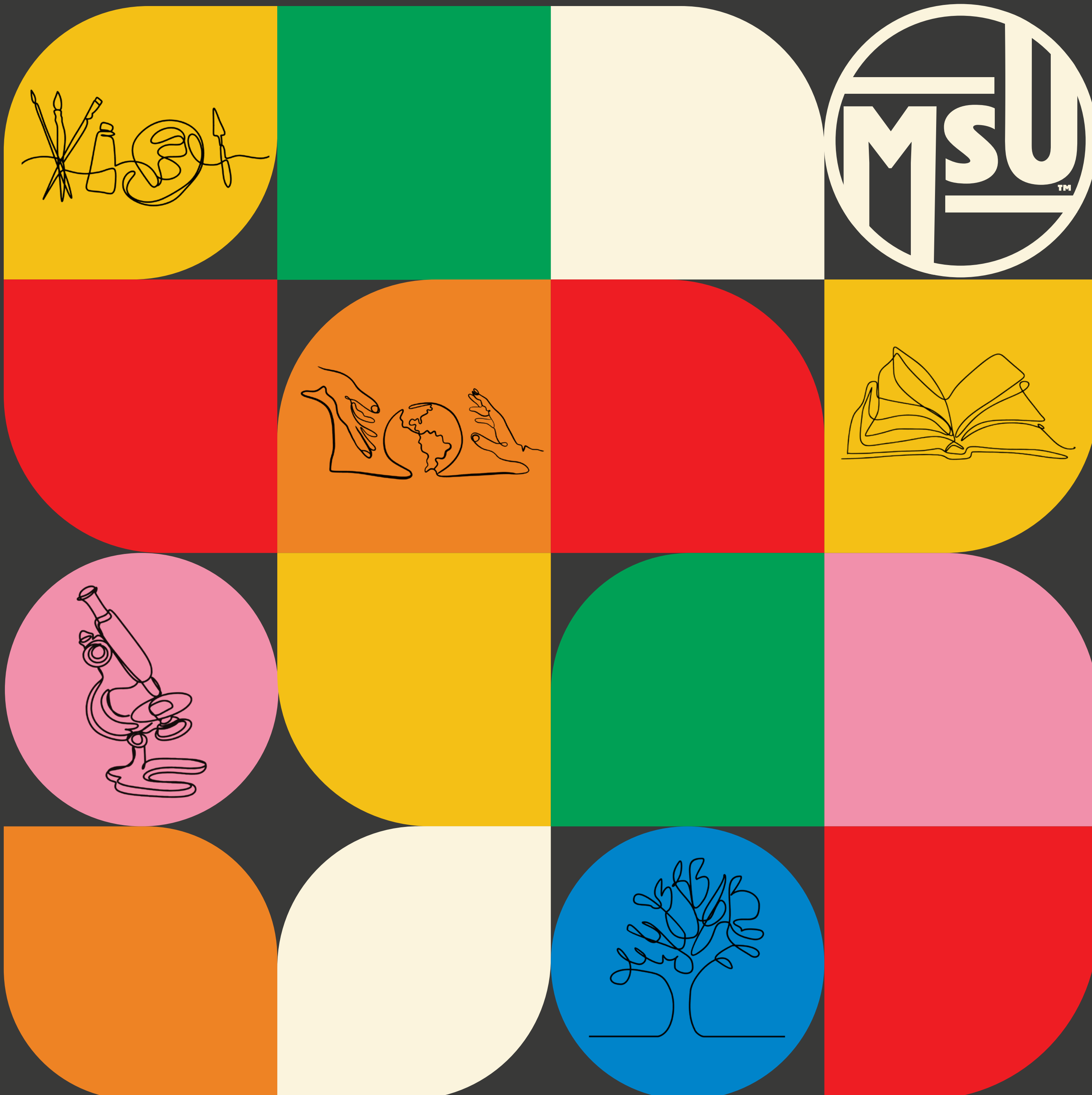

SUMMER UNDERGRADUATE RESEARCH SHOWCASE

MISSISSIPPI STATE UNIVERSITY™
UNDERGRADUATE RESEARCH
AND CREATIVE DISCOVERY

COLVARD STUDENT UNION

AUGUST 2, 2024

CONTENTS

MISSISSIPPI STATE UNIVERSITY™
UNDERGRADUATE RESEARCH AND CREATIVE DISCOVERY

WELCOME TO THE SUMMER UNDERGRADUATE RESEARCH SHOWCASE

Welcome to the 2024 Summer Undergraduate Research Showcase! We are thrilled to have you join us for this exciting event, celebrating the innovative work of our talented students. The dedication to exploring new ideas and pushing the boundaries of knowledge is truly inspiring.

Over the course of today, you will have the opportunity to share your research, engage with peers and faculty, and gain valuable insights from a diverse array of disciplines. This showcase is a testament to the hard work, creativity, and commitment to academic excellence of everyone involved, from presenters and research mentors to evaluators and attendees to organizers and sponsors.

We encourage you to take full advantage of the presentations and discussions, fostering a spirit of collaboration and intellectual curiosity. There are comment cards available for you to complete and share your feedback with students about their work. Your participation strengthens our vibrant research community.

We look forward to an inspiring and rewarding day. Thank you for being a part of this special event.

Sincerely,

Anastasia D. Elder, Ph.D.
Director of Undergraduate Research & Creative Discovery
Associate Dean, Shackouls Honors College

IN LOVING MEMORY

DR. DEB MLSNA

1964-2024

Debra Ann Mlsna, a cherished member of the MSU community, will be deeply missed, particularly during this occasion. Known for her role as a beloved teacher and dedicated mentor to chemistry students, she also advocated passionately for undergraduate research.

Twelve years ago, she established a summer program for a few chemistry students that has since grown in scope, now providing various experiential opportunities for many undergraduate students to engage in research and present at the summer showcase.

Her legacy of academic excellence, unwavering mentorship, and dedication to student advancement will always be treasured. Remembered fondly by her family, friends, colleagues, students, and all who were touched by her kindness, her impact will resonate for years to come.

In honoring Deb, let's emulate her by appreciating life's simple joys- whether it's a leisurely walk, a delicious meal, an exciting adventure, or quality time with loved ones.

Dr. Mlsna pictured with students from the 2023 REU and Summer Research Cohort

UNDERGRADUATE RESESARCH SHOWCASE SCHEDULE
Summer 2024

Friday, August 2nd

Poster Presentations		
TIME	**EVENT**	**LOCATION**
11:30 a.m. - 12:30 p.m.	Project Check-in and Student Viewing of Other Posters	Foster Ballroom, Colvard Student Union Second Floor
12:30 p.m. - 2:30 p.m.	Poster Session	

Oral Presentations		
TIME	**EVENT**	**LOCATION**
11:30 a.m. - 12:30 p.m.	Project Check-in	Whittington Board Room, Colvard Student Union Second Floor
12:45 p.m.	**Christopher Jolivette (50)** 'He was merely pretending': Simulacra and Deterrence in *The New York Trilogy* **Sarah Demus (51)** Herbarium Mural for Harned Hall	

STUDENT PRESENTERS

NAME	RESEARCH CATEGORY	PROJECT NUMBER
Raegan Anderson	Engineering	1
Elizabeth Bryant	Engineering	2
Mackenzie Burnett	Engineering	3
Karl Butler	Engineering	4
Piyush Chaudhary	Engineering	5
Piyush Chaudhary	Biological and Life Sciences	6
Ethan Dean	Engineering	7
Olivia Draughn	Engineering	8
Honor Elchos	Engineering	9
Olivia Goodman	Engineering	10
April Guo-Yue	Engineering	11
Theodore Hoover	Engineering	12
Zac LeBlanc	Engineering	13
Harrison Low	Engineering	14
Jeremy Lugo	Engineering	15
Grayson Luker	Engineering	16
Cooper Medved	Engineering	17
Spandan Niroula	Engineering	18
Chloe Puckett	Engineering	19
Reid Sewell	Engineering	20
Eric Sisson	Engineering	21
Kenna Turner	Engineering	22
Mary-Addison Wolfe	Engineering	23
Andrew Zheng	Engineering	24
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Caden Andrews	Physical Sciences	26
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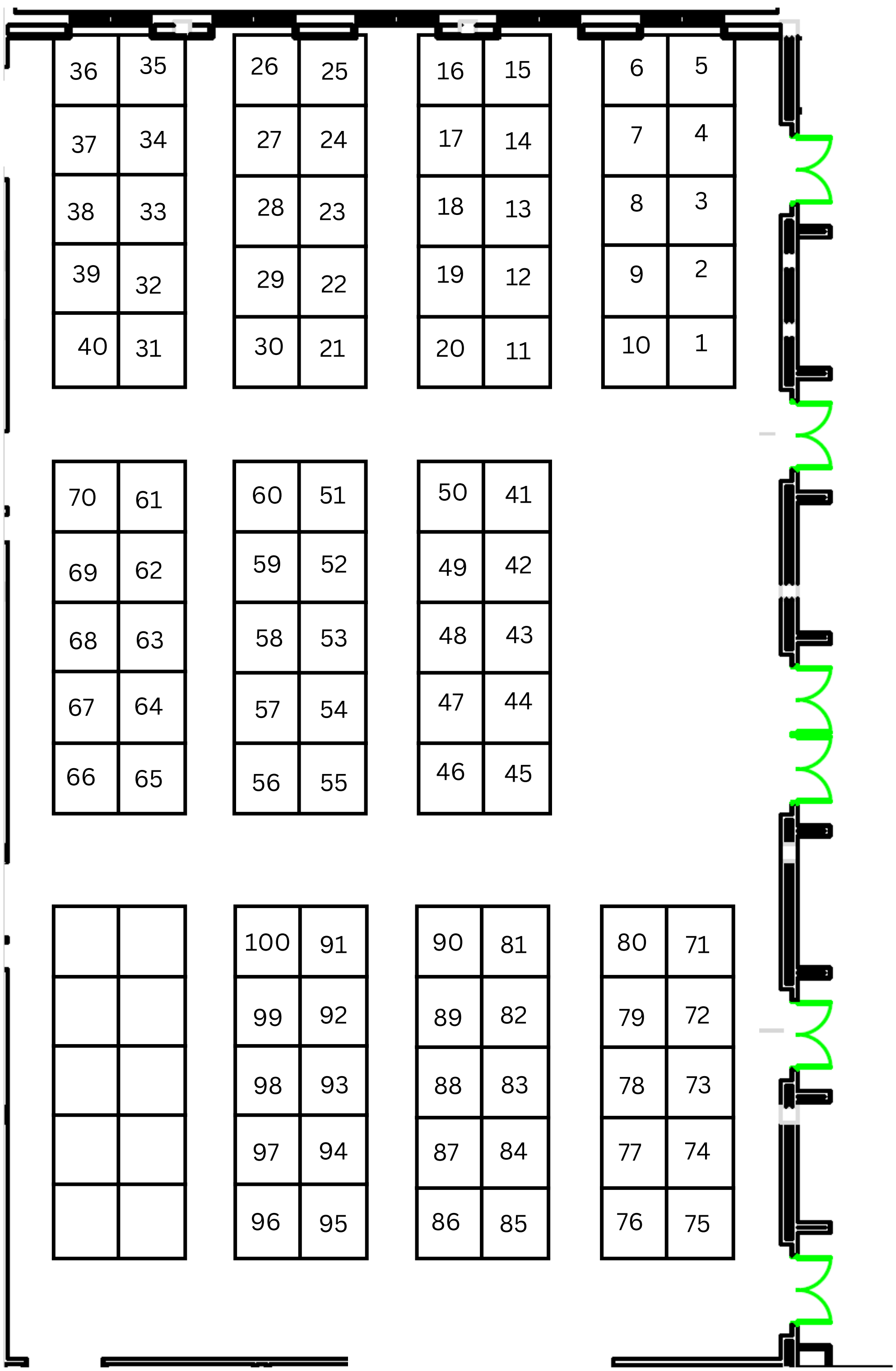
SUMMER 2024 SHOWCASE POSTER MAP

Friday, August 2024
Foster Ballroom, Colvard Student Union
Mississippi State University



56
Name: Adams, Tobias
Major: Biochemistry - Bachelor of Science
Faculty Research Mentor: Richard Baird, Agricultural Science & Plant Protec
Co-Author(s): Hannah Purcha
Funding: ORED Undergraduate Research Program, Mississippi Soybean Promotion Board
Project Category: Biological and Life Sciences

Evaluation of Soybean ROS Metabolism Changes Induced by Drought and *M. phaseolina* Stress

Eukaryotic cells produce highly reactive molecules known as reactive oxygen species (ROS). The compounds are derived from the tendency of the O2 molecule to accept elections, which generate subsequent unstable molecules such as hydrogen peroxide (H2O2), hydroxyl radicals (OH-), and superoxide (O2-). Stable levels of ROS are crucial to the normal function of cells, and excess ROS results in cellular damage due to oxidative stress. *Macrophomina phaseolina* (MP) is a hemibiotrophic, generalist, soilborne fungus that causes severe damage to many crops, especially during hot and dry conditions. MP is believed to upregulate ROS production in its host, leading to membrane damage and cellular death. The goal of this study is to assess the impact of drought (D) and MP infection on the ROS levels in soybean (*Glycine max* (L.) Merr.). In a greenhouse trial, soybean plants were subjected to four treatments: MP-/D-, MP+/D-, MP-/D+, and MP+/D+. Foliar tissue from these plants was harvested across three dates (7/11/23, 8/4/23, and 8/24/23), and the tissue was assayed for key ROS-associated compounds. The results of these analyses are presented in the poster.

57
Name: Adugna, Hawinet
Major: Medical Technology - Bachelor of Science
Faculty Research Mentor: Ryan Folk, Biological Sciences
Co-Author(s): Nicholas J. Engle-Wrye
Funding: NSF REU: NSF DEB-2316266
Project Category: Biological and Life Sciences

Verifying the effective pollinators by using metabarcoding

Most plants find their mates via pollinators; therefore plant-pollinator interactions are essential to understanding gene flow in plant populations. This study tests and uses a molecular metabarcoding protocol to identify what plant pollen flower visitors carry on their legs, thus verifying effective pollination. The three host plant taxa tested were Heuchera americana, Heuchera richardsonii, and their hybrid Heuchera americana var. Hhirsuticaulis. Metabarcoding was tested using the nuclear genetic locus ITS (internal transcribed spacer) and three chloroplast genomic loci: rbcL, matK, and the trnL intron. DNA sequences were identified to plant taxa using the package QIIME 2. MatK and the trnL intron were unsuccessful in identifying plant taxa due to low taxonomic resolution. ITS and rbcL were successful, with ITS demonstrating the most taxonomic resolution. Based on visitation data, three dominant effective pollinators were identified:, Lasioglossum Andrena, and Augochlorella. Pollen metabarcoding demonstrated that these bee genera carry pollen loads almost exclusively of Heuchera, identifying them as the likely effective pollinators and probable specialists of Heuchera. These methodological results will contribute to the overall project goal to test if conservatism of pollinator interactions could act as a driver of hybridization in plants.

25
Name: Allen, Javen
Major: Biological Sciences - Bachelor of Science
University: Tougaloo College
Faculty Research Mentor: Todd Mlsna, Chemistry
Co-Author(s): Olalekan Olabode, Hashani Abeysinghe, Chathuri Peiris, Gavin Potts
Funding: NSF REU: Food, Energy and Water Security Summer Research Program
Project Category: Physical Sciences

Remediation of lead from water and soil using biochar/Mn-FeAl layered double hydroxide

Lead (Pb^{2+}) contamination of water and soil poses significant environmental and health risks, necessitating efficient remediation strategies. In this study, Mn-FeAl layered double hydroxide was synthesized by coprecipitation, deposited onto Douglas fir biochar (Mn-FeAl LDHBC), and evaluated for its Pb^{2+} adsorption capacity. Mn-FeAl LDHBC was characterized by XRD, XPS, BET, FTIR, elemental analysis, SEM, and SEM-EDS. Pb^{2+} adsorption onto Mn-FeAl LDHBC was optimized by studying the adsorption isotherm, adsorption kinetics, initial solution pH, dosage, ionic strength, competitive ions, regeneration, and remediation of contaminated soils. Batch sorption studies were conducted at pH 5, with initial Pb^{2+} concentrations ranging from 1 to 500 mg/L at 5, 25, and 40 °C. The adsorption data conformed to the Langmuir isotherm model, with maximum adsorption capacities of 90, 106, and 129 mg/g at 5, 25, and 40 °C, respectively. Thermodynamic parameters indicated that the adsorption process was spontaneous, endothermic, and feasible. Adsorption kinetics analysis showed fast kinetics, and the adsorption followed a pseudo-second-order model. The effect of initial solution pH on Pb^{2+} adsorption was investigated over a pH range of 1–5 to prevent Pb^{2+} precipitation at higher pH values. Minimal Pb^{2+} adsorption was observed at lower pH values, with increased adsorption efficiency at higher pH values.

58
Name: Anderson, Hayden
Major: Biochemistry - Bachelor of Science
Faculty Research Mentor: Russell Carr, Department of Comparative Bio Scien
Co-Author(s): Shirley Guo-Ross, Kendall McKinnon, Sarah Broadway, Janice Chambers, Edward Meek, Angela Ross
Project Category: Biological and Life Sciences

Effect of Acute Exposure to a Nerve Agent Surrogate on the Expression of Neurological Markers in the Brain

Nerve agents are organophosphate chemicals (OP) that have been utilized against warfighters during combat but have also been used against the civilian population by terrorists. When used against warfighters, the agents are delivered via precise military strikes leading to high levels being delivered in small areas. However, in terrorist exposures to civilians, the delivery is not as precise leading to high sub-lethal exposures. In addition, the civilian population would contain many different ages frequently with the majority being children. Unfortunately, the majority of studies involving the exposure of preclinical models to OP nerve agents or their surrogates have been at lethal dosages and accompanied by the co-administration of therapeutics against OP-induced lethality (i.e., atropine and 2-PAM). Thus, there is a data gap with respect to the effects of nerve agents on the younger population. This project was designed to investigate the effects of a high sublethal acute exposure to the nerve agent surrogate NIMP (nitrophenyl isopropyl methylphosphonate) on juvenile rats. Sixteen-day-old rats were exposed subcutaneously to either the vehicle multisol or 0.175 mg/kg NIMP. All rats exhibited episodic seizure-like signs following exposure. Brain samples were collected at 4 hours, 1 day, and 4 days and RT-PCR was performed. At 4 hours, the expression of c-fos and BDNF was significantly increased indicating cellular excitation. On day 1, there was decreased expression of the neurological markers GFAP (astrocytes), IBA-1 (microglia/macrophages), and SB100 (general damage), TMEM (microglia) with the decreased expression of GFAP, IBA-1, and SB100 continuing through day 4. These data suggest that exposure of juveniles to a nerve agent will decrease the levels of various cell types that are specific to the brain.

1
Name: Anderson, Raegan
Major: Computer Science - Bachelor of Science
University: Southern University and A&M College
Faculty Research Mentor: Ali Gurbuz, Electrical and Computer Engineering
Co-Author(s): Volkan Senyurek
Funding: NSF REU: 2024 Summer REU: Intelligent Edge Computing Systems (iEDGE)
Project Category: Engineering

Real Time Machine Learning: Pruning and Implementing Neural Networks with Jetson Nano Computing Node

AI is continuously developing and misinformation along with redundant systems need to be controlled. Developing pruning techniques to train neural networks to extract and compress large data sets to reduce prediction errors within training sets is a way to keep new technology effective. These types of devices are made to prevent overfitting within data sets and to stay within the determined parameters. Multiple sets of data from radio frequency (RF), multispectral, platform control sensors, and GPS devices are collected and need to be jointly processed to infer target parameters. Attention-based design of deep neural networks (DNN) can improve latency and energy efficiency while preserving inference performance. This project evaluates how sparsity-based DNN approaches, attention, and knowledge distillation mechanisms with a teacher-student network. The benefits of this type of technology include less complexity in models that lead to less overfitting and more generalization. It also improves the efficiency by using less time for inference as there are less connections.

26
Name: Andrews, Caden
Major: Chemistry - Bachelor of Science
Faculty Research Mentor: Joseph Emerson, Chemistry
Co-Author(s): Sean Stokes, Mahshid Attarroshan
Funding: ORED Undergraduate Research Program, MSU HIH COBRE Grant (P20GM103646)
Project Category: Physical Sciences

Efficient Synthesis of Chalcone Derivatives and Their Application towards Aza-Michael Addition Reactions

Chalcone derivatives are highly valued in medicine due to their significant health benefits. In this study, a series of chalcones were synthesized from 2-acetylbenzimidazole and various benzaldehyde derivatives, achieving yields ranging from 60% to 80%. The characterization of these compounds primarily relied on 1H NMR spectroscopy, which provided detailed structural information. These chalcone derivatives are earmarked for future applications in reduction reactions, aza-Michael additions, and other conjugate addition-type reactions. These versatile synthetic pathways are anticipated to facilitate the creation of a diverse array of new compounds with potential therapeutic uses. This research underscores the ongoing exploration of chalcone derivatives as valuable tools in medicinal chemistry, aiming to harness their beneficial properties for improving human health.

59
Name: Antonaros, Bella
Major: Biological Sciences - Bachelor of Science
Faculty Research Mentor: Heather Jordan, Biological Sciences
Co-Author(s): Jordan Smink, Bria Johnson
Funding: This study was supported, in part, by a grant from NSF/REM (Award # 2052454, Supplemental Award # 2206850, Subaward M2202244) awarded to the NSF Industry/University Cooperative Research Center For Environmental Sustainability Through Insect Farming.
Project Category: Biological and Life Sciences

Enhancing Black Soldier Fly (Hermetia illucens) Larvae Health and Growth by Optimizing Ground Chicken Substrate Composition

The poultry industry in the United States faces significant challenges with on-farm mortality, where approximately 500 million chickens (over 5.0% of the 9.3 billion chickens) that are raised annually for meat die prior to reaching the market. This accounts for about a quarter poultry product loss in North America, with around 1.5 million animals perishing daily due to disease and injury. Current methods of disposal include burial and incineration which both contribute to the production of greenhouse gasses. Addressing this issue within the chicken industry presents a considerable opportunity to reduce waste. One innovative solution is the utilization of black soldier fly (BSF) larvae to digest chicken protein, which can then be used as a feed source for livestock, fostering a circular economy. Previous experiments in our lab have shown that BSF larvae raised on ground chicken waste alone experience high mortality rates compared to those fed commercially standardized diets. Larvae reared on a ground chicken-only diet exhibit low weight gain and suboptimal feed conversion rates. This may be due to the high nitrogen content in ground chicken, which many insects find difficult to digest. In this study, we investigated the impact of incorporating varying concentrations of a carbon source, specifically paper towel, into ground chicken substrate on larval digestion and substrate conversion. We hypothesized that the addition of the paper towel carbon source would increase BSF digestion and substrate conversion. Data from our work could provide a sustainable solution to managing poultry and non-recyclable paper waste while enhancing livestock feed resources.

60

Name: Arce-Benitez, Pablo
Major: Environmental Sci in Ag System - Bachelor of Science
University: University of Puerto Rico-Rio Piedras Campus
Faculty Research Mentor: Adam Polinko, FWRC - Forestry
Funding: NSF REU: Forestry REU
Project Category: Biological and Life Sciences

Determining branch autonomy while absorbing water

Trees sequester carbon and provide materials that we use in our daily life. The live crown is the engine of tree growth. Branches support the live crown and are geometrically optimized to capture sunlight. Branches are generally thought to be autonomous units, where each branch supports nutrients, photosynthesis, respiration, growth water and carbon management individually. Water intake is solely managed by the tree trunk and all branches of that tree are dependent on it, although there is a possibility that branch autonomy could prevent localized stress like water loss due to high radiation load, leaving the rest of the tree functional while the stomata closes. While branch autonomy has been observed and studied in various plants species, hyper temporal variation and interactions between branches have yet to be studied. The primary purpose of this study is to determine individual branch autonomy from other branches connected to the same stem when absorbing and releasing water in *Pinus taeda* species. We developed an open-source, Arduino based datalogger that can log up to 8 individual dendrometers. A series of point dendrometers will be used to measure branch radius variations by placing 2 dendrometers facing north and south in 3 different sections of the live crown (top, middle and bottom). Tree bark also absorb and release independently from the stem, meaning that when measuring stem diameter change due to water exchange using a dendrometer it also measures the bark water exchange, making it a non-representative value of stem diameter (Oberhuber et al., 2020). To distinguish between the change in diameter due to stem water exchange versus bark water exchange, we will measure bark water exchange on dead branches in addition to living branches. This could help better understand the dynamics of the live crown and understand knot formation.

61
Name: Askeland, Heidi
Major: Chemical Engineering - Bachelor of Science
University: University of Oklahoma
Faculty Research Mentor: Esteban Galeano, FWRC - Forestry
Co-Author(s): Carlos Rivera
Funding: NSF REU: Forestry REU
Project Category: Biological and Life Sciences

Enhancing Tree Genetic Diversity Assessment Using Linkage Disequilibrium

Genetic diversity assessment in tree populations is crucial for understanding their adaptive potential amidst environmental challenges like climate change. Traditional methods, such as observed heterozygosity (He) and Wright's fixation index (Fst), while informative, rely on assumptions that may not hold in dynamic ecological contexts. Effective population size (Ne), a key parameter in genetic diversity studies, is conventionally estimated through labor-intensive field studies or molecular markers. The study of effective population size in plant species remains limited, presenting an opportunity to explore robust methodologies using linkage disequilibrium (LD). LD offers a snapshot of current population dynamics without requiring multiple temporal samples, potentially enhancing accuracy and practicality in genetic diversity assessments for tree populations. Besides, LD-based Ne is useful in populations with small true effective population size, which makes it feasible for forest management and conservation approaches. The objectives of our study are to 1) evaluate the performance of LD equations under differing sample sizes and pipelines using supercomputing, and 2) assess the influence of sample size on Ne estimates. The study assesses LD and using empirical data from white spruce (Picea glauca). Analyses include the evaluation of an LD equation using different software (TASSEL and PLINK), scripts, supercomputing, and sample sizes, allowing for the calculation of Ne using different LD outputs. This research expects LD-based Ne estimates to demonstrate accuracy and stability across different sample sizes, particularly under conditions where temporal sampling is challenging. An optimal LD equation is anticipated to vary based on sample size, providing insights into practical applications for genetic diversity studies in tree populations. Also, findings from this study contribute to refining methodologies for genetic diversity estimation in tree populations. LD emerges as a robust alternative for estimation, offering practical advantages in accuracy and feasibility over traditional methods. These insights support sustainable forest management strategies amidst global environmental changes.

53
Name: Barlow, Mikenlee
Major: Psychology - Bachelor of Science
Faculty Research Mentor: Mary Dozier, Psychology
Project Category: Social Sciences

A Comprehensive Review of Pain Neuroscience Education as a Treatment for Fibromyalgia.

Pain is a subjective term that cannot be physically observed by a medical provider. However, the subjective feeling of pain does not take away from the severity of its presence. This presentation reviews evidence for a new treatment of fibromyalgia. Fibromyalgia is a chronic neurological disorder characterized by musculoskeletal pain, fatigue, and memory and mood issues. Historically, there was confusion about the etiology of fibromyalgia due to the lack of physical evidence. Presently, this disease refers to our brain plasticity and association of central sensitization. A rising educational component is now considered a treatment for fibromyalgia. Pain neuroscience education (PNE) was introduced in 2002 with a goal in helping patients reconceptualize their pain through techniques such as analogies and metaphors. PNE allows patients to gain more understanding of their chronic pain while perceiving it as more malleable. An important factor in interpreting pain neuroscience education is considering the brain as the main control center to our chronic pain. Whenever objective feelings arrive such as tenderness, soreness, or sensitivity, it travels through our tissues, into our nerves, and arrives in our brain before it outputs pain signals to the affected area. While our brain is associated with receiving and sending signals, it is also associated with our mental state. PNE aims to partner these duties in hopes to find an equilibrium between the two. If PNE becomes a first step treatment for chronic pain disorders such as fibromyalgia, we can reduce the use of pain medication, suicidal ideation and attempts, comorbidities of depression and anxiety, and the pain itself. However, additional research is required on how to effectively implement PNE across treatment setting to find the perfect match of a multi-component treatment.

62
Name: Bernard, Brandon
Major: Biochemistry - Bachelor of Science
Faculty Research Mentor: Peixin Fan, Animal & Dairy Science
Co-Author(s): Himani Joshi, Abigail McBride, Lindsey Reon, Aravind Bethini, Amelia Woolums
Funding: College of Agriculture and Life Sciences URSP
Project Category: Biological and Life Sciences

Establishment of Heat Stress Models for Investigating the Heat Stress Responses of Lactating Holstein Cattle

Heat stress poses a global challenge to sustainable livestock production, particularly for dairy cows due to the elevated internal heat caused by high milk production. During heat stress, dairy cows experience increased respiration rates and reduced feed intake, potentially influencing the respiratory and gastrointestinal microbial ecosystems, leading to higher susceptibility to infections and impaired digestive function. This study aimed to establish heat stress and heat-stress abatement conditions to investigate the relationship between changes in microbial ecosystems of dairy cows and heat stress responses. Twenty-four lactating Holstein cows were divided into Heat Stress (HS) group and Heat Stress-Relieved (HR) group, respectively, which had an entire or limited access to fan and sprinkler cooling system during a 14-day period in June at Starkville, Mississippi. Temperature-humidity indices (THI), respiration rate, rumen contraction frequency, rectal temperature, feed intake, and milk yield were recorded regularly. The THI in both groups remained above 72 from 12 PM to 8 PM for the trial period's duration with no significant differences between groups ($p=0.371$). However, the respiration rate (12pm: 89.45±12.36/min vs 69.15±9.27/min, 6pm: 81.73±16.33/min vs 59.87±9.35/min, $p<0.001$) and rectal temperature (7am: 38.55±0.14° C vs 38.39±0.16° C, 6pm: 39.66±0.61° C vs 38.76±0.31° C, $p<0.01$) were significantly higher in the HS group compared to the HR group. Additionally, HS group exhibited lower rumen contraction frequency (7am: 1.62±0.06/min vs 1.71±0.11/min, 6pm: 1.62±0.07/min vs 1.81±0.05/min, $p<0.001$) and less daily feed intake (44.47±14.22 kg/cow vs 56.63±13.75 kg/cow, $p=0.023$) compared to HR group. However, no significant differences in milk yield were observed between HS and HR groups, $p=0.134$). These findings confirm the successful establishment of heat stress and heat-stress abatement models. Further analysis will focus on the heat stress-induced changes in the microbial ecosystems of these dairy cows.

63
Name: Bock, Landon
Major: Mechanical Engineering - Bachelor of Science
University: East Mississippi Community College
Faculty Research Mentor: Matthew Priddy, Mechanical Engineering
Co-Author(s): Matthew Register
Funding: ORED Undergraduate Research Program
Project Category: Biological and Life Sciences

Polylactic acid (PLA) review

Polylactic acid (PLA) is a versatile polymer with numerous applications in the biomedical industry. As a biocompatible and biodegradable material derived from lactic acid, PLA holds significant potential for medical use. It offers a range of production methods and applications, making it a promising material for bone/tissue scaffolding, drug delivery, and implants. Current research highlights the diverse applications and the ongoing development of PLA while it also faces challenges such as brittleness and strength. The materials performance can be adjusted based on processing conditions and application. This paper reviews PLA's degradation performance for biomedical implant application. There are several methods for modifying PLA's biodegradation rate such as: compounding, surface modifications, and additives or blends. This paper will discuss these methods and how they can be further improved. This review also delves into some of the ideal 3D printing methods. With further research and improvements in material processing and design, the potential for PLA in biomedical application is vast.

2
Name: Bryant, Elizabeth
Major: Biological Engineering - Bachelor of Science
Faculty Research Mentor: Lauren Priddy, Ag & Bio Engineering
Co-Author(s): Michael Hast, Halleigh Falkner, Tanner Jones
Funding: NSF REU: R25 EMCC-MSU BACCALAUREATE PROGRAM
Project Category: Engineering

Differentiating Surface Roughness of Additively Manufactured Zinc Biomaterials

Zinc is being explored for many biomedical applications including orthopedic implants due to its biodegradability, bioactivity, and biocompatibility. Achieving an appropriate surface texture on the implant is crucial for facilitating cell attachment and ultimately bone healing. This study focuses on evaluating the surface roughness of additively manufactured zinc biomaterials fabricated using laser powder bed fusion. The zinc biomaterials were categorized into four groups based on texture: as-built, mild, moderate, and severe (n=5). Surface roughness and line roughness analyses were conducted using a Keyence VR-5000 surface profilometer. As expected, the results revealed distinct differences in roughness across the groups. Line roughness was: lower for as-built compared to all other groups, lower for mild than moderate, and lower for moderate than severe. Similarly, surface roughness was lower for the as built compared to the severe. These findings validate the classification of zinc biomaterials based on their surface roughness levels and pave the way for future investigations into how these textures impact mesenchymal stem cell functions such as proliferation and differentiation. Positive outcomes could establish zinc biomaterials as an innovative degradable option for medical implants, potentially improving patient recovery times and reducing the need for additional implant surgeries. This research exemplifies zinc's potential in advancing orthopedic treatments through tailored biomaterials that optimize biological responses at the cellular level. In conclusion, understanding and controlling surface roughness in zinc biomaterials is critical for enhancing their effectiveness in medical applications. Further research into their biological interactions will be essential for translating these findings into practical advancements in orthopedic surgery applications.

3
Name: Burnett, Mackenzie
Major: Civil Engineering - Bachelor of Science
Faculty Research Mentor: Jun Wang, Civil and Environmental Engineering
Funding: Shackouls Honors College Research Fellowship
Project Category: Engineering

Human-Robot Collaboration (HRC) in Construction: Workforce Preparation and Development

Over the years, the construction industry has seen a decrease in skilled workers due to the dangers of work as well as workers transitioning to retirement. To cut down on both the inevitable labor shortage and injuries within the industry, experts are looking into Human-Robot Collaboration (HRC) for the construction industry. HRC is expected to enhance the construction industry by making it safer and more efficient than ever before. However, contractors are concerned about how trade workers and engineers would react to this highly advanced technology being on a construction site with them, creating the need for a creative solution to provide training to these workers on how to properly collaborate with their robotic counterparts. Therefore, the literature review conducted in this project identified the potential applications of HRC in the construction industry and accordingly identified the potential skills required. Furthermore, reviews and discussions on how to enhance the workforce preparation and development of HRC in construction and how to use immersive technology such as Virtual Reality (VR) to achieve creative training solutions are presented. This project aims to help prepare the workforce for the future of construction by promoting HRC to enhance productivity, improve safety, and increase efficiency.

27
Name: Bush, John
Major: Chemical Engineering - Bachelor of Science
Faculty Research Mentor: El Barbary Hassan, FWRC-Sustainable Bioproducts
Co-Author(s): Ridwan Ayinla, Islam Elsayed, Yunsang Kim
Funding: USDA
Project Category: Physical Sciences

Development of Sustainable Supercapacitors from Chemically Activated Lignosulfonate using KOH Electrolyte

The development of next-generation sustainable energy storage devices is central to the world's renewable energy transition initiative. Lignin, a naturally occurring aromatic polymer is known for its structural integrity and abundance. Despite its abundance, only 2% of lignin produced worldwide is used commercially, while the remaining 98% is burned as fuel. In this project, we used a facile one-step approach to convert sodium lignosulfonate to activated carbon using potassium hydroxide as the activation agent. The physicochemical properties of the activated carbon was tested using thermogravimetric analysis, BET surface area, and Fourier transform infrared spectroscopy. The lignosulfonate-derived activated carbon showed a high BET surface area of 1050.80 m2/g with high thermal stability. The activated carbon was then used to fabricate electrodes of supercapacitor which was tested electrochemically in 6 M KOH electrolyte. The cyclic voltammograms are quasi-rectangular in shape which depicts a double-layer charge storage formation and the galvanostatic charge cycles showed a specific capacitance of 790.70 F/g at 1 A/g current density. The results of this study underscore the potential of lignin-based precursor as electrode material in the development of environmentally sustainable, high-performance supercapacitors.

4
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Project Category: Engineering

Using Machine Learning to Aid the Blind with Reading Challenges

Optical Character Recognition (OCR) is a computer vision task in which a machine extracts text from images. This project aims to apply OCR to developing "Smart Reading Glasses" for the blind and visually impaired. The pipeline begins with a camera mounted on the frames which captures an image at the press of a button. This image is fed into the OCR software which extracts the text and converts it to speech as an audio file. This speech audio is then output via bone conduction, which bypasses the eardrum by transmitting audio as vibrations through the wearer's skull. This project compares the performance of two different neural network architectures: one only uses convolutional neural network (CNN) layers, and the other combines CNN layers with long short-term memory (LSTM) layers. LSTM layers show promising results since it allows the network to "remember" features for a limited amount of time which is useful for processing sequential data, such as strings of characters. Currently, the major challenge is training the CNN to accurately label characters. Training a neural network requires sufficient data to provide enough information for the network to learn features of an object class and generalize its learning onto unseen data. Initial results showed up to 99% accuracy on training and testing data, but in practical testing, the OCR failed to generalize to real world, hand-written characters. Thus, its predictions were inconsistent and often inaccurate. The next wave of training uses new datasets as well as augmentation, such as rotation and color inversion, on both new and old images.

64
Name: Carroll, Caroline
Major: Biochemistry - Bachelor of Science
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Co-Author(s): Shirley Guo-Ross, Hayden M. Anderson Sarah K. Broadaway, Anna Marie Clay Katrina M. Jackman, Noah A. Martin Kendall N. McKinnon, Angela K. Ross, Cameron G. Whitmore
Funding: Halbert Corporation
Project Category: Biological and Life Sciences

The Therapeutic Effects of Novel Nasal Spray on the Behavior of Rats following Traumatic Brain Injury

Traumatic brain injury (TBI), caused by excess amounts of force hitting the skull, can lead to short term and chronic health effects. While the primary impact induces damage, many negative outcomes often result from the inflammation that occur as a result of the secondary immune response. Our laboratory has been working to develop a novel nasal therapeutic that can be used to reduce these immune effects and inflammatory processes. Previously, we demonstrated that repeated administration of our novel therapeutic reduced the level of neuronal damage as measured days after impact. However, a major factor in the severity of the persistent negative consequences is the quality and rapidity of the treatment received. The goal of this study was to determine the ability of the therapeutic to reduce the adverse consequences of TBI following a single administration. Using a weight drop device, different impact levels of TBI (1.0, 1.5, 2.0, and 2.5 Joules) were induced in adult male rats. At 4 hours post-impact, motor activity was measured using an open field test. Rats subjected to the lower impact levels exhibited reduced activity but as the impact levels increased, the rats exhibited increased activity levels. While control animals exhibited the expected decrease in activity over time, impacted animals exhibited a flatter pattern of activity. When the intranasal spray was administered, the pattern of activity of control rats was slightly altered. However, when administered to rats subjected to an impact level of 2.0J (1 hour post-impact), the therapeutic greatly improved the behavioral performance as compared to rats receiving the impact level of 2.0J alone. These data suggest that rapid administration of the therapeutic nasal spray following impact has efficacy in reducing the behavioral effects induced by TBI.

28
Name: Carroll, Ely
Major: Mathematics - Bachelor of Science
University: Arizona State University
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Funding: NSF REU: Research Experiences for Undergraduates in Computational Methods with Applications in Materials Science
Project Category: Physical Sciences

New Weighting Parameters for Non-Local Means based Denoising Algorithm

Current image denoising techniques can be broadly categorized into two types: variational methods which use minimizing functionals, and filtering methods via pixel averaging. Specifically, the non-local means (NLM) filtering based image denoising algorithm involves replacing each pixel value by the weighted averages of all pixels in the entire image. The basic non-local means algorithm is predicated on manually inputting a parameter to determine the weight of each pixel. We introduce and analyze a new method of implementing the weight factors, based on small variances in the pixel values to identify noise. The new method will identify newly classified noisy pixels, then while comparing blocks of pixels for similarity it is possible to disregard noisy pixels and gain a clearer comparison of structure for weighting. The new method is numerically tested and compared to conventional NLM based methods via the peak signal to noise ratio (PSNR), and visual comparison. The results show that the new method is preferable to the current NLM methods.

29
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Co-Author(s): Sean Stokes, Mahshid Attarroshan
Funding: ORED Undergraduate Research Program, NSF REU: Chemistry REU, MSU NIH COBRE Grant (P20GM103646)
Project Category: Physical Sciences

Synthesis and Reduction Activities of Chalcone Derivatives

Chalcones are well-known for their therapeutic potential in treating conditions such as cancer, diabetes, inflammation, and various disorders. This research aims to explore new derivatives of chalcones driven by their promising medicinal properties. Utilized the Claisen-Schmidt condensation, two categories of chalcones were synthesized. The first category involved reacting 2-formylpyridine with different acetophenone derivatives, while the second category reacted 2-acetylpyridine with diverse benzaldehyde derivatives. Both the acetophenone and benzaldehyde derivatives contained distinct substituents at the para position, specifically chosen to assess the impact of electron-donating and electron-withdrawing groups. The synthesized chalcones underwent testing with metal catalysts, ligands, and reducing agents. Using a silane reducing agent like phenylsilane, it was concluded that there was a preference for reducing the alkene rather than the ketone functionality within the chalcone structure.

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Major: Mathematics - Bachelor of Science
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Funding: ORED Advancing Collaborative Research Program
Project Category: Biological and Life Sciences

Harnessing Deep Learning AI and Open-Source Data for Estimation of Hive Strength and Pollination Efficiency

The combined economic value of crop pollination and honey production in the United States is estimated to exceed $20 billion annually. Maintaining healthy colonies stocked at optimal densities is crucial for pollination efficiency. Loss of pollinators, especially honeybees, may have adverse bearing on agricultural economies, crop diversity, food security, and ecosystem stability. A significant number of returning pollen foragers, with respect to strength of colony, will indicate honeybees are foraging for pollen and the colony is actively rearing brood. Counting the number of returning forager honeybees with pollen pellets on their hind legs also indicates successful pollination. Traditional methods like manually counting foragers or using cumbersome forager traps are time-consuming and stressful for bees. Other recent attempts to automate these processes have shown promise but face limitations such as non-representative colony sizes, inability to differentiate bee castes, and challenges with changing light conditions. In this study, we present deep learning AI-based approach to estimate hive strength and pollination efficiency by detecting and tracking bees as they enter and exit hives. We created a publicly available labeled dataset consisting of 4,590 frames containing 78,812 bees annotation across different videos representing diverse lighting and seasonal conditions. We train five state-of-the-art object detection models (YOLOv10, Faster R-CNN, RetinaNet, FCOS, SSD) to detect bees and classify them as pollen carrying forager, non-pollen carrying forager or drone bees. The models achieved 0.9 mAP@50, 0.92 F1-score and 93.4% accuracy on test data. We then use DEEPSort and ByteTrack algorithms to track their movements and assign persistent IDs to bees. This way we achieve more accurate counts and classifications over time, rather than relying on frame-by-frame averages. Our novel approach provides a reliable, non-invasive method to estimate hive strength and monitor pollination efficiency, representing a step toward precise beekeeping while reducing its labor-intensive aspects.

5

Name: Chaudhary, Piyush
Major: Computer Science - Bachelor of Science
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Project Category: Engineering

Cost-Effective Fully Automated Segmentation and Comparison of Additive Manufactured Scaffolds for Bone Tissue Engineering

Additive manufacturing, also called 3D-printing, has promising application prospect for creating bone scaffolds to treat bone defects. Traditional bone grafts, such as allograft and autograft used to restored damaged bone have drawbacks such as limited donor availability and increased risk of infection. Bone scaffolds are three-dimensional biomaterial structures used for bone defect reconstruction. Given the recent significant developments made in biomaterials and scaffolds, need for methods to compare printed scaffolds arises. In this study, we introduce a cost-effective, fully automatic novel approach for segmenting and comparing 3D-printed bone scaffolds. A scaffold should have porous structure of proper pore size and interconnected pore networks. It manages nutrient diffusion and cell migration and controls cell proliferation and differentiation. Traditional approaches, such as manual measurement or CT scans have high expenses in labor and equipment. In the manufacturing process, the scaffold is built layer-by-layer (25 layers) through adding materials based on computer-aided-design model. Our proposed method processes images taken at each layer of the manufacturing process, allowing for detailed assessment of the scaffold's structural integrity and precision. These images are automatically segmented and compared against a model scaffold to identify deviations from the desired design. The main challenge lies in the small size of the scaffolds, i.e. just 5mm on each side (half the width of a typical fingernail), with pores being 750 microns. Given the small size of the scaffolds, accurate segmentation and comparison comes with different challenges. Our proposed method addresses these challenges to consistently and accurately analyze scaffold images. Automating this process ensures quick and reliable comparisons, significantly reducing manual intervention and potential errors. Our method not only substantially reduces costs but also offers a consistent, accurate and efficient alternative for evaluating bone scaffolds, potentially improving the quality and availability of scaffolds for treatments of bone defects.

30
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Major: Biochemistry - Bachelor of Science
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Funding: NSF REU: INFEWS
Project Category: Physical Sciences

Applying Spectroscopic Methods to Compare Dye Extraction from Fluorescent Polystyrene Nanoparticles in Different Solvents

Fluorescent polystyrene nanoparticles (fPSNP) are versatile materials employed in various fields such as biomedicine and imaging systems due to their unique optical properties. Understanding the process of dye unloading from fPSNP is crucial for optimizing their applications. In this study, we investigated the efficiency of dye extraction from 180 nm fPSNP using three different solvents: ethanol, acetone, and water.
Preliminary experiments demonstrated that ethanol and acetone were effective in extracting the dye from the fPSNP, while water simply dispersed the fPSNP without extracting dye. However, the ethanol and acetone both disintegrated the PSNP, showing that the PSNP were unstable in these solvents. The PSNP precipitated in ethanol and became a gel-like substance in the acetone. In this experiment, we left the stock fPSNP in different extraction solvents overnight, syringe-filtered out the dye supernatant, and then performed three washes of the remaining PSNP with each solvent. To assess the relative quantities of extracted dye, we scanned each sample and wash using UV-Vis, fluorescence, and Linearly Polarized Resonance Synchronized (LPRS) spectroscopic methods. Comparison of the data obtained from these spectra show that the absorbance value obtained from the UV-Vis takes into account the absorbance extinction, scattering extinction, and forward fluorescence emitted by the solutions. The fluorescence and LPRS scans highlight the distinction between these spectroscopic differences. This study underscores the complexity of analyzing dye unloading from fPSNPs, highlighting the limitations of UV-Vis spectroscopy in distinguishing between dye absorbance and light scattering. Recently developed instrumentation will be used to support the ongoing research into the dye extraction process.

65

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Major: Animal and Dairy Science - Bachelor of Science
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Co-Author(s): Abigail Victory, Kenneth Graves, Allison Griffin, Christopher Hudson
Funding: College of Agriculture and Life Sciences URSP
Project Category: Biological and Life Sciences

Automated Identification and Behavioral Estrus Detection in Freestall-Housed Dairy Cows Using Computer Vision and Machine Learning: A Two-Layered Algorithm Approach

Recent advancements in precision livestock management, utilizing computer vision and machine learning technologies, have paved the way for automated and precise solutions in estrus detection in dairy herds. The objective of this study is to investigate applications of computer vision and machine learning for identification and behavioral estrus detection in dairy cows housed in freestall settings.
Research was conducted at the Joe Bearden Dairy Research Center with ten lactating Holstein-Friesian cows assessed across seven-day trial periods. Cows were provided a single injection of Prostaglandin F2α at trial initiation for synchronization efforts. Continuous video was captured using a five-camera closed caption media recording system and was extrapolated into frames, with manual annotation utilized to generate the machine learning algorithm's training data.
A two-algorithm approach was employed, with the first algorithm detecting behaviors and the second identifying specific cows. The first model was trained on 682 frames and validated against 123 manually annotated frames. The second model was trained on 102 frames and validated against sixteen frames manually annotated for individual animals.
Results demonstrated that the model for mounting behavior identification has high precision (0.819) and recall (0.89), achieving a 0.926 mAP at an IoU of 0.5. This model achieved an F1 score of 0.86 at a confidence threshold of 0.268. The model used for individual animal identification across different classes achieved high precision (0.861) and recall (0.842), with a mAP of 0.897 at an IoU of 0.5. The F1 score for all classes was 0.89 at a confidence threshold of 0.788. These promising findings underscore the potential of computer vision and machine learning technologies to revolutionize dairy cow management practices. This innovative approach has the potential to enhance operational efficiency and significantly improve reproductive management, thereby advancing precision and productivity in dairy operations.

66
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Funding: NSF REU: EMRAF
Project Category: Biological and Life Sciences

Populus short rotation woody crops for sustainable bioenergy and ecosystem services: an analysis of greenhouse gas efflux

Eastern cottonwood trees (Populus deltoides) and their hybrids have shown potential as exceedingly fast-growing short rotation woody crops (SRWCs) which can be converted to liquid fuels to replace traditional fossil fuels. Growing these trees around agricultural fields can also provide ecosystem services such as reducing nutrient runoff from leaching fertilizers, providing wildlife habitats, retaining carbon in the soil, and reducing the efflux of trace greenhouse gasses from the ground. These gasses, including methane (CH4) and nitrous oxide (N2O), are present in much smaller concentrations in the atmosphere than CO2, but trap heat more effectively, making them a climate change concern. We tested the extent to which Populus SRWCs reduce N2O and CH4 flux by installing PVC collars in the soil across multiple alluvial and upland sites. The hybrids studied included Populus deltoides × P. maximowiczii (D×M) and P. deltoides × P. trichocarpa (D×T). Monthly measurements of N2O and CH4 were conducted using a cavity ring down analyzer, with gas samples collected in the field for each collar over a 10 minute period and returned to the lab to be analyzed. Point measurements over time were converted to greenhouse gas (GHG) exchange (flux; mol m-2 s-1) from the soil using corresponding temperature, pressure and chamber volume data. Preliminary results indicate that N2O flux was approximately 20 times lower in SRWC tree plots than in adjacent agricultural fields when averaged across taxa, field sites and months, while CH4 was not consistently reduced. We will continue to analyze differences in flux by month, site, genotype, monoculture versus functionally diverse plots, and alluvial versus upland environments. However, overall these findings support that Populus SRWCs have substantially less GHG emissions than traditional row crop agriculture providing another example of the ways that Populus plantations represent a climate change solution.

54
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Funding: EMCC-MSU Bridges to Baccalaureate
Project Category: Social Sciences

The impact of individualized psychotherapy sessions incorporating equine interaction on the emotional safety of substance abuse disorder patients

Substance abuse disorder (SUD) is the leading cause of death in young adults in the United States. This is due to the fact that traditional treatment approaches have shown limited success. However, research studying psychotherapy incorporating equine interaction (PIE) has shown promise in promoting retention and engagement in group treatment programs. Although research is available for SUD patients engaging in group PIE sessions, research is absent concerning the efficacy of individualized treatment sessions. Therefore, the objective of this study was to determine the effectiveness of an individualized PIE session in promoting emotional safety within SUD patients. Participants (n=22) in an intensive outpatient program at Oxford Outpatient Treatment Center undertook an hour-long individualized PIE session with a licensed mental health professional. Participants were given a pre- and post-session survey rating their emotional safety. The survey consisted of 60 questions that rated the four categories of emotional safety (personal security, connectivity, self-esteem, and respect) using a 5-point Likert Scale with a lowering of score demonstrating improvement. The majority of participants (82%) showed improvement in emotional safety, with the category of connectivity showing the most improvement. The average pre- and post-score for all participants was 155.55 and 149.59, respectively. This is important to note as previous research demonstrates an increase in stress during the first group PIE session due to the introduction of the horse. Thus, those taking part in their first session of PIE may select an individualized session over a group session initially to allow more direct interaction with the therapist facilitating more effectively an emotionally safe therapeutic environment where initial stress associated with the first introduction of the horse can be minimized.

31
Name: Cox, Kaitlyn
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Co-Author(s): Ishmael Apachigawo
Funding: National Institute of Health
Project Category: Physical Sciences

Fractal Dimension, Entropy, and Correlation Analysis in Diseased Brain Tissues

The deadliest brain diseases are those classified as neurodegenerative, including Parkinson's disease (PD) and Alzheimer's disease (AD). Currently, both AD and PD affect nearly eight million Americans, with numbers projected to double by 2050. Conventional diagnostic methods, which rely on brain images via MRI and CT scanning and human judgment, have a misdiagnosis rate of one in five patients. Thus, early and precise detection is essential for timely intervention and disease management. Structural rearrangement occurs with the progression of AD/PD, resulting in increased density fluctuations and structural disorder within the diseased tissue. In this research, we expand on previous studies based on self-similarity, porosity, and space-filling for early diagnosis by incorporating entropy and spatial density correlation calculations of brain tissues to provide a more objective and accurate assessment of AD/PD progression. Our findings establish a relationship among different biomarkers, which can improve diagnostic accuracy and reduce misdiagnosis, enhancing clinical outcomes for both Alzheimer’s and Parkinson’s disease patients.

32
Name: Crawford, Jackson
Major: Physics - Bachelor of Science
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Funding: NSF REU: 2150130
Project Category: Physical Sciences

Circuitry Design for Metal Halide LED Displays Demonstrated by using Homemade Smartwatch

Low-dimensional copper halides are drawing attention as a new type of material for light-emitting diode (LED) applications due to their broadband yellow emission, which is extremely suitable for household and industrial lighting. The abundance, low cost, and non-toxicity of copper, along with its stability under ambient conditions, make copper halides a very appealing LED material. These LEDs can be integrated into displays used for a variety of applications. For instance, LED displays are employed in-home devices such as televisions and digital screens on appliances, as well as in larger installations like scoreboards and stadium screens for sporting events. The number of applications for displays is extremely large and can serve any number of functions. In this project, a smartwatch is built from scratch to illustrate the electrical circuitry required to power and control a generic LED display. The objective is to gain a comprehensive understanding of the intricacies involved in building a circuit, thereby facilitating the development and utilization of displays incorporating copper halide thin films. This will allow for an assessment of their efficiency and effectiveness compared to current display technologies.

67
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Major: Ag Educ., Leadership & Comm - Bachelor of Science
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Co-Author(s): Ed North, Toree Williams
Funding: ORED Undergraduate Research Program
Project Category: Biological and Life Sciences

Pedigree tracing to determine coat color phenotype found within the Mountain Pleasure Horse Breed

The Mountain Pleasure Horse (MPH) is classified as "threatened" according to the Livestock Conservancy with only 2,670 purebred MPHs living today. In order to expand numbers, the registration books for MPH Association (MPHA) were opened in 2009, however, five years later the books were closed due to concerns of potential loss of phenotypical traits characteristic of the breed. While registration within MPHA does not require a specific coat color, the palomino coat color is characteristic of the foundation sires of the breed and sets the breed apart from the chocolate coat color commonly found in the Rocky Mountain Horse. To determine whether there is a dominant coat color phenotype found within the breed, the objective of this study was to utilize pedigree tracing to identify the phenotypic coat color assignments making up the MPH breed. Utilizing the MPHA Database a total of 1,410 pedigrees were sampled. Coat color assignments were documented for each pedigree sampled with percentages determined for the 11 coat colors identified. While there were only 16.4% of horses that were identified as palomino, if percentages from other coat colors derived from the cream dilution allele like the palomino are added to this percentage, the total number of coat colors from the cream dilution allele would be 21.3%. The chocolate coat color was found to make up 16.9% of the sampled pedigrees. However, the most predominant coat color was the chestnut at 31.4%. This is important to note as unlike the cream dilution allele the silver allele that creates the chocolate coat color does not show visual changes within the chestnut base coat. As such, chestnut horses could have offspring with a chocolate coat color. Therefore, without DNA testing targeting color genetics, the palomino coat color found within the foundation sires could be bred out of the breed.

68
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Major: Biochemistry - Bachelor of Science
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Co-Author(s): Hannah Purcha
Funding: Mississippi Soybean Promotion Board
Project Category: Biological and Life Sciences

Temporal Investigation of Insect Populations in a Mississippi Soybean Greenhouse Trial

All experiments seek to minimize as many external variables as possible. However, in the context of greenhouse trials, insects serve as not only pests but also vectors of additional diseases that can potentially confound results. Furthermore, the population composition fluctuates with time, atmospheric conditions, and food availability. To assess the fluctuations in insect populations, a study was conducted in the summer of 2024 where soybeans were being grown in a greenhouse at the Mississippi State University North Farm for a separate study. A malaise trap was placed outside the greenhouse to evaluate the general population, while cross-vane and sticky traps were placed above each block of the soybean trial. These traps were collected biweekly, and species were visually identified. The results of this experiment and suggestions for researchers are presented in the poster.

7
Name: Dean, Ethan
Major: Sustainable Bioproducts - Bachelor of Science
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Funding: USDA-REEU
Project Category: Engineering

The Effect of Wood Species on Rolling Shear Performance of Cross-Laminated Timber (CLT)

Cross-laminated timber (CLT), a mass timber product, is gaining momentum in sustainable construction due to its carbon-sequestering properties and renewability. CLT is competing with common construction materials such as steel and concrete in the construction of tall buildings. However, one of the limitations of CLT is the rolling shear failure which occurs in the transverse layer when exposed to out-of-plane stress such as bending load. This failure limits CLT's load-bearing capacity as it can lead to failure before tensile and compressive failures in the outer layers. This study evaluates the effect of different wood species on rolling shear strength of CLT. The species experimented include softwood, southern yellow pine, and hardwood species- yellow poplar, sweet gum, and red oak. Rolling shear specimens composed of southern yellow pine as outer layers and these species as mid-layer were manufactured and then submitted to rolling shear testing. Overall, the hardwood species showed higher rolling shear performance compared to softwood.

51
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Funding: ORED Undergraduate Research Program
Project Category: Arts, Music, & Design

Herbarium Mural for Harned Hall

Depicting scientific subjects through artistic expression, this initiative aims to connect the artistic and scientific communities at MSU.
The Biology Department sought out prospective art students to collaborate on the fifth mural inside Harned Hall. These murals, while being pieces of artistic expression, are intended to reflect the current research of the faculty members residing on each floor. This fifth mural, a continuation of the fourth, measures 6.6 feet high and 21.6 feet long. Faculty members provided research materials and photographs that served as reference and inspiration. This collaboration, along with the previous mural, helped shape the primary ideas for the theme concept.
Dr. Folk, the university's Herbarium curator and an assistant professor in the Department of Biological Sciences, leads efforts to digitize herbarium collections across the state to make them more accessible. Through meetings with Dr. Folk and his students, the artists gained insight into the herbarium's purpose. This information was used to create an elaborate composition aimed at raising awareness of native Mississippi plant life. The variety of research and photographs offered a wide range of colors, textures, and shapes for the mural. The plant life depicted is intertwined with the pre-existing scene, with new pollinators added to enhance the lush atmosphere.
To successfully complete the mural, various technologies and techniques were employed. Traditional sketching, combined with photo manipulation software and projection technologies, enabled the artists to turn their renderings into a captivating visual experience. The mural honors the specimens that inspired it, reminding viewers of biology's beauty and the dedication involved in studying and showcasing it. This collaboration between the Biology Department and arts students has produced a work that not only enhances Harned Hall's aesthetics but also educates and inspires its viewers.

69
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Major: Environmental Sci in Ag System - Bachelor of Science
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Funding: NSF REU: Sustainable Bioproducts
Project Category: Biological and Life Sciences

Efficacy of Chitosan Crosslinked Citric Acid on Reticulitermes Termites

The effects of chitosan crosslinked with citric acid were tested to determine its efficacy as a pesticide against Reticulitermes termites. One-gram samples of southern yellow pine species were treated with various concentrations of chitosan-citric acid before the Introduction of the Termites. These concentrations consisted of 0.25 g, 0.50 g, 0.75g, and 1.0 g of chitosan-citric acid. The crosslinked mixture greatly reduced termite activity. These results suggest that this crosslinking has potential as a long-term alternative to standard chemical treatments due to the environmentally friendly components of chitosan and citric acid. The termite repellency test used was adapted from an AWPA (American Wood Protection Association) E1 two choice test. Incubation of the termites occurred at 28oC.
The visual ratings were taken after two weeks according to AWPA standards. The concentration of 1.0g chitosan showed termite swarms. The concentration of 0.50 g Chitosan showed no signs of termite activity. The concentration 0.75 g chitosan showed some termite activity, but the rest stayed on the 1g sample. The concentration 0.25g showed no signs of termite activity, but later showed signs of a growing fungi (Aspergillus).

8

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Funding: Mechanical Engineering
Project Category: Engineering

Using Finite Element Modeling to Characterize the Scaling Effects of Lattice Structures Leveraging Multiple Material Models

As biomedical implants are increasingly favored for replacing bone tissue, the customization, characterization, and development of these implants through finite element modeling becomes imperative to the success of surgical operations and patient satisfaction. To combat stiffness mismatches and prevent stress shielding between implant and bone tissue, lattice structures can be implemented within bone implant design to reduce the effective Young's modulus (EYM) of the implant. Lattice structures are highly customizable, three dimensionally repeated patterned unit cells that can be manipulated to mimic the porous nature of bone tissues, increasing implant-bone interface longevity. To help determine if plastic strain hardening drives mechanical response within lattice components, the current study employs linear elastic-perfectly plastic (EPP) models and a linear elastic-Johnson-Cook plastic model. The study investigates the scaling effects of additively manufactured (AM) 316L stainless steel lattice components simulated with each material model. Additionally, the study assesses whether friction induced by self-contact is negligible by comparing frictionless interactions to penalty interactions with a friction coefficient of 0.2. Five lattice structures with unit cells at scales of 1, 2, 3, 4, and 5 and volumes of 10 cubic millimeters are analyzed to understand scale-dependent behaviors. Results reveal significant variations in the EYM and stress responses across scales, influenced by the choice of material model. At smaller scales, structures exhibit higher stiffness and plateau at smaller strain values compared to larger scales on the stress-strain curve. Because each model produced has unchanging weight, lattice structures with smaller scaling produce a topologically strengthened mechanical response that can allow for lightweighting. For the material models, the EYM and stress values are largest using the Johnson-Cook model and smallest using the EPP model without friction.

9

Name: Elchos, Honor
Major: Biomedical Engineering - Bachelor of Science
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Funding: NSF Grant 2046515
Project Category: Engineering

Material Characterization of Polymer-Ceramic Composite Biomaterial

Developing biomaterials for tissue engineering requires studying composite materials that harmonize biocompatibility and structural integrity for cell adhesion, proliferation, and tissue growth. The objective of this study is to determine the material properties of a composite poly(lactic-co-glycolic acid) (PLGA, 95%) and nano-hydroxyapatite (nHA, 5%) material, compared to pure PLGA. PLGA and nHA were combined by dissolving in acetone and mixing overnight to form a stable dispersion. The solvent was removed using a vacuum oven at 20 inHg and 115°C for one hour. The material was cooled, producing a dry, uniformly mixed composite suitable for 3D printing. Rotational rheometry was used to analyze the composite's flow behavior and viscosity, crucial for optimizing the 3D printing process. These insights help ensure uniformity and accuracy of fabrication, focusing on shear thinning behavior under differing shear rates to facilitate effective extrusion. Scaffolds with a cross-hatch structure and uniform cubic pores were printed at 115°C, 250 kPa, 2 mm/s, and a layer height of 0.4 mm. To evaluate their elastic modulus and stiffness, the printed scaffolds underwent compression testing with a preload of ~1 N, a max force of 100 N, and loading at 1 mm/min. The top surface was scanned with a profilometer to evaluate flatness, as nonparallel surfaces would induce nonuniform loading. Rheological testing indicated the composite exhibited favorable flow properties and viscosity profiles, which are essential for improving 3D printing parameters and ensuring uniform material deposition and scaffold formation. Profilometer scans showed negligible change in height across the top of the scaffold. Compression testing of composite scaffolds is ongoing. This study provides insights into the rheological and mechanical properties of a PLGA-nHA composite, advancing the development of biomaterials for effective tissue engineering.

33
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Faculty Research Mentor: Doyl Dickel, Mechanical Engineering
Co-Author(s): Kip Barrett
Funding: NSF REU: REU in Computational Methods with Applications in Materials Science
Project Category: Physical Sciences

Validation and Runtime Improvements in Neural Networks for Interatomic Potentials via Automatic Fingerprint Selection

The development of interatomic potentials via machine learning on first principles results is driven by the need to accurately and quickly analyze atomic environments. When encoding atomic environments for neural networks, a series of different two and three-body functions are used to transcribe the local environments to produce a vector of inputs, making it imperative that the local environments are encoded optimally. Given a set of atomic environments, we generate a series of different fingerprints and by analysis of the data select the most optimal ones which demonstrate a reduced validation error and computation time in our model. To select the best fingerprints for the network, we first construct a large dense matrix A, where each row is an atomic environment and each column is a fingerprint with a different set of parameters. We look to create the most optimal rank k approximation of A, by factoring it as A = CUR where C is made up of k columns of A, R is made up of k rows of A and U is square and of rank no greater than k. We employ the singular value decomposition followed by two rounds of sampling the column space of our matrix, where we utilize weights based on spectral properties and then adaptively compute leverage scores to select fingerprints that were not initially chosen and that require a low computational cost with high probability. By computing the matrices C and R we find the optimal representation of our fingerprint and training data respectively. Our optimal fingerprints achieve on average a 39% reduction in validation error with comparable training errors to naive fingerprint selections for unary and binary systems, while minimizing the computational cost for fingerprint generation.

70
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Faculty Research Mentor: Christine Fortuin, FWRC - Forestry
Funding: NSF REU: Ecology and Management for Resilient and Adapted Forests REU
Project Category: Biological and Life Sciences

Survey of Insect Diversity in Restored Mountain Longleaf Pine

Longleaf pine ecosystems of the Southeastern U.S. are thought to contain high levels of biodiversity across various taxonomic groups, including insects. Mountain longleaf pine systems are unique ecoregions within the longleaf pine range, differing in soil type, elevation, temperatures, and fire frequency. Despite the taxonomic diversity of these regions, a formal survey of insect diversity of mountain longleaf pine has yet to be carried out. Longleaf pine ecosystems are dependent on prescribed burns, which reduce competition and preserve the openness of the canopy. Until recently, lack of proper forest management has led to an absence of eligible mountain longleaf pine ecosystems for study. Recent restoration efforts in northern Georgia have opened up two eligible sites for completion of a survey that will reflect insect biodiversity of restored mountain longleaf pine ecosystems. We set pan traps and blue vane traps at a site in the Sheffield Wildlife Management Area (WMA), along with a site in the Paulding Forest WMA, and inventoried all insects which were collected. Because insects often serve as indicators of forest health, starting a record of insect biodiversity is creating an important reference point for future research. As attempts to restore longleaf pine continue, and existing stands face consequences due to environmental disturbance, insect surveys have the potential to give us pertinent clues regarding forest health and development of more effective management practices.

71
Name: Ferrari, Abriana
Major: Biochemistry - Bachelor of Science
University: Lebanon Valley College
Faculty Research Mentor: Nick Fitzkee, Chemistry
Co-Author(s): Tanveer Shaikh
Funding: NSF REU: INFEWS
Project Category: Biological and Life Sciences

Understanding the interaction between gold nanoparticles and complement component C3dg

Nanoparticles have been widely used as drug carriers and therapeutic agents in medicine. However, when administered intravenously, these nanoparticles interact with blood proteins such as albumin, complement proteins, and immunoglobulins, forming a layer called protein corona. The interaction of nanoparticles with complement proteins can influence their recognition and uptake by macrophages and other immune cells, potentially altering nanoparticle behavior in vivo. This research examines how complement component C3dg, a fragment containing the active region of complement C3, interacts with gold nanoparticles (AuNPs) to understand the fundamental mechanisms governing protein-nanoparticle interactions in biological systems. Dynamic light scattering confirms that C3dg forms a protein corona around AuNPs. ^{1}H NMR analysis reveals that the binding capacity of C3dg is 93±8 proteins per AuNP. Furthermore, thermal denaturation experiments using circular dichroism demonstrate that AuNP-bound C3dg exhibits greater stability than its unbound counterpart. Future work will focus on completing NMR assignments for C3dg to study protein dynamics and using isothermal titration calorimetry to examine the thermodynamics of C3dg exposed to human serum-coated AuNPs. These findings will provide valuable insights into protein-nanoparticle interactions, facilitating more efficient and effective nanoparticle design for medical applications.

10
Name: Goodman, Olivia
Major: Data Science - Bachelor of Science
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Co-Author(s): Samata Luintel
Project Category: Engineering

Detection and Prevention of Synthetic Speech Using Mel-Frequency Cepstral Coefficients and Machine Learning Models

Synthetic speech, also called deep fake audio, is speech generated using artificial intelligence that attempts to mimic the speech of particular humans. These techniques have improved significantly in recent years resulting in the need for better detection methods. Mel-Frequency Cepstral Coefficients (MFCCs) are coefficients derived from the Mel-Frequency Cepstrum and capture parts of speech such as respiration, phonatory deficits, articulation, and velopharyngeal control. These coefficients allow us to capture the human perception of speech features and turn them into a numerical value. By calculating MFCCs, we were able to use machine learning techniques to train and test our detection model. Using a sequential model and Long Short-Term Memory (LSTM) from the TensorFlow library, we assessed the accuracy and loss of our approach. Not only do promising detection methods exist but also preventive measures that one can take to protect against nonconsensual deep fakes.

72
Name: Goodnow, Sasha
Major: Nat Res & Envir Conservation - Bachelor of Science
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Co-Author(s): Ashley Schulz, Hui Liu
Funding: NSF REU: Forestry REU
Project Category: Biological and Life Sciences

Studying the impacts of southern pine beetle on loblolly pine in the Homochitto National Forest using remote sensing

By using remote sensing, we can assess how abiotic and biotic forest disturbances can impact canopy density and forest water use. These types of studies have been conducted on the mountain pine beetle (*Dendroctonus ponderosae*) in western North America, but not on the southern pine beetle (*Dendroctonus frontalis*), which is a native pest of loblolly pine (*Pinus taeda*) and shortleaf pine (*Pinus echinata*), in the eastern United States. Pine trees in this region have been stressed due to drought, foliar diseases (e.g., brown spot needle blight), root diseases (e.g., Annosus root disease, *Leptographium* spp.), and/or competition within dense stands due to a lack of thinning from poor timber markets in some areas. Stressed trees produce pheromones that attract southern pine beetle and, with enough stressed trees, beetle populations can quickly grow and attack healthy trees. As the mass-attack on healthy trees results in widespread tree mortality, the USDA Forest Service has documented beetle spots from 2012-2021 within the Homochitto National Forest. Using the coordinates of the beetle spots, we analyzed the dynamics of normalized difference vegetation index (NDVI) using Landsat satellite observations on Google Earth Engine, and extracted evapotranspiration (ET) data at stand level from the OpenET platform. These two analyses were run two years before and after each spot's detection year, for comparative analysis. Results show beetle outbreaks reduce NDVI and ET within the forest stand, during detection year, as well as the following year. By understanding the relationships between disturbance agents and forest canopy and water use capability in pine forest ecosystems, we can improve management recommendations. Specifically, this analysis demonstrates the negative impact bark beetles have on canopy cover and forest water use, further supporting the value of mechanical thinning and prescribed burning to reduce southern pine beetle infestation risk.

34
Name: Graveman, Mary
Major: Mathematics - Bachelor of Arts
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Faculty Research Mentor: Amanda Diegel, Mathematics & Statistics
Funding: NSF REU: "REU in Computational Methods with Applications in Materials Science"
Project Category: Physical Sciences

Continuous Data Assimilation for Two-Phase Flow

We propose a numerical approximation method modeling two-phase flow (via the Cahn-Hilliard equation) that incorporates data to achieve long-time accuracy. The underlying numerical method utilizes the Galerkin finite element method for spatial discretization and a method known as continuous data assimilation to incorporate the known data. We demonstrate the method is long-time stable and long-time accurate provided enough data measurements are incorporated into the simulation, overcoming possibly inaccurate initial conditions. Numerical experiments illustrate the effectiveness of the method on a benchmark test problem. All computations are completed in MATLAB.

73

Name: Green, David
Major: Forestry - Bachelor of Science
University: Alabama A&M University
Faculty Research Mentor: Ashley Schulz, Department of Forestry
Co-Author(s): Devin Mabry, Drew Williams, Joshua Granger
Funding: NSF REU: Forestry program
Project Category: Biological and Life Sciences

Non-indigenous woody plant species composition and stand structure in the Mississippi State University Arboretum

The five-acre Mississippi State University Arboretum was established in 1990 on the west side of South Farm and was maintained until 2014-2015. Several species, varieties, and cultivars of indigenous and non-indigenous woody plants were established at the site for forest genetics research and to aid teaching of field-based courses, such as Dendrology. Examples of planted non-indigenous taxa include Japanese holly (Ilex crenata), weeping Chinese privet (Ligustrum sinense 'Pendulum'), and black bamboo (Phyllostachys nigra). Around 2015, the site was abandoned due to faculty turnover and gate access restrictions. Other than mowing along the perimeter of the arboretum, the site has remained unmanaged and inaccessible until the present time, which has resulted in approximately 10 years of unrestricted growth for both the indigenous and non-indigenous woody plant taxa. The objective of this study was to assess the composition and stand structure of non-indigenous woody plant taxa at the arboretum to determine if any of the taxa have proliferated since site abandonment. An inventory was carried out in June and July 2024 to identify taxa, measure the diameter-at-breast-height and height for each specimen, assess each specimen for defects, and rate them based on management priority. For shrubs, we estimated stem count, and only measured the largest and smallest stems to streamline inventory. Data were analyzed in Microsoft Excel to assess size class distributions and diversity indices. Preliminary results indicate that several non-indigenous woody taxa, especially Chinese privet, have established large populations and spread throughout the site, developing dense thickets at the understory to mid-story level in the arboretum. Other non-indigenous taxa, such as Chinese elm (Ulmusparvifolia), are still present in the arboretum, but have not spread extensively. These results provide evidence of non-indigenous woody plant species invasiveness potential and will inform arboretum management plans to restore the site for research and teaching.

11
Name: Guo-Yue, April
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Co-Author(s): Faiza Akram
Funding: NSF REU: Intelligent Edge Computing Systems (iEDGE) REU
Project Category: Engineering

Real-Time Data Optimization with Edge Stream Processing for Low Latency Medical Applications

Timely access to critical data in emergency medical settings is crucial for effective decision-making. This research investigates the application of edge computing to enhance data processing speed and reliability for future medical applications. We compare the performance of virtual machines (VMs) and Raspberry Pis in terms of latency and throughput, highlighting the advantages of using Raspberry Pis as edge devices near data sources. Our system integrates existing data infrastructures, utilizing Apache Storm for real-time data streaming and Kubernetes and Docker for containerized deployment. Apache Storm processes continuous data streams reliably and in a distributed manner. Kubernetes automates the deployment, scaling, and management of Docker containers. These containers are lightweight, portable units that package applications and their dependencies, ensuring consistent performance across different environments. We validate our system with RIoTBench, a benchmark suite for evaluating Distributed Stream Processing Systems (DSPS) performance. Experimental results show significant differences in latency and throughput between VMs and Raspberry Pis. Latency, the delay before data transfer begins following an instruction, is critical in high-stake environments where every millisecond counts. Throughput, the rate at which data is processed, is essential for handling high volumes of data. Our findings show that Raspberry Pis, when deployed as edge devices, reduce latency and improve data processing efficiency compared to VM-based approaches. Ongoing and future work includes validating our topology on both VMs and Raspberry Pis to ensure effective handling of high data volumes. We are developing methods to schedule priority data, ensuring critical data is processed first, and running topologies on multiple nodes to distribute the processing load, minimizing latency and maximizing throughput. Faster and more reliable data processing can lead to quicker diagnoses and treatments, directly impacting patient outcomes. By optimizing resource management and reducing data processing times, our approach revolutionizes the quality and efficiency of emergency medical response.

74

Name: Hanson, Izak
Major: Animal and Dairy Science - Bachelor of Science
Faculty Research Mentor: Russell Carr, Department of Comparative Bio Scien
Co-Author(s): Shirley Guo-Ross, Sarah Broadaway, Janice Chambers, Kendall McKinnon, Edward Meek, Angela Ross
Funding: In House
Project Category: Biological and Life Sciences

Effects of Acute Exposure to a Nerve Agent Surrogate on Brain and Serum Cholinesterase Activity in the Adolescent Rat

Sarin is an odorless and colorless nerve gas developed in the early stages of World War II. Sarin's toxic functional group is an organophosphate. Organophosphates exert their toxicity through the inhibition of acetylcholinesterase (AChE), leading to accumulation of the neurotransmitter acetylcholine which induces hyperactivity in the peripheral and central nervous systems, leading to loss of function in the respiratory system, which results in death. Though initially intended for use on military personnel, the gas has been used on civilian populations in the Halabja Massacre, the terrorist attacks in Tokyo, and the attacks during the Syrian Civil War. in total, these resulted in around 20,000 civilians receiving injuries related to nerve gas exposure. Within most of these civilian groups, there were many children and adolescents affected. This research was aimed to determine the effects of the nerve gas surrogate NIMP (nitrophenyl isopropyl methylphosphonate) on inhibition and recovery of AChE in adolescent rats. Adolescent rats (35 days old) were exposed subcutaneously to vehicle multisol or 0.325 mg/kg NIMP. The rats were sacrificed at 4 hours, 1 day, 4 days, 7 days, and 14 days post-exposure. Brain AChE and serum ChE activities were then determined. NIMP-treated rats exhibited episodic seizure-like signs. Serum ChE was inhibited 71% below control at 4h. However, the activity recovered with inhibition levels of 47% at 1 day, 16% at 4 days, and recovery to control levels at 7 days. Brain AChE was inhibited to a greater extent with with slower recovery, inhibition of activity was 87% at 4 hours, 71% at 1 day, 46% at 4 days, 39% at 7 days, and 33% at 14 days. These data suggest that NIMP exposure can induce high levels of AChE inhibition that elicit episodic seizure-like signs in adolescent rats.

75
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Co-Author(s): Rabia Amen, Waqar Shafqat, Heidi Renninger, Austin Himes
Funding: NSF REU: Forestry REU
Project Category: Biological and Life Sciences

From Farm to Stream: Leveraging Woody Bioenergy Crop Diversity for Sustainable Water Management

Due to its fast growth and coppice ability, eastern cottonwood (*Populus deltoides* Bartr. Ex. Marsh) and its hybrids are a potential source for biomass production as short rotation woody crops (SRWC) in the southeastern United States, and a solution to water quality issues in agricultural areas. Although Populus species have been investigated for their positive effects on groundwater quality and nutrient concentrations, the studies have been in paucity. Furthermore, studies of the efficacy of taxonomic and functionally diverse hybrids of *Populus* to reduce nutrient runoff in riparian zones adjacent to agricultural areas have not yet been achieved. To address this deficit in knowledge, we designed our study to measure the difference in nitrate and ammonia levels in groundwater within experimental *Populus* trials adjacent to conventional agricultural lands containing corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.) in the southeastern United States. Within replicate plots, we tested planting combinations of single genotypes and mixtures of up to six genotypes to represent varying taxonomic and functional diversity related to nitrogen use efficiency. In each plot, we installed ground water wells to a depth of 2 meters to monitor the reduction of nutrient leaching from agriculture. The results of this study will be presented and discussed. Understanding the ability of *Populus* diversity to reduce nutrient leaching will refine silvicultural management practices for biomass production, allow for the quantification of ecosystem service payments to stakeholders who engage in the practice, and potentially integrate these methods into common agricultural practices to enhance water quality of riparian zones.

76
Name: Hill, Cheyenne
Major: Chemistry - Bachelor of Science
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Faculty Research Mentor: Richard Baird, Agricultural Science & Plant Protec
Co-Author(s): Hannah Purcha
Funding: NSF REU: REU-INFEWS, Mississippi Soybean Promotion
Project Category: Biological and Life Sciences

Investigating the Impact of *M. phaseolina* on the Metabolome of Soybean

Soybean (*Glycine max* (L.) Merr.) is an important agricultural crop across the world and is utilized in countless industries. However, soybeans are especially susceptible to a devastating pathogen: *M. phaseolina* (MP). This soilborne fungus prefers hot and arid conditions, which are becoming increasingly common in soybean growing regions due to climate change. To date, efforts in breeding soybeans that are fully resistant to MP have failed. Furthermore, the biochemical interactions between MP and its host have proven to be enigmatic. To explore the interactions between this vital host and destructive pathogen, the metabolic composition of soybeans subjected to MP infection have been analyzed using the Pyrolysis-GC-MS platform and compared to control samples to determine the metabolomic fluctuations associated with MP infection with the aim of identifying specific biochemical pathways impacted by MP. The results of this experiment and their implications are presented in the poster.

12
Name: Hoover, Theodore
Major: Computer Engineering - Bachelor of Science
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Faculty Research Mentor: Aly Abdalla, Electrical and Computer Engineering
Co-Author(s): Wen Chen
Funding: NSF REU: iEdge
Project Category: Engineering

Intelligent Intrusion and Attack Detection and Prevention

Many facets of the modern world rely on wireless infrastructure. This infrastructure is transitioning from proprietary radio access networks (RAN) to nonproprietary open RAN (ORAN), exposing many vulnerabilities and attack surfaces. One vulnerability resides in the E2 interface between the near real-time RAN intelligent controller (Near-RT RIC) and the RAN. We investigated the capability of the E2 interface to operate while experiencing a naive flooding attack from a device not authorized to be in the RAN and found that the interface was resilient to this attack and prevented significant resources from being wasted. However, if an attacker obtains credentials, they can flood the E2 interface. Flooding the E2 interface will reduce the quality of service (QoS). There exists a secure slicing xApp (AI-based controller located within the near-RT RIC) which can be utilized to de-allocate resources from malicious users attacking the network. We investigated a simulated RAN environment that can be used to pass previously collected data to a simulated Non-RT RIC. We modified the simulated RAN to accept additional data parameters of interest to this attack and prevention scenario and examined how to modify the rApps (AI-based controller located within the Non-RT RIC). The downstream behavior of a simulated Near-RT-RIC and xApp can then be examined. Conventional methods for identifying and mitigating flooding-based attacks rely on preconfigured thresholds. With advancements in artificial intelligence (AI) neural networks can be used to predict legitimate traffic and update thresholds. We gathered data of a physically deployed sliced RAN experiencing flooding-like traffic. We aim to use this data to train a Long-Short Term memory (LSTM) to update the thresholds for traffic throughput in the rApp context and forward policies for enabling or disabling base stations to the xApp context. The performance of the rApp using AI will then need to be compared against using a conventional threshold.

77
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Faculty Research Mentor: Tamara Filgueira Amorim Franca, FWRC-Sustainable Bioproducts
Co-Author(s): Amy Rowlen
Funding: USDA-REEU
Project Category: Biological and Life Sciences

Development of Fungi Test Method for Preservative Treated Cross-Laminated Timber

This project was carried out to investigate the efficacy of Micronized Copper Azole (MCA) as a wood preservative in commercially treated cross-laminated timber (CLT) in accordance with the American Wood Protection Association (AWPA) standard setup. Blocks of solid wood, wood-based composites, and Wood-strips composites (Southern Yellow Pine) are utilized for testing. The experimental design involves exposing conditioned blocks with treated concentrations of MCA, as well as exposing the same amount of untreated wood samples to achieve a range of preservative retentions. Following periods of conditioning, drying, or weathering, the impregnated blocks are exposed to destructive species of both brown-rot and white-rot fungi. Specifically, this study focuses on three brown-rot fungi: *Postia placenta, Coniophora puteana*, and *Neolentinus lepideus*, and one white-rot fungus: *Pleurotus ostreatus*. The objective is to determine the threshold retention levels of MCA required to protect the treated blocks against decay. The efficacy of MCA is measured by the weight loss of treated blocks at the end of a stipulated exposure period (16 weeks), indicating the extent of fungal decay. Wood blocks not treated with any wood preservatives are included for comparison. The results aim to refine the preservative thresholds and enhance the understanding of MCA's performance in protecting CLT against fungal degradation.

78
Name: Ishee, Zoé
Major: Psychology - Bachelor of Science
Faculty Research Mentor: Matthew Brown, Biological Sciences
Co-Author(s): Tristan Henderson
Funding: ORED Undergraduate Research Program
Project Category: Biological and Life Sciences

Unveiling the Hidden Life Cycles of Amoebas

The research that we produce examines the cell biology and behaviors of protists, particularly those exhibiting unique and uncommon characteristics, such as emergent collective behavior. By combining meticulous observation, biological understandings, methods of artistic modeling, and scientific illustration, we eagerly communicate under-examined life cycles for the purpose of broader comprehension. This interdisciplinary approach bridges gaps in traditional biology and artistic modeling, enhancing our understanding of protist diversity and evolutionary dynamics.

79
Name: Jackson, Zori
Major: Chemistry - Bachelor of Science
Faculty Research Mentor: Joseph Emerson, Chemistry
Co-Author(s): Kathryn Dove Power
Funding: Airforce Research Laboratory
Project Category: Biological and Life Sciences

Exploring the Chlorination of Tryptophan by RebH

Lentzea aerocolonigenes, a bacteria from Japanese soil, produces rebeccamycin. Rebeccamycin is an anti-tumoral agent that has been studied for its ability to possibly kill cancer cells. *Lentzea aerocolonigenes* carries an 11 gene pathway that is homologous with known rebeccamycin biosynthetic pathways. The first step of this pathway uses a flavin dependent oxidase RebH to catalyze the chlorination of the 7th position of tryptophan (Trp). This enzymatic process utilizes dioxygen and a chloride ion to regioselectivity Trp by carefully orienting the substrate for a specific C-H activation. The intermolecular forces between protein and substrate have been initially identified by X-ray crystallography, and these interactions are thought to govern the selectivity of this process. Here, we report our efforts to characterize the thermodynamics associated with a Trp substrate and its substrate analogues (e.g. alternative amino acids like Ala and indole) in relation to their binding to RebH using both spectroscopic and calorimetric methods. Correlating association constants (Ka) and related thermodynamic terms from these studies with steady-state kinetic affinity measurements (KM) will allow a higher understanding of the mechanism of this system. Improving upon our understanding of RebH paves the way for further experimentation toward developing biochemical systems for targeted aromatic halogenation pathways.

81
Name: Johnson, Bria
Major: Biochemistry - Bachelor of Science
Faculty Research Mentor: Heather Jordan, Biological Sciences
Co-Author(s): Jordan Smink, Bella Antonaros, Brandon Pierce
Funding: This study was supported, in part, by a grant from NSF/REM (Award # 2052454, Supplemental Award # 2206850, Subaward M2202244) awarded to the NSF Industry/University Cooperative Research Center For Environmental Sustainability Through Insect Farming.
Project Category: Biological and Life Sciences

Evaluating the Impact of Paenibacillus polymyxa on the Growth and Survivability of Black Soldier Fly Larvae in Organic Waste Management

Organic waste, especially manure, is often improperly managed, leading to environmental pollution. The black soldier fly larvae (*Hermetia illucens*, BSFL) are being researched as a means to digest this waste while creating a sustainable bioproduct (i.e. insect protein). Bacterial amendment may benefit BSFL by aiding the digestion of animal manure and making nutrients within the substrate more readily available. Attractive bacterial amendments would have diverse metabolic capacity as well as cellulase activity, with little or no BSFL toxicity. Here we evaluated whether a potential bacterial amendment, the cellulase producing bacterium, *Paenibacillus polymyxa*, can increase BSFL survivability and weight gain. We hypothesize that addition of *P. polymyxa* will enhance BSFL fitness through decreased mortality, reduced moisture retention, and an increase in larval weight gain. This experiment used 50 mL Falcon tubes, with four tubes per treatment group and ten BSFL. The larvae were fed Gainesville diet (50% wheat bran, 30% alfalfa, and 20% corn) with 70% moisture content. Two treatments groups (no bacterial supplementation and bacterial supplementation) were evaluated over the course of 10 days. This research will be useful in optimizing insect-microbe interactions using bacterial amendment for enhancing the performance of BSFL to digest manure and other organic wastes, and increasing BSFL nutritional value in the BSFL animal feed, thereby creating a circular economy.

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Name: Jolivette, Christopher

Major: English - Bachelor of Arts

Faculty Research Mentor: Agota Marton, Oxford University

Project Category: Humanities

'He was merely pretending': Simulacra and Deterrence in *The New York Trilogy*

In a step away from the prototypical detective novel, Paul Auster's *The New York Trilogy* erases all sense of certainty and intentionally leaves the reader wanting more. Scholars have attempted to grapple with the postmodern elements of Auster's writing, noting the ways in which this story challenges the traditional notions of modernism which had prevailed in the detective novel up until that point. Espejo (2014) goes as far as to conclude that Auster is moving between the modern and the postmodern in order to showcase both epistemologies. In addition to these elements, however, Auster's use of postmodern theory is an undoubtably significant element in his writing. Jean-François Lyotard's definition of the postmodern, presenting that which is often unpresentable, I show, is an undeniable element of Auster's work. Using Jean Baudrillard's theoretical frames of simulacra and deterrence, I detail how Auster's writing is more postmodern in its nature than scholars may surmise. The cases that each of the characters work are substitutions and simulations for a greater conflict unbeknownst the the character. I choose, therefore, to focus on the ways in which the characters' individual identity issues throughout *The New York Trilogy* represent the true case, not the inciting incidents that are seemingly straightforward. Auster shows through his postmodern affectation that each character is entangled in a simulacra, a deterrence of another larger conflict that in reality drives the plot.

35

Name: Jones, Wykendrick

Major: Biological Sciences - Bachelor of Science

University: Tougaloo College

Faculty Research Mentor: Todd Mlsna, Chemistry

Co-Author(s): Daniel Oguntuyi, Christiana Eziashi

Funding: NSF REU: INFEWS Chemistry

Project Category: Physical Sciences

Controlled synthesis and characterization of Calcinated Fe3O4-Kaolin nanocomposite for efficient removal of Brilliant Blue in aqueous media

Dyes are organic compounds that represent a significant group of environmental recalcitrant pollutants. The complex structure of dyes makes it very difficult to degrade. Therefore, a low-cost and eco-friendly calcinated Fe_3O_4-Kaolin nanocomposite (C-Fe_3O_4@K) adsorbent was synthesized for adsorption of the anionic Brilliant Blue (BB) dye in aqueous media. The adsorbent was characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Brunauer-Emmett-Teller (BET) measurement, point of zero charge measurement (pHpzc), amount of metal (mg g^{-1}) and percent metal oxide determination in digested sample via ICP-MS analysis. The C-Fe_3O_4@K was investigated as an adsorbent in the adsorption of four different dyes such as Crystal Violet (CV), Methyl Orange (MO), Brilliant Blue (BB), and Brilliant Green (BG), though the C-Fe_3O_4@K adsorbent exhibited better adsorption capacity for anionic brilliant blue (BB) dye. The impact of adsorption parameters such as adsorbent dosage (1-5 g/L), pH of the solution (2-8), and contact time (5-180 min) were investigated. The optimum value for adsorbent dosage, pH, contact time, and initial BB dye concentration was found to be 1 g/L, 5, and 90 min. The Freundlich and Langmuir isotherm models were used to examine the equilibrium data. The Langmuir and Freundlich isotherm with a significant R^2 value (~ 1) effectively captured the experimental results, while the pseudo-first-order and pseudo-second-order kinetic model controlled the dye removal. Thermodynamic data of the adsorption (ΔH =+ 7.99 kJ mol^{-1}; $\Delta G > 0$) suggested that the dye adsorption was non-spontaneous and endothermic. The Langmuir maximum adsorption capacity was found to be 103.23 mg/g. Overall, the nanocomposite (C-Fe_3O_4@K) of magnetite (Fe_3O_4) and kaolin clay is a potent adsorbent for remediating wastewater containing recalcitrant dyes.

80
Name: Joyce, Daniel
Major: Biochemistry
Faculty Research Mentor: Dr Galen Collins
Project Category: Biology and Life Sciences

Investigating if DDI2 gene deletion induces compensatory expression of other shuttling factors or retroviral proteases.

Cancer is a major cause of illness and death worldwide. One mechanism cancer cells use to evade the immune system is restricting how many antigens they present to immune cells. Recently, the HIV drug Nelfinavir was found to inhibit the shuttling factor DDI2 and subsequently increase antigen presentation. However, the effects of deleting DDI2 seem to dissipate as cells are continuously cultured, suggesting some adaptive response to DDI2 deletion. We are therefore investigating whether expression of other retroviral proteases or shuttling factors increase to compensate for the reduction of DDI2 function. Understanding the mechanism and insight into the cancer cell mechanisms for reduction of antigen presentation and immune system evasion. A greater understanding of the mechanism and proteins involved could result in the development of improved immune therapies for cancer. To investigate the restoration of protease function, we used two human cell lines (A375 melanoma and HAP1 leukemia) engineered to lack DDI2 by CRISPR-CAS 9. We compared the mRNA expression of TK with different shuttling factors and five different retroviral proteases that might compensate for the loss of DDI2 in both cells. So far, our data may suggest that ΔDDI2 samples have lower mRNA expression for some shuttling factors. More data needs to be collected and analyzed to verify the validity and statistical significance of these preliminary findings. Going forward, we will continue data collection and analysis for shuttling factors and beginning investigations into the mRNA expression of retroviral proteases

36
Name: Koloc, Jackson
Major: Physics - Bachelor of Science
Faculty Research Mentor: Dipangkar Dutta, Physics & Astronomy
Funding: ORED Undergraduate Research Program
Project Category: Physical Sciences

Utilizing Machine Learning Track Stitching Methods to Reconstruct Fragmented Proton Tracks from the Jefferson Labs TDIS Experiment

Tracking the path of protons in a continuous manner can prove difficult with modern instrumentation. Tracks can be left with gaps in between them where data was unable to be recorded which makes utilizing that data less reliable. This missing data can be predicted using machine learning software to essentially "stitch" the tracks together. The database this project seeks to benefit comes from the Jefferson Lab Tagged Deep Inelastic Scattering experiment (TDIS), which will measure the mesonic content of protons and neutrons by
scattering off the virtual pion cloud that surrounds them. The TDIS experiment will need to pick out a small number of low energy recoiling protons form a very high rate charged particle background (10s of MHz). To achieve this, a multi-time projection chamber is being built as the recoil proton detector with high occupancy in addition to the high rate. Using simulated ideal tracks, a GNN (Graphic Neural Network) prediction model can be constructed to hypothesize the full stitched tracks from the TDIS experiment data. Utilizing a primarily python dependency database called "Stone-Soup", this project aims to refine the process of track stitching to be used in predicting proton tracks and evaluate the prediction confidence for realistic tracks generated from fragmented data sets.

13
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Faculty Research Mentor: Wenmeng Tian, Industrial and Systems Engineering
Funding: NSF REU: 2046515
Project Category: Engineering

Can We 3d Print 100% Dense Copper? A Process Parameter Study for Metal Fused Filament Fabrication

Metal Fused Filament Fabrication (mFFF) is an increasingly popular Additive Manufacturing technology that allows for the efficient production of complex metal geometry while reducing cost and waste. Parts can be printed with metal filament to maintain the material properties and reliability of metal while creating the possibility for complex internal structures. The mFFF process consists of three major steps: Printing, Debinding, and Sintering. While mFFF prevails as a promising production method, there are a lot of process variations being propagated across the steps, due to the complex manufacturing process chain. Within all the inherit defects, porosity significantly weakens a part creating small internal stress concentrations throughout. This leads to the major limitation of mFFF when compared to its traditional counterparts.
The objective of this research is to understand the effects of printing process parameters on the internal porosity patterns of a mFFF copper print. The parameters chosen are Layer Height (The height between layers), Extrusion Width (The width of the internal struts), and Extrusion Multiplier (The rate the material is extruded). A full factorial design was used with three centerpoint control runs. X-ray Computed Tomography is utilized to analyze the internal structure of the mFFF copper before and after debinding and sintering processes. Subsequently, a porosity algorithm was used to identify and characterize the internal porosities. Descriptive features of each pore (e.g., XYZ coordinates, probability, sphericity, radius) can be extracted. First, the porosity distribution patterns were evaluated and the effects of printing parameter on the porosity distribution were examined. This facilitates printing process parameter optimization for mFFF. Secondly, the growing trajectory of the internal pores were analyzed to elucidate different porosity growth patterns in the debinding and sintering stages of mFFF. The results will enable internal structure prediction, facilitating in-situ decision making for process adjustment and control in mFFF processes.

37
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Funding: ORED Undergraduate Research Program, MSU NIH COBRE Grant (P20GM103646)
Project Category: Physical Sciences

Synthesis and Characterization of Symmetrical C-4 substituted Pyridinyl Tetradentate Cu(II)-NHC (N-Heterocyclic Carbene) Complexes and their Application in Cross-Coupling Reactions

N-heterocyclic carbenes (NHCs) have shown remarkable potential in supporting novel and unique reactivity with first-row transition metal ions. Known for their strong σ-donating properties and stability, these ligands facilitate the formation of highly reactive metal complexes. Building on our recent work describing copper(II) complexes, we synthesized a series of tetradentate NHC complexes with symmetrical C-4 substitutions on their pyridine rings using straightforward methodology. Substituents such as methoxy (OMe), and chloro (Cl) groups were introduced. The ligand precursors and copper(II) complexes were characterized using various techniques, including nuclear magnetic resonance (NMR) spectroscopy for 1H, 13C, 31P, and 19F nuclei, electrospray ionization mass spectrometry (ESI-MS), X-ray crystallography, cyclic voltammetry, and UV-Vis spectroscopy. The newly obtained Cu(II) tetradentate catalysts were used to generate C-C and C-N bonds via cross-coupling reactions.

14
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Major: Computer Science - Bachelor of Science
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Funding: NSF REU: iEdge
Project Category: Engineering

Environment-Aware Mobile Intelligent Edge (MAVS)

Autonomous driving is continuously becoming a more prevalent aspect of our lives, with many companies such as Tesla releasing their own self-driving cars. However, data relating to autonomous vehicles in off-road scenarios is much more scarce and contains many more complications, with terrain in one area having the potential to be vastly different than the terrain in another. To improve off-road autonomy, we have developed a digital twin of the Center for Advanced Vehicular Systems (CAVS) backyard test track, integrating it into the Mississippi State Vehicular Simulation (MAVS) tool. To achieve this, we used camera data from the backyard to create mesh models of different objects such as corrugated pipes, trees, etc. This digital twin functions as a precise virtual representation of a sample physical environment, enabling comprehensive testing and evaluation of autonomous driving algorithms and systems. We utilized this digital twin to assess the performance of autonomous vehicles in off-road scenarios, considering a variety of environmental conditions, and its changes on the terrain. Additionally, we are using lidar data to improve autonomous driving algorithms. We are also running semantic segmentation algorithms on images and videos with the use of large datasets to identify different objects. This work contributes to advancing the reliability and safety of autonomous vehicles not only for commercial consumers but also for military and scientific circles by providing a robust testing framework that replicates real-world conditions.

15
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Funding: NSF REU: Computational Methods with Applications in Materials Science
Project Category: Engineering

Developing Machine Learned Interatomic Potentials for Hydrogen Dissociation over Molybdenum Phosphide

Molybdenum phosphides are promising catalysts for biomass conversion, particularly in the hydrogenation of organic molecules. Hydrogen dissociation on the surface of such catalysts is a critical step in the process. Traditional computational methods such as density functional theory (DFT) can provide valuable insights into hydrogen-catalyst interactions but are limited by their high computational cost and inefficiency for large systems and long time scales. Machine learning has emerged as a solution to these limitations. Machine learned interatomic potentials (MLIPs), trained on ab initio molecular dynamics (AIMD) simulations, enable the development of molecular dynamics (MD) for much larger systems over much longer time scales, with significantly reduced computational cost. This allows more complex interactions and rare reactive events to be observed that would otherwise be inaccessible with traditional methods. In this study, MACE, a message passing neural network, is employed to develop MLIPs for the dissociation of hydrogen on molybdenum phosphide surfaces. Utilizing MACE results in highly accurate MD simulations with time scales on the order of 1,000 times longer than those achievable with AIMD. These MD simulations provide key insights about the system, including preferred adsorption sites and atomic interactions and serve as a bridge to studying biomass conversion. This study demonstrates the efficacy of machine learning for catalytic research, illustrating the robust and efficient predictive capabilities of MLIPs and underscoring the potential of machine learning techniques for the efficient discovery, optimization, and understanding of new catalysts.

82
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Funding: MSINBRE
Project Category: Biological and Life Sciences

Dynamic Light Scattering Measurement of Nanoparticle Size in Human Serum

Nanoparticles are particularly important to the biomedical field, because of the way they interact with the environment around them. A liposomal nanoparticle is a vesicle that can encapsulate drugs, which is useful for drug delivery in the body. When these nanoparticles are introduced to human serum, the proteins from the serum adhere to the surface of the nanoparticle. A protein corona is then formed, so the nanoparticle's original properties are changed. Hydrodynamic diameter (DH) influences how the body reacts to nanoparticles. Dynamic Light Scattering (DLS) is a method that measures the size distributions of the nanoparticles, but it relies on viscosity to measure DH. The issue with this is most researchers do not measure and change the original viscosity values in the DLS machine. So, we wanted to measure different concentrations of human serum and see how they affect the size of the nanoparticles. We focused on concentrations of 5% to 100% of human serum and measured their viscosity. We found that the uncorrected values for viscosity differ up to 30% when compared to the corrected values. This difference in size is pivotal and measuring the size of nanoparticles accurately ensures their efficacy, safety, and performance in biological settings, ultimately leading to better outcomes in therapeutic and diagnostic applications.

16
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Co-Author(s): Rahul Shetty
Funding: NSF REU: iEDGE
Project Category: Engineering

Environment based Dynamic Partition of Neural Networks

Neural networks are integral to computer vision machine learning models, utilizing multiple layers to process and identify objects in near real-time. This process emphasizes important data through weighted connections while reducing the weights of less relevant information as it passes through each layer. Devices that can use computer vision models like the Jetson Nano can not quickly process larger, more accurate computer vision models like YOLO v3, so it is necessary to dynamically partition and transmit the intermediate results to more powerful servers via wireless channels like WiFi or 5G, achieving rapid response times for the user in milliseconds. This research builds upon the YOLO v3 model to explore practical implementations of dynamic partitioning for small autonomous vehicles to detect objects in their path efficiently and accurately. The potential applications for dynamic partitioning without the vehicle could extend to environments such as construction sites, where real-time accident detection could significantly enhance safety protocols.

83
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Funding: NSF REU: College Of Forest Resources
Project Category: Biological and Life Sciences

Native woody plant species composition and stand structure in the Mississippi State University Arboretum

The Mississippi State University Arboretum, spanning five acres, was founded in 1990 adjacent to South Farms western edge. Its purpose was to serve as a research hub for forest genetics, focusing on various species, varieties, and cultivars of both native and non-native woody plants. These plant collections were also curated to support education, particularly field-based courses like Dendrology, thereby enriching hands-on learning experiences for students. The arboretums native species composition reflects the region significant biodiversity, with many trees, shrubs, and other woody plants unique to the area. This diversity provides the opportunity to investigate the ecological roles, adaptations, interactions, and distribution patterns of these species. Unfortunately, the site has remained inaccessible and unmanaged from 2015 until the present time, which has resulted in approximately 10 years of unrestricted native and non-native woody plant growth. Our objective was to assess how a lack of management has impacted the composition and stand structure of native woody plant taxa at the arboretum. We conducted an inventory in June and July 2024 to identify taxa, measure the diameter-at-breast-height and height for each specimen, and assess each specimen for defects. We examined species diversity and stand structure variables, such as stand density and size and height class distributions. Preliminary results show that many native woody plant species remain in the area, including common species like common persimmon (Diospyros virginiana), sweetgum (Liquidambar styraciflua), and cherrybark oak (Quercus pagoda), and less common species like Kentucky coffeetree (Gymnocladus dioicus). These species predominantly occur in the mid-story and overstory, though natural regeneration can be found in the understory. Overall, the species and structural diversity at the arboretum helps provide habitat for wildlife, carbon storage capability, and overall resilience to environmental change. The results of this study will help direct planning to restore the arboretum for research and teaching purposes.

84

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Funding: R25 Bridges to Baccalaureate, None

Project Category: Biological and Life Sciences

Unveiling Cerebral Palsy Risks: Behavioral insights from *metro* and *mrtf* mutants in *Drosophila melanogaster*

Cerebral palsy (CP) is the primary neurodevelopmental disorder (NDD) affecting motor function, with a prevalence of approximately 2–3 per 1,000 children worldwide. The onset of movement disorders such as spasticity, dystonia, choreoathetosis, and/or ataxia occurs within the first few years of life, resulting from disrupted brain development. Akin to other NDDs like autism spectrum disorders (ASDs) and intellectual disability (ID), no single causative factor has been definitively attributed to CP onset. However, several environmental factors, including prematurity, infection, hypoxia-ischemia, and pre- and perinatal stroke, significantly contribute to the risk of CP. Notably, around 40% of CP cases are idiopathic, with no identifiable etiology suggesting that a substantial number of CP cases are genetically inherited.

In this study, we focused on two critical genes, *metro* (ménage à trois) and *Mrtf* (myocardin related transcription factor), which are essential for neuromotor development in *Drosophila melanogaster*. Metro is crucial for the proper formation of synaptic junctions at neuromuscular junctions (NMJs), and its absence results in reduced growth and structural abnormalities in NMJs. MRTF is a key regulator of smooth muscle differentiation and function, with its deficiency leading to disrupted muscle gene transcription and developmental defects in NMJs. We tested null mutants for each gene alongside parallel controls in behavioral assays, such as rapid iterative negative geotaxis (RING) and locomotor behavior, to determine which mutation confers a greater risk for the development of CP in the fly model. Preliminary behavioral analysis suggests that mutations in either gene can increase the risk of developing pathological symptoms that are linked to CP. Our findings demonstrate that a *Drosophila* model of CP can be robustly generated, providing a valuable tool for further studies on the pathways likely affected by CP.

85
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Funding: Department of Defense TX220231
Project Category: Biological and Life Sciences

Assessing Behavioral Effects of the Carbamate Drug Pyridostigmine Bromide

Pyridostigmine bromide (PB) is a nerve agent prophylactic used to protect warfighters against the organophosphate (OP) warfare agents. OPs inhibit acetylcholinesterase (AChE), which leads to the buildup of acetylcholine. This can lead to a disruption of autonomic processes known as a cholinergic crisis, causing respiratory failure, seizures, and death. PB, a carbamate, is administered daily and functions by temporarily inhibiting ~30% of peripheral AChE. During a nerve agent exposure, the rapid recovery of the PB-inhibited AChE allows the body to restore sufficient cholinergic function. PB does not cross the blood-brain barrier. Thus, it cannot directly act on the brain. However, it may indirectly affect the brain due to repeated inhibition of AChE and persistent increased cholinergic activity in the periphery that would occur as a result of daily dosing. The aim of this study is to determine if repeated PB treatment alters behavior in regard to anxiety, memory, activity, and anhedonia/depression. Male and female rats were administered either vehicle or PB orally. Behavioral testing was conducted on days 14-19. The “elevated plus maze” was used to test for anxiety, the “novel object” test was used to assess memory, the “open field” test was used to analyze locomotor activity and anxiety, and the “sucrose preference test” was used to measure anhedonia/depression. Treatment did not affect performance in the elevated plus maze, novel object test, or sucrose preference test. In the open field test, activity levels were not affected. However, female PB-treated rats entered and spent more time in the center of the maze than did the female controls. This may suggest a subtle reduction of anxiety levels. These data suggest that PB treatment may exert sex-specific effects on behavior in the brain despite being unable to cross the blood-brain barrier.

52
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Project Category: Business and Economics

Utilizing the Data Lifecycle Process to Provide Information on all NCAA Universities and their Data Science Programs for Recruitment Purposes

Data science is an emerging field that is becoming popular as a bachelor’s degree. It is a unique program that can have many variations between universities. Some universities require a second major or minor, and some require a concentration or emphasis. Universities and colleges across the United States are beginning to add data science as a major, so it is crucial to obtain a competitive advantage when recruiting. If a program director, program advisor, or admissions counselor wants to find what is unique about their program, it is vital to consider many factors. By collecting data from all NCAA colleges about the college and the data science program, utilizing Jupyter Notebook to organize the data, and creating a public Tableau dashboard, directors, advisors, and admission counselors can pinpoint what is unique about their program. I will continue to add factors to the spreadsheet and features to the dashboard. I am also exploring ways to scrape college websites to simplify the data collecting process.

86
Name: McBride, Abigail
Major: Biochemistry - Bachelor of Science
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Funding: College of Agriculture and Life Sciences URSP
Project Category: Biological and Life Sciences

Heat Stress Models for Assessing Breed-Specific Responses in Holstein and Jersey Dairy Cattle

Heat stress is a major threat to dairy cattle due to their high metabolic heat load caused by high milk production. Dairy cows under heat stress experience respiratory rates and reduced feed intake, potentially impacting the microbial ecosystems in their gastrointestinal tract and respiratory tract, increasing their vulnerability to infections and impaired digestive function. The objective of this research was to investigate the relationship between the physiological and microbial ecosystems of Holstein and Jersey cattle breeds to heat stress conditions and to identify breed-specific differences in heat tolerance and adaptive mechanisms. 24 lactating dairy cows and were divided into Heat-stressed Holstein (HS_H) and Heat-stressed Jersey (HS_J) with limited access to fan and sprinkler cooling systems during a 14-day period in June at Starkville, Mississippi. Temperature-humidity indices (THI), respiration rate, rumen contraction frequency, rectal temperature, feed intake, and milk yield were recorded regularly. We didn't observe any significant differences between the two groups except for the respiration rates, the Jerseys tended to have higher respiration rates during the adaptation period (12pm: 65.7±9.4 vs. 83±15.4, 4pm: 55.7±13.9 vs. 62.7±10.2). The THI in both groups remained above 75 from 12 PM to 8 PM for the trial period's duration with no significant differences between groups ($p=0.181$). However, the 10.2). respiration rate (12pm: 89.45±12.36/min vs 100.49±9.39/min, 6pm: 81.73±16.33/min vs 95.45±10.82/min, $p<0.0238$) were significantly higher in the HS_J group compared to the HS_H group. Additionally, HS_H group exhibited significantly higher feed intake (44.47±14.22 kg/cow vs 37.12±9.4 kg/cow, $p=0.0003$) compared to HS_J group. However, no significant differences in the rectal temperature ($p=0.403$), rumen contraction frequency ($p<0.61$), and milk yield were observed between HS_H and HS_J groups ($p=0.744$). Further analysis will focus on the differences in the microbial ecosystems of the two breeds.

87

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Funding: R25 Bridges to Baccalaureate Program
Project Category: Biological and Life Sciences

Bile Acids and Their Effects on Human Carboxylesterase 1 Activity

Carboxylesterase 1 (CES1) is one of the most abundant serine hydrolase enzymes that catalyzes the hydrolysis of endogenous molecules and xenobiotics. These include cholesterol esters, triglycerides, organophosphate poisons, ester- and amide-containing drugs, and many other substrates. Pharmaceutical and genetic CES1 inactivation has been shown to exacerbate inflammation, which can lead to the onset of many diseases. Bile acids, which are hepatically synthesized and used to digest lipids in the GI tract, can non-covalently bind to CES1 at a regulatory site, defined as the Z-site, that is distant from the active site. However, the functional significance of this interaction is unknown. We hypothesized that this interaction could allosterically activate the catalytic activity of CES1. The bile acids cholate, taurocholate, and lithocholate 3-sulfate were pre-incubated at increasing concentrations with pure recombinant human CES1 enzyme. The bile acid treated CES1 enzyme was then incubated with the ester substrate p-nitrophenyl valerate (pNPVA), and its catalytic activity measured by a kinetic spectrophotometric assay. Activity-based protein profiling (ABPP) was also used to determine the level of CES1 activity after bile acid treatment. Our data showed that cholate and taurocholate could enhance the catalytic efficiency of CES1 by about two-fold, whereas inhibitory effects were seen with lithocholate 3-sulfate (up to 80% inhibition). Bile acid enhancement of CES1 catalytic activity unfolds new avenues for pharmacological modulation by small molecules. Enhancing CES1 activity could potentially reverse inflammation, which ultimately slows down or reverses the progression of diseases like atherosclerosis and type 2 diabetes mellitus.

17
Name: Medved, Cooper
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Funding: NSF REU: IEDGE
Project Category: Engineering

Low Latency Optimization For Real-Time Edge Stream Processing

This research tests low-latency optimization for real-time stream processing on edge devices. It has potential applications in autonomous vehicles, healthcare devices, and predictive maintenance. We aim to improve decision-making capabilities in these domains by enhancing low-latency data processing. We conduct comprehensive performance comparisons between Raspberry Pis and virtual machines (VMs), focusing on throughput and latency measurements. The primary objective is to evaluate the advantages of edge devices like the Raspberry Pi over cloud-based environments using VMs, providing a detailed understanding of their performance in real-time data processing. Our software stack features Apache Storm, a distributed real-time computation system known for low-latency processing of large data streams. Riot-Bench is a benchmark application that evaluates the performance and metrics of real-time stream processing produced by Apache Storm. Apache Storm and Riot-Bench are deployed using Docker to containerize their components, ensuring consistent runtime environments and simplifying deployment. Kubernetes is utilized for container orchestration, resource allocation, and scaling. This setup enhances the Raspberry Pi's processing capabilities, enabling real-time data analysis, efficient resource utilization, and seamless integration into distributed systems. Testing results indicate differences in performance between VMs and Raspberry Pis. We measure throughput, the amount of data a system can process in a given time, and latency, the time it takes for a piece of data (tuple) to travel from source to output after being processed. Our findings show that Raspberry Pi demonstrates better results than VMs, with lower latency and more efficient data processing. These results suggest that edge devices like the Raspberry Pi can offer significant advantages for low-latency, real-time data processing applications compared to traditional cloud-based environments. Future research will focus on further optimizing these systems, exploring additional edge computing devices, and expanding the scope of real-time applications to maximize the benefits of edge computing in various industries.

38
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Funding: NSF REU: Chemistry
Project Category: Physical Sciences

Discovery of New Z-type Rh(I)-Zn(II) Heterobimetallic Complexes for Catalytic Hydrogenation

Contrast to homobimetallic complexes, which are seen as having limited potential for stoichiometric H_2 reductive elimination due to symmetry-forbidden transition states, heterobimetallic systems with Lewis acidic and basic metal centers are poised to facilitate heterolytic H_2 cleavage effectively and offer promising avenues for activating the H-H bond. However, the catalytic mechanisms and efficiencies of these systems require further exploration and understanding. Herein, the synthesis and structural characterization of a new Z-type Rh(I) – Zn(II) heterobimetallic complex were studied using SCXRD, IR, and NMR spectroscopy. The zinc metalloligand [Na{Et_2Zn(OPy-6-Me)}] was produced by the nucleophilic attack of Na(OPy-6-Me) on Et_2Zn, and the subsequent alkane elimination reaction with 6-methyl-2-hydroxypyridine resulted in [Na{EtZn(OPy-6-Me)$_2$]. Simultaneously, the metalloligand [Zn(OPy-6-Me)$_2$] was formed via alkane elimination from Et_2Zn with 6-methyl-2-hydroxypyridine. The addition of chlorobis(ethylene)rhodium dimer ($Rh_2Cl_2(C_2H_4)_4$ to the reaction resulted in [Rh{EtZn(OPy-6-Me)$_2$}(C_2H_4)Et]. In recent work, Z-type Rh(I)-Ga(III) complex [Rh{MeGa(OPy-6-Me)$_2$}(C_2H_4)Me] displayed superior performance in the hydrogenation of styrene and other alkenes providing a promising future for future work of Rh(I)–Zn(II) complex to highlight the efficiencies of metal -metal cooperativity in hydrogenation reactions.

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Name: Morrow, Ethan
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Co-Author(s): Dikshya Pokhrel
Funding: USDA-REEU
Project Category: Biological and Life Sciences

Cellulose nanofibril stabilized Pickering emulsions as a method of utilizing Parthenium argentatum (guayule) resin

The extraction of natural, latex-free rubber from the Parthenium argentatum (guayule) plant produces a sticky, viscous resin as a byproduct that is difficult to work with. However, this resin has many potential applications in fuels, pesticides, wood coating, and more if its physical workability constraints can be mitigated. This study explores the effectiveness of utilizing oil-in-water (O/W) Pickering emulsions stabilized by (2,2,6,6-Tetramethylpiperidin-1-yl)oxyl (TEMPO)-oxidized cellulose nanofibrils (TCNF) to enhance the dispersion and application of guayule resin in aqueous environments. O/W Pickering emulsions, consisting of TCNF suspension in water and guayule dissolved in toluene as the water and oil phases, respectively, were prepared using ultrasonication with a 2:1 water-to-oil ratio. The concentrations of the water and oil phases of the emulsion were systematically varied to determine their influence on the size and stability of resultant emulsions. These emulsions were analyzed using thermogravimetric analysis and Fourier-transform infrared spectroscopy to determine the guayule loading and composition. Additionally, emulsions were observed with an optical microscope and analyzed with ImageJ to measure stability in droplet size over time. Emulsion droplets averaged 3 micrometers in size when made but coalesced into larger droplets over time in emulsions with less TCNF. We found that emulsions with 0.5% TCNF by weight exhibited the least variation in droplet sizes over time, corresponding with increased emulsion stability. The guayule concentration used does not seem to affect the stability of the emulsion. Furthermore, the emulsions were tested in solutions with varying pH from 2 to 12 and ionic concentrations ranging from 0.01 to 0.4 M NaCl to determine stability under different environmental stresses.

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Co-Author(s): Serge Kameni, Notsile Dlamini
Funding: ORED Undergraduate Research Program
Project Category: Biological and Life Sciences

Blood plasma-derived extracellular vesicles decrease post-thaw sperm motility

Sperm cryopreservation is crucial in animal breeding, allowing for long-term genetic material storage and transport. Despite its benefits, the freezing-thawing process often reduces motility, adversely affecting fertility outcomes. Extracellular vesicles from blood plasma (BP-EVs) have emerged as potential biological tools for enhancing cell function. This study explored possible benefits of BP-EVs on bovine sperm post-thaw survival. BP-EVs were isolated from bull blood plasma via differential centrifugation and quantified for protein concentrations. Frozen-thawed straws (n=4) containing spermatozoa of a Charolais bull were diluted in a pre-warmed bovine extender and incubated at 37°C with different concentrations of BP-EVs: 0 µg/mL (control), 0.05 µg/mL (EVs1), 0.1 µg/mL (EVs2), and 0.2 µg/mL (EVs3). Sperm motility parameters were analyzed using a Computer-Assisted Sperm Analyzer after 15 minutes, 1 hour, 2 hours, and 3 hours of incubation. The BP-EVs binding to spermatozoa was visualized (confocal microscopy) and quantified (flow cytometry) after labeling BP-EVs with a lipophilic fluorescent dye. Data were analyzed with SPSS and expressed as mean±SEM. $P<0.05$ was set as a significance threshold. The average BP-EV protein concentration was 21.82±1.22 µg/mL of blood plasma. The percentages of total motile sperm significantly differed between treatment groups after 15 minutes of incubation ($p<0.03$) but remained comparable at other time points. The percentages of progressive spermatozoa showed similar results at 15-minute incubation ($p<0.02$). Both parameters progressively decreased during incubations and in BP-EV groups, with consistently lower percentages than the controls. The decreased effect of BP-EV appears in a dose-dependent manner. Overall, the control and the EVs3 groups consistently had the highest and the lowest values ($P<0.05$ – Total motility: 41.53±3.56% and 30.82±4.34%; Progressive: 25.98±2.76% vs 14.69±3.01%, respectively). We conclude that BP-EVs have no beneficial effect on post-thaw bull sperm motility. Instead, they may have adverse effects at higher concentrations.

18
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Funding: ORED Undergraduate Research Program, BRIDGES, CAVS
Project Category: Engineering

Development of a Novel Test Apparatus Model for Ventricular Shunts: A Conceptual Design

Ventricular shunts, widely used to manage hydrocephalus by redirecting cerebrospinal fluid (CSF) to other body cavities for drainage or reabsorption, face significant challenges such as blockages, infections, mechanical failures, disconnections, and placement issues. These complications often lead to increased failure rates and necessitate multiple shunt replacements or revisions, resulting in a high rate of complications and substantial costs. Studies show that only 30%-37% of shunts remain functional over time, underscoring the need for improved design parameters (Chang & Avellino, 2018).
Various research groups are actively addressing these challenges by focusing on different aspects to enhance shunt reliability. Our research group is specifically focused on obstruction mitigation, which is a primary cause of failure, including proximal and distal obstructions. While many groups can test their designs theoretically and via simulations, existing methodologies often fall short in replicating near-real conditions. For instance, Researchers Lee et al. from Harvard Medical School, Boston Medical Center, and Institute of Medical Engineering and Science at MIT developed a testing model for their designs, identifying several shortcomings and providing a foundation for our innovative solution (Lee et al., 2020).
To move beyond theoretical modeling and computational simulation, we have developed a conceptual testing device that replicates cranial conditions in both humans and animals. This apparatus allows real-time monitoring of shunt performance under various orientations and conditions, bridging the gap between theoretical designs and clinical practice. Our next step involves constructing this device to validate our findings and facilitate the transition of new shunt designs into clinical use, ultimately aiming to improve patient outcomes and address the limitations of current ventricular shunt technologies.

90
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Funding: USDA-NRCS
Project Category: Biological and Life Sciences

Aquatic macroinvertebrate assessment of restored wetlands in the Lower Mississippi Alluvial Valley

Ecological assessments provide important information about restoration success, such as monitoring wetland restorations. Conservation efforts by the U.S. Department of Agriculture Natural Resources Conservation Service include the Wetland Restoration Easement (WRE) program, which has been implemented in the Mississippi delta region. The WRE program works to restore frequently flooded and non-productive agricultural lands to wetlands and bottomland hardwood (BLH) forests. After 30 years of the program, there is limited data on its environmental impact. Thus, there is a need to assess the ecosystem services in WREs in the Mississippi delta region. This research aims to investigate aquatic macroinvertebrate (AMI) communities in WREs, as compared to agricultural drainage ditches and reference wetlands. Assessments of AMI were conducted using an aquatic D-net, where each site (n=38) was sampled once in three different environments to ensure samples were representative of WREs where semi-permanent water holding areas occur. Soil samples of AMI were collected during March to May 2024 and will be sampled again in August to September 2024, to account for seasonal variation within each site. Samples were transported on ice to Mississippi State University where initial sorting and separation of AMI from organic material occurred. Samples were preserved in 95% ethanol for the duration of collection, sorting, and identification. Preserved samples underwent identification to at least two taxonomic levels, where orders and families are catalogued into abundance of these taxonomic groups. Subsequently, taxa were assigned a pollution tolerance level and to develop a biotic index of taxa present as a bioindicator of water quality condition. Analysis of results will include relative abundance of AMI bioindicators present at each site. Outcomes of this work are expected to provide information that helps quantify environmental outcomes associated with WRE program implementation.

39
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Major: Physics - Bachelor of Science
University: Sam Houston State University
Faculty Research Mentor: Torsten Clay, Physics & Astronomy
Funding: NSF REU: REU Computational Methods with applications in Materials Science
Project Category: Physical Sciences

Repulsive Coulomb interactions enhance superconductivity selectively at density 0.5 per site

The globally accepted Bardeen-Cooper-Schrieffer (BCS) theory explains the pairing mechanism in low-temperature elemental superconductors but fails to explain pairing in high critical temperature superconductors. Unconventional superconductors with higher critical temperatures require more exotic pairing mechanisms considering electron-electron interactions, such as spin fluctuation-mediated pairing. Many-body calculations within the Hubbard model, which includes short-range electron-electron repulsion, have shown that superconducting pair correlations are enhanced when the density of carriers is close to one-half per orbital, a characteristic density in many unconventional superconductors. However, questions related to the accuracy of previous calculations remain. In this work, we employed a more accurate numerical method, Self-Consistent Constrained Path Quantum Monte Carlo (SC-CPMC), to check the accuracy of CPMC calculations without the self-consistent optimization of the trial wave function. By eliminating the artificial lattice symmetry breaking previously included, we restored the intrinsic symmetry of the lattice. This study also investigated the effects of a larger Hubbard U. Our results confirm that the Hubbard U significantly enhances superconducting pair-pair correlations for carrier densities close to 0.5 per site.

40
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Funding: NSF REU: REU in Computational Methods with Applications in Materials Science
Project Category: Physical Sciences

A Docking Analysis of Reactivators for Sarin-Inhibited Acetylcholinesterase Can Aid in Screening Candidate Compounds

Organophosphate (OP) poisoning disrupts nerve signaling by inhibiting acetylcholinesterase (AChE), an essential enzyme. Current oxime-based treatments for OP poisoning lack efficacy in severe cases due to blood-brain barrier (BBB) impermeability. A prior machine learning study identified promising AChE reactivators with BBB permeability and synthetic feasibility. Our study employed in silico docking simulations using AutoDock to evaluate the interactions between these potential reactivators and a sarin-inhibited human AChE model. The 35 compounds proposed in the earlier study, along with five known good AChE reactivators, were docked against a model of human AChE that was inhibited by the OP nerve agent sarin. While all the positive control molecules yielded good docking results, none of the newly proposed compounds did. The results of this docking analysis will inform the development of novel OP antidotes capable of reaching the brain and effectively reactivating AChE in severe poisoning scenarios. We suggest adding a docking screening to any future protocol designed to generate potential reactivators.

41
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Funding: NSF REU: REU-INFEWS
Project Category: Physical Sciences

Qualitative Measurement and Adsorption Capacity of Microplastics Using PY–GC–MS and ICP–MS

Microplastics are defined as plastic particles with dimensions less than 5mm and are insoluble and non-degradable in the environment. Microplastics come from the breakdown of larger plastic debris and have been detected in soil and marine environments. Although plastics were synthesized to improve human quality of life, they have become a danger to the health and safety of the environment and all organisms. Within environmental samples, microplastics can be qualitatively and quantitatively measured using pyrolysis–GC/MS. This instrument produces GC traces with distinguishable peaks and corresponding mass-to-charge ratios, which identify specific compounds and their configurations. This characteristic enabled the creation of a new database for the qualification of several microplastics. The new database was developed by analyzing pure and mixed microplastic samples through pyrolysis–GC/MS and comparing these traces and their corresponding indicator compounds to other databases found in scientific literature. In the natural environment, microplastics interact with additional debris and become contaminated. Common contaminants in marine environments include heavy metals. Accordingly, this project employed the use of an ICP–MS to measure the intensities of heavy metals within a solution. Additionally, the ICP–MS can measure the adsorption of heavy metals by other materials, allowing for the measurement of the adsorption capacity of each microplastic for the heavy metals. These contaminated microplastics were then analyzed through pyrolysis–GC/MS and compared to the pure traces to identify the impact that the heavy metals had on the qualification of the microplastics. This procedure was conducted to validate the method and database. Once these samples were analyzed, the database was updated to account for the contamination likely to be found in natural environments. In future research, this valuable information will be consulted qualitatively and quantitatively to analyze environmental samples.

19
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Funding: Shackouls Honors College Research Fellowship
Project Category: Engineering

Synergistic Pollution: Interactions Between Polyethylene, Surfactants, and Antibiotics in Aquatic Environments

Plastics, surfactants, and antibiotics are all, separately, damaging pollutants commonly found in aquatic environments. Plastics are not biodegradable, and many chemical surfactants are toxic to marine life. In aquatic environments, plastics are immediately subjected to microbial attack, where biofilms form on the plastics by microorganisms. Antibiotics can be absorbed onto the plastics, which can cause chemical leaching, or they can be consumed by marine life, spreading antibiotic resistance resistant microbes. Due to water currents, these pollutants mix and interact with one another, and the consequences of these interactions are yet to be fully understood. We hypothesize that plastic waste interacts with antibiotics as well as surfactants, which are constantly present in many aquatic environments, to produce further leaching of chemicals. Polyethylene (PE) is one of the most common nonbiodegradable plastics found in aquatic environments. Three of the most common surfactants, which are used in farming, cleaning supplies, and pharmaceuticals, include dodecyl sulfate (SDS), chitosan, and biosurfactants known as rhamnolipids. We studied an 11.11% penicillin-streptomycin and de-ionized (DI) water solution. Five test solutions were created, a control with no plastics, an antibiotic/plastic mixture, and then an antibiotic/plastic mixture with each of the three surfactants. The amount of each surfactant added was determined using the Critical Micelle Concentration (CMC). The PE, antibiotic solution, and surfactant were combined and then tested using UV/Vis Spectroscopy. From our findings, we discovered that the combination of all three pollutants caused either chemical leaching or a reaction between the antibiotics and the surfactants. This gave the appearance that the antibiotic concentration was increasing over the 20 days. These findings highlight the complex interactions between pollutants in aquatic environments and underscore the need for further research to mitigate their combined effects.

91
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Project Category: Biological and Life Sciences

Anatomical Changes to Southern Yellow Pine Caused by *G. trabeum*

Southern Yellow Pine (*Pinus* spp.) is a widely used structural material in the southeastern United States, a region with a humid climate that promotes decay by brown-rot fungi such as *Gloeophyllum trabeum*. In a previous work, the brown-rot fungi *G. trabeum* was inoculated in *Pinus* spp. for twelve weeks, and decay was detected after four weeks of exposure using non-destructive mechanical testing (NDT). This study aims to investigate the anatomical changes in *Pinus* spp. caused by *G. trabeum* using conventional wood anatomical techniques. Sections of *Pinus* spp. were obtained using a microtome and stained using lactophenol cotton blue and safranin before being mounted. A light microscope and stereomicroscope were used along with ProgRes software to capture high-resolution images. The presence of *G. trabeum* was first observed in the third week of exposure. Light microscopy revealed distinct anatomical alterations, including early hyphal penetration in pits and ray parenchyma cells through bordered pits, cell separation, and checking of the secondary cell wall. Progressive decay was observed in week nine, manifested as cell wall degradation, further hyphal penetration, and the formation of cavities, consistent with typical brown-rot decay patterns in softwoods. These findings corroborate previous NDT results and observations of brown-rot fungal degradation and highlight the utility of wood anatomy techniques for early decay detection.

92
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Project Category: Biological and Life Sciences

New Tools for Studying Protein Breakdown in Bovine Muscle

Background: Intracellular protein degradation through the ubiquitin- proteasome pathway regulates cellular events. We are using bovine muscle to test how shuttling factors affect the balance of muscle synthesis and degradation. Assisting proteasomes in degrading proteins, shuttling factors recognize ubiquitylated proteins and bring them to proteasomes for their destruction. However, such a role is surprising. Proteasomes can also recognize ubiquitin independently. Therefore, the role of shuttling factors in protein degradation is mysterious. I am building tools with molecular biology and protein biochemistry to better understand shuttling factors in protein degradation, especially in cattle muscle. These recombinant proteins will enable us to see how protein degradation occurs with shuttling factors in muscle extracts and identify which specific substrates these various shuttling factors bind.

Methods: mRNA was extracted using TRIzol reagent. This was used to prepare cDNA using oligo-dT primers and reverse transcriptase. This cDNA was the template for amplifying eight different shuttling factor genes. Gibson Assembly inserted these into Bam-HI digested pGEX-6P bacterial expression vector. The genes will then be sent off for sequencing.

Results: We have successfully amplified shuttling factors, RAD23A, UBQLN1, UBQLN2, ZFAND1, ZFAND2A, ZFAND2B, ZFAND3, and ZFAND5 from bovine muscle. We have ampicillin-resistant clones from these genes, from which we have prepared plasmid preps that we will sequence.
Conclusion: The resources generated this summer are expected to aid in investigating shuttling factors and their role in protein degradation. It should allow us to identify their targets and see how they regulate muscle growth, especially in cattle.

93
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Funding: Airforce Research Laboratory
Project Category: Biological and Life Sciences

Calorimetric and Stability Study of Tryptophan and PyrH from *Streptomyces rugosporus*

Streptomyces rugosporus is a species of bacteria in the family *Streptomycetaceae*. This bacterium produces pyrroindomycins, a group of novel antibiotics with broad activity. The synthesis of Pyrroindomycin B starts by modifying tryptophan (Trp) by the flavin dependent halogenase, PyrH, to catalyze the chlorination of the fifth position of Trp to produce 5-chlorotryptophan (5Cl-Trp). This enzyme uses an FAD-dependent active site to activate O_2 in the presence of a chloride ion to generate a hypochlorite ion that is guided for the regioselective electrophilic aromatic substitution of Trp. The intermolecular forces between substrate and protein are believed to govern the selectivity of this process. Here, we report our efforts to characterize the thermodynamics associated with a tryptophan substrate and its substrate analogues in relation to their binding to PyrH using both spectroscopic and calorimetric methods. Correlating association constants (K_a) and related thermodynamic terms from these studies with steady-state kinetic affinity measurements K_M) will allow a higher understanding for the mechanism of this system. Improving our understanding of PyrH will yield continued experimentation toward developing biochemical systems for targeted new halogenation pathways.

94
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Funding: USFA-NIFA
Project Category: Biological and Life Sciences

The wettability properties of creosote treated wood ties

Wood is renewable and an environmentally friendly construction material; however, it is susceptible to damage from environmental influences. Creosote, a coal-based chemical, is often used to protect wood against water damage, fungi, and insects, making it an effective method to reduce potential damage. It is currently restricted to use in railroad ties and utility poles. There is insufficient data on the behavior of different creosote-treated wood species in response to various environmental conditions, including rain and humidity. This research investigates the wetting properties of various wood tie species treated with creosote over time. One way to measure the effectiveness of creosote treatment against potential water absorption is by measuring wettability. The wetting angle, the angle between the wood surface and a water droplet, indicates this. The wetting angle is governed by the ratio of surface tension of the liquid to the surface energy of the solid surface. If the wetting angle is more than 90°, it means that only a small amount of water has been absorbed into the wood. If the angle is less than 90°, it means either the surface area doesn't have the surface tension to support droplet formation, or a significant amount of water has been absorbed by the wood. By comparing the wetting angles of untreated and treated wood species, it can be determined which species demonstrates the greatest hydrophobic behavior (low surface energy). The creosote treatment was imparted into the wood via a vacuum-pressure chamber. After curing the wood, water droplets were placed onto the tangential and radial surfaces of each wood specimen and the wetting angle was measured. Each sample demonstrated hydrophobic behavior, though some species of wood had higher wetting angles than others. Future research will explore the treated wood's resistance to pests, fungi, and weathering conditions, including UV light.

55
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Funding: ORED Undergraduate Research Program
Project Category: Social Sciences

An Empirical Evaluation of Suicide in the Construction Industry

Suicide in the construction industry is an important issue that has not gotten the attention it deserves from researchers. Mental health problems have been widely addressed in other industries but are still overlooked throughout construction. Multiple sources have shown evidence suggesting the suicide rate in the construction industry is up to three times higher than in other industries. This becomes more alarming when the sheer number of workers in the construction industry is considered. To gain a more developed understanding of the issue and insight into construction professionals' perceptions of suicide, a quantitative study was conducted in 2024. 73 participants from multiple companies took part in this study by answering questions online. From their answers, statistical software compiled data and concluded that suicide and its effects are thought to be not as serious as it is in the construction industry. The statistical software also highlighted pitfalls in identifying and preventing suicide within common construction practices. This study shows the need for professionals in both the construction and the psychology industries to come together and fight this problem.

20
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Project Category: Engineering

Small Image Source Classification Using a Convolutional Neural Network

Synthetically generated images such as those created by artificial intelligence programs can be difficult to tell apart from non-synthetic images. Convolutional neural networks (CNNs) are frequently used for computer vision tasks and may have applications in classifying images as synthetic. A CNN was trained using small image data and evaluated on its ability to correctly classify images as synthetic or non-synthetic. The CNN shows promising results on the test data, and strategies such as data augmentation were found to help boost accuracy and slow overfitting.

21
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Project Category: Engineering

Secure Authentication of Digitally Recorded Media in the Age of Deepfakes

The current capabilities of deepfake technology make it difficult to distinguish original media from fabricated media. PDFs have digital signature verification and authentication capabilities and are admissible in legal court, whereas IoT devices like police body and security cameras are vulnerable to deepfake manipulation and inadmissible in court. This research explores the hypothesis that digitally signing image and video data, similar to Adobe's eSignatures, could render them admissible in court. Our study employs a hardware cryptographic coprocessor integrated into security and police body cameras to create a digital signature of a SHA-256 hash of the image data and generate a public/private key pair using Elliptic-Curve Cryptography for validating the digital signature and hash. The process begins with the camera capturing picture or video data. Next, the cryptographic coprocessor hashes the data using SHA-256 to produce a 32-byte hash. This hash is then digitally signed with the private key in the cryptographic coprocessor. The digital signature and public key are subsequently added to the EXIF data of the image or video, which is then sent to storage or the cloud. To validate the image or video, the camera manufacturer's Public Key Infrastructure service uses the digital signature and public key to extract the data's original hash. The data is then hashed again using SHA-256. If the two hashes are identical, it confirms that the image data was not tampered with-validating and authenticating it as the original and not a deepfake. This method ensures the authenticity and integrity of image and video data, potentially qualifying it as credible evidence in legal proceedings. Our approach addresses a critical need in the justice system to combat the challenges deepfakes pose and could pave the way for enhanced trust in digital evidence, bolstering the integrity of the judicial process.

42
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Project Category: Physical Sciences

Use of a Novel Reagent for Installing a Methylidyne Ligand on Early Transition Metals

Developing iron-carbon multiple bonded complexes is important for improving catalytic processes such as Fischer-Tropsch synthesis. Previous studies have explored synthetic routes to achieve metal-carbon multiple bonds; however, Shrock type iron-carbon methylidynes have not been reported. Developing an effective transfer reagent for C-H is the first step towards achieving an iron methylidyne. In previous work, our lab used [N3N]MoCl as a model platform to test a new transfer reagent, lithiated methanoanthracene. Building on this work, the present study aims to install a methylidyne on a molybdenum complex and study the kinetics of the C-H transfer process. UV-Vis spectroscopy was used to probe the mechanism and determine the kinetics of the model reaction by tracking the formation of anthracene over time. To test the transfer reagent on another complex, ^{pyr}PNPMoI2 was chosen. Anthracene was seen in the NMR spectrum which suggests the methylidyne may be forming. Future studies will optimize this reaction and further investigate the formation of a methylidyne on ^{pyr}PNPMoI2. Additionally, ^{bistol}PNP ligand was used to synthesize Mo(III) and Mo(IV) complexes which have not yet been reported. Further characterization is needed to confirm the identity of the complexes before testing the transfer reagent. This project provided insight on the synthesis of metal-carbon multiple bonds and laid groundwork for future development of iron methylidyne complexes.

95
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Funding: College of Agriculture and Life Sciences URSP
Project Category: Biological and Life Sciences

Influence of a Proteasome Mutation on Cell Viability in Response to Protein Misfolding Toxins

Based on National Health Interview Survey data, around 8.5% of children aged 3 to 17 have some type of neurodevelopmental disability, such as autism spectrum disorder, attention-deficit/hyperactivity disorder (ADHD), or learning disability. These disabilities can include a mutation in the gene that encodes one of the proteasomes 26S subunits ATPase 5, PSMC5. The 26S proteasome is a highly ordered, multicatalytic protease complex composed of 2 complexes, a 20S core and a 19S regulatory subcomplex. In animal models, mutations of regulatory particle subunits eventually manifest as mental incapacity or lack of muscle function, resulting in total mental/physical degeneration. In humans, this would be characterized by Alzheimer's, Lou Gehrig's (ALS), and Parkinson's Diseases. Six unrelated children have a mutation of Proline 320 to Arginine (P320R) in PSMC5 and share neurodevelopmental delay and autism-like behaviors. A neuroblastoma line has been used with this mutation to examine the effects of protein misfolding stresses on cell viability. Protein misfolding stress is hypothesized to increase the load on proteasomes. Therefore, if this mutation compromises protein degradation, it is expected that this could serve as a good screening model for compounds that restore proteasome function and as a model of what might go awry in the development of neurons. Two different proteostatic stressors have been selected: hygromycin B, which inhibits protein synthesis, and canavanine, which is an amino acid analog of arginine and induces misfolding when incorporated into proteins. Surprisingly, it has been found that cells with the PSMC5 P320R mutation had greater resistance to these drugs. This result could point to unexpected therapeutic strategies and force us to look more closely at how protein degradation defects lead to neurodevelopmental delays.

43
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Project Category: Physical Sciences

Methylene Blue Adsorption of Treated Biochar Sourced from Lumber Gasification Waste

Southern Yellow Pine is a common and natural resource whose processed sawmill waste is often used in gasification. The consumer drive for effective and affordable contaminate adsorption material has spurred research as to the effectiveness of carbon sourced from southern yellow pine gasification waste. As an untreated waste product, this biochar shows poor adsorption characteristics. Physicochemical treatment methods of sonification in Sodium Hydroxide (NaOH) at a 50% concentration, and impregnation of 71% Sulfuric Acid (125 degrees Celsius for 1 hour) where investigated. Adsorption kinetics and equilibrium were determined through observation of various methylene blue (MB) concentration solutions and monitored for 1 week. Treatments were deemed effective and enhancing adsorption capacity. It is commonplace for similar equilibrium studies to determine equilibrium at 48 hours, however at 1 week it was shown that biochar had adsorbed additional methylene blue since its 48 hour time interval. Therefore, 48 hours is insufficient time to assume equilibrium of adsorption. These findings underscore the potential for optimizing biochar treatment processes to improve adsorption efficiency and meet the increasing demand for high-performance contaminant absorption material

96
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Project Category: Biological and Life Sciences

Studying the impact of cover crops on rhizosphere bacterial communities under corn production systems: Using Bioinformatics tools to compare microbiome assembly.

Recent advancements in the analysis of amplicon sequence datasets have catalyzed a methodological transition in microbial biodiversity research. This shift moves away from sequence identity-based clustering, which generates Operational Taxonomic Units (OTUs), towards denoising techniques that produce Amplicon Sequence Variants (ASVs). The ASV-based DADA2 and the OTU-based MOTHUR pipeline are two widely used sequence-processing methods for analyzing the diversity, ecological and compositional patterns of bacterial communities. DADA2 allows sequence variation to be identified by a single nucleotide change enabling minuscule variations to be found. In contrast, MOTHUR clusters similar organisms together into one sequence creating focus on larger variations. The rhizosphere microbiome, which consists of microbial communities residing in the plant root zone, is crucial for modulating plant growth, nutrient acquisition, and stress tolerance. In our study, we utilized an amplicon sequence dataset derived from soil samples collected within cover crop-corn production systems to investigate these microbial communities' diversity and compositional patterns. By employing these two bioinformatics pipelines on this data, we reveal the influence of two widely used sequence processing methods, namely the ASV-based DADA2 and the OTU-based MOTHUR pipeline, on the diversity patterns of the bacterial communities in cover crop corn production systems. The analysis revealed significant differences in read counts between the two pipelines. Specifically, the OTU-based pipeline yielded 7,113,561 counts, whereas the ASV-based pipeline produced 6,703,699 counts. Additionally, the average read counts per sample were significantly different, with 84,685 OTUs and 79,805 ASVs. We evaluated the impact of each methodological choice on alpha and beta diversity, as well as taxonomic composition. The selection of the pipeline had a substantial effect on both alpha and beta diversities.

44
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Project Category: Physical Sciences

Quantifying Tornado Outbreak Intensity and Frequency Relationships with Interannual and Intraseasonal Variability

Tornado outbreaks (TOs) are a highly dangerous meteorological phenomena common to the United States that have limited known relationships to climate variability. Many of the challenges of understanding TOs result from a lack of formal TO quantification (both in definition and impact). We present a TO definition based on a spatially cohesive and distinct region of tornado activity and present a TO intensity index using tornado characteristics within the TO region. In developing this index, we present a support vector regression based detrending methodology to remove secular trends within tornado reporting. The resulting TO definition suggests a decline in TO activity of roughly 1 TO per 4-5 years, with a similar decline in TO intensity. In addition, the relationship between this new quantification of TOs and common North American interannual and intraseasonal climate variability indices is explored, namely the El Niño Southern Oscillation, the North Atlantic Oscillation, the Arctic Oscillation, and the Pacific North American Oscillation. In general, the links between these teleconnections and TO frequency and intensity were minimal (and sometimes in opposition when comparing TO frequency and intensity), but interesting patterns emerged that may offer an initial pathway to exploring longer-term TO predictability.

97
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Project Category: Biological and Life Sciences

The Effect of Viscosity on Dynamic Light Scattering Nanoparticle Measurements

Nanoparticles open a world of possibilities for the medical field due to their biocompatibility and performance. Liposomal nanoparticles are particularly valuable due to their ability to encapsulate nutrients, RNA, or drugs and effectively deliver them within the human body. This process can be hindered when proteins in human serum bind to the surface of nanoparticles, altering the nanoparticle's properties and triggering the host's immune response. The hydrodynamic diameter (D_H) reflects how a particle diffuses within a fluid and indicates its effective size in a biological solution. Dynamic Light Scattering (DLS) is a technique commonly used to measure nanoparticle D_H, but its accuracy depends on knowing the solution's dynamic viscosity. Despite this fact, many researchers fail to incorporate correct viscosity values into their DLS workflow. We explored how the viscosities of human serum dilutions (5% to 100%) affect apparent liposomal nanoparticle sizes. We discovered that failing to correct viscosity values can inflate the presumed D_H of nanoparticles by more than 20%. This finding reinforces the importance of correcting for parameters like viscosity and refractive index in DLS measurements. The sizes of nanoparticles influence their utility, and when precise values are integrated into studies, we can more reliably correlate nanoparticle size with their safety and efficacy.

98
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Funding: NSF REU: Forestry REU.
Project Category: Biological and Life Sciences

Geographic Variations in Biomass Partitioning of Loblolly Pine (*Pinus taeda*)

Quantifying forest biomass is crucial for understanding forests' potential to mitigate climate change. Information about how biomass is distributed among different tree parts also provides valuable insights for wildfire models. Total and component biomass levels are influenced by numerous factors, including geographic location. Yet, current modeling approaches often overlook the geographic variations in biomass partitioning, contributing to uncertainties in model outcomes that rely on these estimates. This study addresses these challenges by investigating reliable techniques to quantify the geographic variations in biomass partitioning for loblolly pine (Pinus taeda) trees in the southern United States. We utilized Dirichlet Regression models incorporating predictors such as diameter at breast height (dbh), tree height (tht), latitude (lat), and longitude (lon) to analyze how biomass proportions are distributed among stem wood, stem bark, branches, and foliage. Our findings reveal significant effects of dbh and tht on biomass distribution among tree components. The inclusion of spatial predictors like lat and lon significantly enhanced model accuracy, thereby reducing prediction errors and improving precision in biomass component estimation. Notably, foliage proportions exhibited substantial variation with latitude, while longitude predominantly influenced bark proportions. Branch proportions varied significantly with both latitude and longitude, underscoring the spatial complexity of biomass distribution in loblolly pine forests.

99
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Project Category: Biological and Life Sciences

Molecular cloning of UGT34, a silk-gland specific gene in the corn earworm

The corn earworm, *Helicoverpa zea*, is a moth damaging many important agricultural plants, such as corn, cotton, and soybean. Although farmers use pesticides to combat this rampant pest, the corn earworm has developed resistance to these toxic chemicals. Insects have evolved to have many detoxification pathways one in particular involves a multigene family of enzymes responsible for catalyzing glycosylation of small hydrophobic molecules known as uridine diphosphate glycosyltransferase (UGT). In humans, it plays a role as an enzyme within the liver that modifies bilirubin into a compound that can be excreted from the body through bile, and it can also allow certain medications, hormones, and toxins to be non-threatening. Recently, the corn earworm genome was analyzed, identifying 45 UGT genes. In this study we focused on the UGT34 gene, which is uniquely found in the silk gland, a tissue that is not commonly associated with detoxification. The main goal of this study is to amplify the UGT34 gene in the corn earworm larva using polymerase chain reaction (PCR), verifying PCR product by gel electrophoresis and gel extraction, carefully inserting the UGT34 gene into the pIB/V5-His expression vector, and finally cloning by transformation into *E. coli* cells. The recombinant plasmids produced from this study can be further utilized in future research such as sequencing and establishing Sf9 insect cell lines.

22
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Project Category: Engineering

Microparticle drug delivery for the release of punicalagin in the treatment of osteoarthritis

Punicalgin (PCG), a polyhenolic ellagitannin that is found in pomegranate (Punica grunatum L.), has been investigated as a potential disease-modifying osteoarthritis drug (DMOADs) due to its potent antioxidant and anti-inflammatory properties. In the context of osteoarthritis (OA) treatments, polymeric drug delivery systems have been investigated as a method for utilizing the therapeutic benefits of drugs like PCG. Both polycaprolactone (PCL) and poly(lactic -co-glycolic acid) (PLGA) have been utilized for situ forming microparticle drug depots, but not for the intra-articular route of delivery. We hypothesize that in situ forming PCL-PLGA microparticles could slowly release PCG and suppress inflammation within the joint. We are exploring in situ forming microparticle systems using dioxane as a solvent and sesame oil as an emulsifier. The purpose of this study is to investigate the effect of PCL:PLGA ratio on microparticle size and morphology, as well as PCG loading efficiency and release kinetics. Early results indicate that a higher proportion of PCL is associated with smaller particles, higher loading efficiency, and extended time to release PCG

45
Name: Vane, Lindsey
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Funding: NSF REU: Chemistry
Project Category: Physical Sciences

Assessing Engineered Biochar for Effective Phosphate Capture in Agricultural Runoff

Fertilizers have long been an integral part of the agricultural world and domestic lifestyles. However, the engineering of fertilizers with more bioavailable contents of nitrates and phosphates in the early 1900s has contributed to the increased eutrophication of aquatic environments. Biochar, a coproduct of the pyrolysis of biomass, has been engineered to adsorb phosphates. Its porous chemical structure and high surface area are key factors in accounting for its ability to adsorb desired elements. Through the introduction of a heavy metal solution and strong base to raise the pH, the biochar forms layered double hydroxides that allow for anion exchange to occur and entrap phosphate ions within the structure. In 2022, a combination of biochar and slag, a gravel-like co-product of recycling steel, was placed in existing gullies along a portion of Catalpa Creek, which runs through a dairy farm in Starkville, MS. Designed to capture phosphates in stormwater runoff, these now called bioreactors have since been tested yearly for phosphate concentrations. In the two years following their installment, the phosphate capacity of the biochar in the bioreactors decreased, signifying the successful uptake of phosphates from the environment. We hypothesized that the phosphate capacity of the biochar in the bioreactors will continue to decrease due to an approach of the maximum phosphorus capacity. All samples were analyzed using an ICP-MS, and the data showed a significant decrease in maximum capacity between the 2023 and current 2024 samples. Furthermore, the data indicated that the bioreactors reach their maximum capacity in the field after approximately three years.

46
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Project Category: Physical Sciences

Development of a Simulation Tool to Study Secondary Electron Emission in Copper Coated with Graphene

Secondary electron emission (SEE) arises from the interaction of high-energy particles with metallic surface materials. The emission of electrons from copper surfaces can be problematic in a variety of applications, such as parandaccelerators or microchips operating in spacecraft. Emitted electrons can build up in accelerator walls, reducing the accuracy of the experiment. SEE in microchips can flip logical bits, create unwanted heat, and reduce the device's lifespan. In recent years, graphene has been proposed as a potential moderator to prevent or mitigate these effects. Graphene can be applied in layers on top of a copper substrate to reduce the secondary electron yield (SEY): the ratio of emitted secondary electrons to total incident electrons. The focus of this investigation has been to simulate the SEE process in copper and to obtain its SEY at various energies of incident primary electrons. Monte Carlo methods, such as the continuous-slowing-down approximation and numerical integration schemes, have been used to generate and track secondary electrons within the copper. The simulation generates secondary electrons from primary electron interactions consistent with existing material models. The positions and energy losses of the secondary electrons are updated using Mott's cross-section formula and the stopping power, respectively. Electrons' paths are then propagated until their energy falls below a prescribed threshold or the electron is emitted from the surface. Simulations have successfully reproduced SEY results for copper with and without graphene surface layers for an incident electron energy range of 60 eV to 1000 eV. The results show that the SEY of the copper with graphene layers is reduced by 20% compared to the SEY of pure copper.

47
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Project Category: Physical Sciences

Alkylidyne Molybdenum Formation from Lithiated Transmetalation: A Computational Insight

Alkylidyne complexes have garnered significant interest for advances in catalysis in various industrial processes, such as Fischer-Tropsch synthesis and alkyne metathesis. Recently, the alkylidyne complex [N3N]MoCH was synthesized by reacting [N3N]MoCl with lithiated methanoanthracene. Despite the structural similarity between norbornadiene and methanoanthracene, as well as the overall exergonic nature of the reactions, the reaction only proceeds experimentally with lithiated methanoanthracene. To shed light on this transformation, which involves multiple spin states of various short-lived intermediates, we report a computational study elucidating the structure-reactivity relationship of lithiated cyclic reagents. The reaction proceeds through a transmetallation step followed by an endergonic carbon transfer. The carbon transfer is expected to occur via a stepwise mechanism, breaking two C-C bonds separately. The short-lived intermediate after transmetallation can potentially be observed through absorption spectroscopy; thus, simulated spectra and Natural Transition Orbital (NTO) analysis are performed for reference. The proposed mechanism from the computational results suggests a switch in spin states from triplet to singlet during the reaction. We extend our study by examining the reaction between a molybdenum complex with a pyridine-based PNP pincer ligand (PNP = 2,5-bis(di-tert-butylphosphinomethyl)pyrrolide) and lithiated methanoanthracene.

48
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Funding: USDA NIFA REEU Program
Project Category: Physical Sciences

Southern Yellow Pine Particle Board Manufactured with the Inclusion of Dried Distillers Grains with Solubles and Microcrystalline Cellulose

Particleboard is a composite wood product that is widely used in the furniture industry and produced in large quantities. Traditionally, particleboard is made with southern yellow pine (SYP), but this study aims to incorporate various rates of additives such as distiller's dried grains with solubles (DDGS), a more economically efficient feedstock alternative, and microcrystalline cellulose (MCC), an additive filler. This study also aims to analyze the efficacy of DDGS to determine if it can be used as a substitute feedstock in particleboard. Six boards measuring 30 inches by 30 inches were produced with varied levels of DDGS and MCC. The boards include a control board (pure SYP), a 1% MCC board, a 2% DDGS board, a 1% DDGS and 1% MCC board, a 5% DDGS and 1% MCC board, and a 25% DDGS board. The objective of incorporating these additives is to evaluate the overall effects of DDGS and MCC on the internal bond strength, water absorption, thickness swelling, modulus of elasticity (MOE), and modulus of rupture (MOR) of SYP particleboard.

23
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Funding: USDA
Project Category: Engineering

Survey of AI in Agriculture

The field of artificial intelligence was first introduced in 1956 at a Dartmouth workshop, with sporadic but continued research throughout the second half of the 20th century. With the advent of new methods and new processor technologies, research in artificial intelligence and machine learning has dramatically increased over the past 10 years. The field of agriculture is one of the areas where the growth has been dramatic. While studies about the use of AI in other areas, such as language recognition, language generation, visual recognition and medical scan detections has been studied and reviewed, the agricultural field has not been systematically studied and surveyed even though the research has increased rapidly inline with other fields. Current topics of research range from pH content in soil, to monitoring the paths bumble bees take in order to best fit the hive, to anything in between. Between 2022 and 2023, there has been nearly a 40% increase in published papers studying AI in agriculture. Additionally, 2024 is predicted to have a nearly 75% increase over 2022. This study examined the rates of publication of articles that are based on Artificial Intelligence and Machine Learning related techniques in agricultural fields. Specifically, the study examined the publications since 2017 of three journals Computers and Electronics in Agriculture, Smart Technology, and Biosystems Engineering, as well as world wide patent publications since 2015 in the CPC Patent Classification for agriculture. The results year to year show increases in AI and machine learning in all countries and specific agricultural-related technology areas. This work will be used for an in-depth review of AI and machine learning usage in agriculture.

49
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Funding: NSF REU: REU-INFEWS
Project Category: Physical Sciences

Depolymerization of Waste Plastics with a Cationic Ruthenium Complex by Hydroboration

Plastics are incredibly useful in modern society because of their broad range of physical properties and their low cost to produce. However, their persistent nature and limited recyclability has led to the accumulation of plastic waste in the environment. To address these challenges, this study proposes a method of recycling polyesters and polycarbonates using an organometallic catalyst of ruthenium (Ru^{II}) and different hydrogen sources (boranes, silanes, H_2). Assessed polymers include polycaprolactone, polylactic acid, polyethylene succinate, polydioxanone, and polypropylene carbonate. To conduct the experiment, each polymer was dissolved in chloroform, mixed with the catalyst and reductant, and reacted under mild conditions. Monitoring of the reactions via ^{1}H and $^{13}C\{^{1}H\}$ NMR confirmed depolymerization by hydroboration, while product analysis using NMR and GCMS showed the transformation to borylated alcohols in good yields. The obtained boron-containing products are functional and attractive building blocks employed in organic synthesis.

24
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Funding: NSF REU: Intelligent Edge Computing Systems (iEDGE)
Project Category: Engineering

Performance Differences between Real-World and Lab Deployments of Real-Time Edge Stream Processing for Critical, Time-Sensitive Areas

When developing computing applications in critical high-stakes environments such as healthcare or transportation, every second counts. Though powerful, its extreme latency and delay renders cloud computing impractical for these efforts, so attention is instead turned towards edge computing, the field of processing data directly inside or near these environments rather than on a faraway cloud server.
Due to convenience and ease of use, most edge computing software is developed and tested inside a virtual machine (VM) on a workstation, but this does not reflect their actual, real-life deployment. In our research, we compared the differences between Raspberry Pis and VMs with regards to their latency and other performance benchmarks in order to better understand differences that arise in a realistic Raspberry Pi deployment versus an idealized VM deployment. Our software consists of using Apache Storm for real-time data streaming and the RIoT Bench system for data processing, as well as Docker and Kubernetes for scalability, error handling, and consistency across different software environments. Results indicate that there exists a difference in latency and data throughput between Raspberry Pis and VMs. Though the performance of both start off being similar to each other, as the amount of data that needs to be processed is increased, the Raspberry Pis' performance decreases significantly more than the performance of the VMs does.
These findings indicate that edge computing applications developed on a VM may not have the expected performance when deployed in the real world on small, economical devices like a Raspberry Pi, as utilizing a normal everyday computer for hundreds of thousands of edge computing applications is unviable. As a result, further research into this variability, as well as ways to reduce the latency, is necessary in order to ensure that applications perform as expected in environments where time is of the essence.

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