to aid in the development of reliable AI models, in addition to improving dataset diversity and segmentation accuracy. These models have the potential to generalize across different imaging modalities and patient demographics, enabling more precise diagnosis and individualized treatment regimens. Moreover, the method circumvents the ethical and privacy issues that arise from using real patient datasets by producing non-personal data. In the field of brain tumor diagnosis and treatment, this study helps close the gap between computational innovations and clinical applications by providing a scalable way to improve AI-driven analyses and enrich medical imaging datasets.

32.Haoyuan Wang
Faculty Mentor: Qiang Wu and Donlin Wang
Mathematics – Doctoral

Neural Network Custom Loss Function for Flexible and High-Quality Prediction Intervals

In the realm of deep learning, interval prediction plays a crucial role in diverse applications. However, the rise of complex challenges in these domains requires more flexible and high-quality prediction intervals. To address this need, we present a novel custom loss function specifically designed for deep learning models. This function optimizes both prediction interval width and coverage, boasting superior flexibility compared to traditional approaches. Specifically, our loss function utilizes multiple penalty coefficients to precisely control the interval width. Higher coefficients favor wider intervals to guarantee coverage, while lower ones prioritize narrower intervals for improved prediction accuracy. This delicate balance allows the model to adapt to different situations and application demands. Extensive experiments on ten public datasets across various domains reveal the impressive performance of this custom loss function. It consistently generates high-quality prediction intervals with remarkable generalization capabilities, readily adapting to diverse application scenarios.

117.Calleigh Warren
Faculty Mentor: Dr. Warner Cribb
Geosciences – Undergraduate

Cloud Cap: A Case Study of Flank Eruptions at Mount Hood Volcano

Mount Hood volcano is in the northern Oregon Cascade Range, a volcanic mountain system extending from northern California to British Columbia. According to the U. S. Geological Survey, the threat potential for eruption at Mt. Hood is high. In addition to 'Main Stage' cone-building eruptions from the central volcanic vent, beginning approximately 730,000 years ago, minor flank eruptions repeatedly produced hazardous flows of mixed volcanic gas, ash, and volcanic mudflows. Understanding how flank eruption magmas form and chemically evolve during ascent through the central volcanic cone and underlying crust is essential to predicting a volcano's eruptive hazards. Cloud Cap is a flank eruption vent on the northwest side of Mount Hood. Lavas erupted from Cloud Cap do not exhibit evidence of glacial erosion and, therefore, must be younger than 10,000 years, the close of the most recent Pacific Northwest glacial period. This research aims to compare the chemical and mineralogical compositions of Cloud Cap lavas to those of lavas that make up the underlying 'Main Stage' volcanic edifice. Significant differences in Si, Al, Mg, Rb, and Sr concentrations indicate separate magma sources and variability in subvolcanic processes that produced Cloud Cap magma. Mineralogically, Cloud Cap and Main Stage lavas are similar but exhibit different amounts of microscopic textural features, such as crystal resorption, a characteristic of chemical disequilibrium. Along with differences in chemical compositions, textural differences suggest that Cloud Cap magmas were more chemically isolated than Main Stage magmas during crustal ascent. Mineralogical and chemical compositions are also critical magma density and viscosity factors, both of which impact the rates at which magmas ascend and exsolve volatile phases, such as H2O and CO2. Because rapid exsolution of volatile phases is a contributing factor to hazardous eruptions, continuing research will investigate relationships between Cloud Cap magma density, viscosity, and ascent rate.

119.Amber Washington
Faculty Mentor: Dr. Kiel Ormerod
Biology – Undergraduate

Imaging Mutagenized Drosophila Genetically Engineered with a Fluorescently Tagged Neuropeptide to Identify Novel Proteins Involved in Dense Core Vesicle Biology

Neuromodulatory substances regulate critical processes spanning from regulated secretion to physiology and behaviour. It is therefore not surprising that most genomes encode hundreds of neuromodulatory substances and their receptors. The Drosophila genome encodes over 30 genes for neuropeptides alone. Neuromodulatory substances like neuropeptides are packaged within cells in large electron dense structures known as dense core vesicles (DCVs). DCVs are responsible for the transport, storage, and release of proteins and neuropeptides at multiple cellular locations and are known to be involved in a multitude of biological processes including synaptogenesis, synaptic transmission, synaptic plasticity, and others. However, much of cellular machinery involved in sorting, processing, trafficking, and ultimately secretion of DCV contents remains largely unknown. Here we have taken advantage of the genetic and molecular toolkit of Drosophila to conduct a genetic screen for changes in cellular localization of fluorescently labelled neuropeptides. We have identified several critical proteins necessary for proper processing of prepropeptides into bioactive neuropeptides ultimately impacting their ability to be trafficked to and undergo regulated secretion at the neuromuscular junction. Using this EMS screen and other approaches in our lab, we are beginning to characterize cellular mechanisms of sorting of different uniquely tagged DCV cargo. Lastly, by employing quantal resolution imaging of vesicle fusion at individual active zones, we are also characterizing the synaptic machinery mediating trafficking and secretion of DCVs. The novel mutants isolated here enable a more comprehensive understanding of the critical mechanisms of neuropeptide sorting, trafficking, and secretion in vivo.

34. Olivia Westfall
Faculty Mentor: Dr. Gregory McPherson
Physics and Astronomy – Undergraduate

What's the Point(e)?

Classical ballet, renowned for its elegance, conceals the demanding physical toll it exacts on dancers. Delicate, yet rigorous, pointe technique, in particular, places immense strain on the feet, ankles, and knees, contributing to a high incidence of injuries across all skill levels. Central to this challenge are the pointe shoes themselves, which serve as both a tool of artistic expression and a mechanism for distributing pressure. However, despite their significance, a critical gap remained in understanding the real-time pressure dynamics within these shoes during performances. In response to this gap, an innovative solution emerged: a new detector capable of measuring pressure distribution within pointe shoes as dancers execute movement en pointe. This breakthrough not only deepens our understanding of the physics behind ballet but also offers practical insights for optimizing dancer performance and injury prevention through improved footwear design. In essence, this research bridges the realms of physics and artistry, enriching both disciplines and enhancing our appreciation for the intricate interplay between science and dance.

36. Derek Wiggins
Faculty Mentor: Dr. David Nelson
Biology – Doctoral

Regulation of IFNy-Stimulated Gene Expression in Macrophages by the Transcriptional Co-Regular CITED1

Macrophages are pleotropic innate phagocytic cells that maintain tissue homeostasis by taking on contrasting phenotypes during different phases of an infection. Exposure to pathogen-associated molecular patterns and/or interferon-gamma (IFNγ) polarizes these cells to the highly pro-inflammatory, microbicidal M1 state, enhancing their ability to kill invading microbes and initiating a broader immune response. At the resolution of the infection, rising levels of interleukin (IL) 4 and IL-13 triggers the anti-inflammatory M2 polarization. Transition between these states, which involves the altered expression of >1000 genes, is largely governed by the JAK-STAT pathway and a range of positive/negative feedback loops which help to ensure clear and timely phenotypic shifts. Dysregulation of these molecular feedbacks are associated in various inflammatory disorders. In this study we identify CITED1, a transcriptional co-regulator, as an enhancer of IFNγ-stimulated gene expression and M1 polarization. Using a combination of RNA sequencing, qRT-PCR, and western blot analysis, we show that IFNγ stimulation increases the expression of CITED1 at the transcript and protein level in RAW264.7 murine macrophages. Expression of CITED1 was found to be STAT1 and IRF1-dependent with putative cis-regulatory sites for both transcription factors identified within the cited1 promoter. Using a loss- and gain-of-function approach, we found that CITED1 enhanced the expression of IFNγ-stimulated genes (ISGs). While the mechanism for this has yet to be resolved, it is likely that CITED1 enhances the ability of STAT1 and IRF1 to recruit the histone acetyltransferase, CBP/p300 to ISG promoters by acting as a scaffold. This role is in direct contrast to another CITED protein, CITED2. CITED2 is a constitutively expressed nuclear protein that attenuates IFNγ-stimulated gene expression through its sequestering of CBP/p300. Proposed future studies will investigate how CITED1 is regulated by post-translational modification and characterize the contrasting roles of CITED1/2 in the control of macrophage polarization and pro-inflammatory gene expression.

121. Weston Williams
Faculty Mentor: Dr. Tony Johnston
Agriculture – Undergraduate

Removal and Bioconversion of Pharmaceutical Waste Created by the Production of Antibiotic Penicillin, and the Spread of Antibiotic Resistance in the Environment

Since its discovery Penicillium sp. has been a highly utilized cure-all for many bacterial caused illnesses, this is in no doubt due to penicillin's antimicrobial property, Penicillium chrysogenum is a mold like growth that prevents reproduction of gram-positive bacteria. In recent years antibiotics like penicillin have seen increased use and production on a national scale. Industry scale production of penicillin is a tenuous process of purifying and harvesting bio-active penicillin. The synthesis and production of penicillin involves the use of various chemicals, reagents, and solvents. The waste generated from the chemical processes includes unused or spent chemicals, byproducts, and leftover biomass growth from the fermentation process. The release of these products into wastewater creates many ecological concerns and challenges. Primarily the spread of the antimicrobial resistance gene in bacteria. A development in bacteria where a sublethal exposure to antimicrobial properties is subverted and is ineffective to bacterial growth. Potential spread of the antimicrobial resistance gene would not only occur in wastewater but spread to livestock and crops through irrigation and finally towards humans. This project is aimed at studying biological treatment and conversion of these toxic antimicrobial wastes. Some of the methods discussed include Incineration, Chemical oxidation, Biodegradation and Absorption. These processes aim to remove the bioactive function of the byproduct and seek to create an ecologically safe product. Ideally the solution to the pharmaceutical waste issue would be not only environmentally stable but also economically viable. The proposed strategy should encompass proper disposal practices, advanced waste management systems, and innovative treatment methods.

123.Ian Wilson
Faculty Mentor: Dr. Cole Easson
Biology – Undergraduate

Alternative Splicing of CMK-1 in C. Elegans form Paraquat-Induced Oxidative Stress

Aging is a complex process with classifiable hallmarks such as impaired intracellular communication and nutrient sensing. Research aging-implicated genes provides an avenue toward interventions to improve human longevity. One gene implicated in aging is CMK-1 in nematodes and CAMK4 in humans. This gene plays a key role in the nutrient signaling pathways of C. elegans and decreases expression with age. Knockdown of the gene in nematodes increased lifespan by 15%. Environmental stressors, such as oxidative stress, also affect lifespan. One stressor is paraquat, a pesticide that induces oxidative stress, impacting longevity, gene expression, and mitochondria. While CMK-1 is known to be an aging-related gene, the impact of environmental stressors on the expression and regulation of CMK-1 are unexplored. The aim of this study was to explore the changes in alternative splicing, one type of gene regulation, under stress conditions. First, nematodes were treated with paraquat or saline, a control. RNA was isolated and used to produce cDNA. Exon-specific primers were used to test whether alternative splicing of exon 4 occurred in stressed nematodes compared to non-stressed nematodes by analyzing DNA fragment sizes using agarose gel electrophoresis. Alternative splicing did not occur under either condition. To better understand changes that skipping exon 4 skipping might have, bioinformatics tools were used to compare sequences and function of proteins encoded by RNAs that skipped or included exon 4. These analyses revealed that skipping exon 4 would interfere with kinase domain TIGR0393, suggesting that if exon 4 had been skipped, protein function would be eliminated. Overall, alternative splicing was not observed for CMK-1 exon 4 in response to paraquat-induced oxidative stress. This outcome invites further exploration into alternative stressors that do elicit alternative splicing. In addition, 3-dimensional analysis of predicted proteins could yield insight into their function, including use in targeting the aging process.

112.Ahmeed Yinusa
Faculty Mentor: Dr. Misagh Faezipour
Engineering Technology – Doctoral

Effect of Behavioral Risk Factors on YPLL Health Disparities Across Racial and Ethnic Groups in the US

This research explores the impact of behavioral risk factors on Years of Potential Life Lost (YPLL) and their contribution to health disparities among racial and ethnic groups in the United States, using data from the 2023 County Health Rankings National Findings Report. Our analysis focuses on the prevalence of smoking, obesity, physical inactivity, and excessive drinking and their effects on YPLL across African American, Asian, Hispanic, White, and American Indian/Alaska Native (AIAN) populations. Employing advanced statistical analyses, including linear regression models and correlation assessments, we examined the relationship between these health behaviors and YPLL, controlling for socio-economic and geographic variables to refine our insights. The comprehensive dataset encompassed both state-level and individual demographic data, offering a detailed picture of health outcomes. Through this rigorous analytical approach, we aim to provide actionable insights into the patterns and predictors of health disparities, facilitating the development of more effective public health strategies and policies. Our results reveal pronounced disparities in YPLL, with AIAN populations bearing the highest burden, followed by African American and Hispanic communities. The statistical analysis showed a moderate to strong correlation between health behaviors and YPLL within these groups, with AIAN groups exhibiting especially high YPLL rates associated with teen birth rates and obesity. Smoking and obesity prevalence varied significantly across the studied groups, ranging from 5-35% for smoking and 20-50% for obesity. This research not only highlights the critical need for targeted public health strategies but also serves as a vital evidence base for policymakers and health practitioners in developing interventions aimed at curtailing health disparities and enhancing the health and longevity of minority populations in the U.S. Through a nuanced understanding of the complex interplay between behavioral risk factors and YPLL, this study contributes to the ongoing efforts to achieve health equity and improve the overall well-being of all Americans.