The 19th Annual

2024 RESEARCH & CREATIVE INQUIRY DAY

Tennessee TECH

tntech.edu/research/research-day

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Preface

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U.S. House of Representatives Resolution

H. Res. 1654

IN THE HOUSE OF REPRESENTATIVES, U. S.
NOVEMBER 16, 2010

WHEREAS, close to 600 colleges and universities in the United States and thousands of undergraduate students and faculty pursue undergraduate research every year, providing research opportunities that will shape the trajectory of students' lives and careers and researchers' and institutions' purpose and contributions to academia and the research enterprise;

WHEREAS, students and faculty engaged in undergraduate research contribute to research across many disciplines, including arts and humanities, biology, chemistry, health sciences, geosciences, mathematics, computer science, physics and astronomy, psychology, and social sciences;

WHEREAS, research at the undergraduate level provides both students and faculty members opportunities for improving and assessing the research environment at their institution, develops critical thinking, creativity, problem solving, and intellectual independence, and promotes an innovation-oriented culture;

WHEREAS, undergraduate research is essential to pushing the Nation's innovation agenda forward by increasing the interest and persistence among young people in the crucial science, technology, engineering, and mathematics (STEM) disciplines, and to cultivating the interest of would-be researchers who pursue a new aspiration of graduate education after participating in undergraduate research; and

WHEREAS, the week of April 11, 2011, would be an appropriate week to designate as "Undergraduate Research Week." Now, therefore, be it

Resolved, That the House of Representatives—
supports the designation of "Undergraduate Research Week";
(1) recognizes the importance of undergraduate research and of providing research opportunities for the Nation's talented youth to cultivate innovative, creative, and enterprising young researchers,

in collaboration with dedicated faculty;
(3) encourages institutions of higher education, Federal agencies, businesses, philanthropic entities, and others to support undergraduate research and undergraduate researchers and their faculty mentors;
(4) encourages opportunities, including through existing programs, for females and underrepresented minorities to participate in undergraduate research; and
(5) supports the role undergraduate research can and does play in crucial research that serves the Nation's best economic and security interests.

Attest: *Clerk.*

National Medal of Technology & Innovation

The National Medal of Technology and Innovation is the nation's highest honor for technological achievement, bestowed by the President of the United States on America's leading innovators.

The medal is awarded annually to individuals, teams, companies or divisions of companies for their outstanding contributions to America's economic, environmental and social well-being. The purpose of the National Medal of Technology and Innovation is to recognize those who have made lasting contributions to America's competitiveness, standard of living, and quality of life through technological innovation, and to recognize those who have made substantial contributions to strengthening the nation's technological workforce. By highlighting the national importance of technological innovation, the medal is also meant to inspire future generations of Americans to prepare for and pursue technical careers to keep America at the forefront of global technology and economic leadership.

Established by the Stevenson-Wydler Technology Innovation Act of 1980, the medal was first awarded in 1985. The first National Medals of Technology were also issued in 1985; among the first recipients were technology giants Steve Jobs and Stephen Wozniak, founders of Apple Computer. The America COMPETES (Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science) Act of 2007 amended Section 16 of the Stevenson-Wydler Technology Innovation Act of 1980, to change the name to the "National Medal of Technology and Innovation."

The National Medal of Technology and Innovation is the work of medalist and sculptor Mico Kaufman. The obverse side depicts the technologist as something of a modern "wizard," with a concentrated beam bouncing off the palm of his hand, representing the input and the output of technology and of the innovation process. On the reverse is an eagle clutching an olive branch and arrows encircled by the inscription "AWARDED BY THE PRESIDENT OF THE UNITED STATES OF AMERICA."

https://www.uspto.gov/learning-and-resources/ip-programs-and-awards/national-medal-technology-and-innovation-nmti

Foreword

Welcome to the 2024 Research and Creative Inquiry (RCI) Day. This is the 19th annual RCI Day where students will once again have an opportunity to showcase their research, scholarship, and creative talents for a campus-wide audience. College education is a game changer, where students traditionally learn the knowledge and skills for a career. However, the most valuable knowledge and skills for students to learn today are no longer concepts and formulae in the textbooks, but how to learn and how to solve problems. Problem-solving and effective communications are perhaps the two most important qualities students must gain to become effective as the next generation of society leaders, scientists, engineers, educators, artists, doctors and nurses, among various other professions. Research is exactly such a platform for students to gain hands-on experience, involving leadership, project planning and execution, collaboration, critical thinking, problem-solving, and verbal and written communication.

To our students, I commend you on your participation in research in the past year, and your sharing of that experience and research results with the campus community. For many of you, this may be the first time you make a public presentation, but as you will realize later in your career, it is this day that marks the start of your professional career. While congratulating you on your research achievements to date, I also challenge you to grasp every opportunity to gain skills of problem-solving and effective communication, not only within your field of study, but also in interdisciplinary and transdisciplinary fields. As the pandemic finally tails off, the world is still facing grand challenges related to matters of human health, the environment, climate change, natural resource sustainability, food security and safety, clean and renewable energy, cyber and national security, poverty and world peace, among many other challenges. In addition, rapid technology advances are having an impact on real-world situations. These challenges are waiting for you, as leaders of tomorrow, to meet.

To our faculty and staff, and the campus community in general, I thank you for your mentoring and supporting our students with their research activities. Please participate and show support to our students. Your presence, engagement, and interactions with students on this RCI Day mean so much to students and their families. Please also let the RCI Day be the new beginning of greater levels of research and collaborations; be creative in offering opportunities of experiential learning, discoveries and innovations.

We most certainly need to acknowledge the Center for Career Development and their efforts in providing resumé-critiquing services. They also extended invitations to employers/recruiters looking to hire capable, confident, and well-educated Tech interns and graduates. RCI Day affords students with a tremendous opportunity to share a great story with potential employers.

I want to thank everyone involved in the planning and preparation for the RCI Day from logistical support to generating posters and presentations. We should all recognize and applaud the judges tasked with reviewing and scoring presentations. I would like to thank our staff from the Office of Research and Economic Development, as well as volunteers and supporters from various colleges and schools, units, and offices, who worked hard in making this RCI Day a great success.

Congratulations to all presenters, their co-workers and mentors who have worked diligently and with a zealous passion to prepare presentations that demonstrate the breadth of Tech's commitment to academic excellence. We look forward to the visibility that students will receive as RCI Day highlights exciting developments and breakthroughs.

And as Research and Creative Inquiry events get underway, WINGS UP!

Dr. John Liu
Vice President for Research
On behalf of the **Tennessee Tech Research & Economic Development Team**

Special Appreciation & Acknowledgments

Tennessee Tech Offices, Departments and Staff

Center for Career Development

Exercise Science

Information Technology Services

Library Services

Office of Creative Inquiry/QEP

Office of Enrollment and Communication

Printing Services

Research and Outreach Center

Student Services

We would like to extend a special thanks to **Kristen Deiter,** associate professor of English, for coordinating the paper portion of the event; **Holly Mills,** assistant professor in the Volpe Library, for providing poster-design resources; and the Center for Career Development for providing resumé critiquing and opportunities to network with potential employers.

We also wish to acknowledge **David and Sherri Nichols** for their endowment to support student research and creative inquiry.

The 19th Annual Research and Creative Inquiry Day

Schedule of Events

Wednesday, April 17

11 a.m. – 3 p.m. — **Student Registration & Poster Setup**
Memorial Gym

Students are invited to be available to discuss posters. Light snacks will be served.

Thursday, April 18

9 a.m. – 11 a.m. — **Poster Display for Campus and Community**
Memorial Gym

Students are invited to be available to discuss posters. Light snacks will be served.

The Center for Career Development will be offering a resumé critiquing opportunity. Several employers will be available for potential networking.

11 a.m. – Noon — **Awards Ceremony**
Memorial Gym

Noon – 2 p.m. — **Poster Pickup/Cleanup**
Memorial Gym

STATE OF TENNESSEE

PROCLAMATION

BY THE GOVERNOR

WHEREAS, graduate education attracts over 48,000 students nationally and internationally to Tennessee universities, awards over 14,000 degrees annually, and contributes to the economic growth and stability of the state, generating more than $1.1 billion in economic impact; and

WHEREAS, graduate education is an essential part of developing the workforce in highly specialized, technical, and licensed professions; and

WHEREAS, graduate education in Tennessee is enhanced by assistantships and involvement with local organizations and businesses that participate in the advancement of resources to the community and to the public; and

WHEREAS, Tennessee graduate students and graduate education across the state have helped increase the earning power of Tennessee citizens, have attracted new businesses and creative ideas such as artificial intelligence, neuroscience, the arts, biomedical engineering, nanotechnology, information technology, literacy, materials science, and children's health; and

WHEREAS, Tennessee's graduate faculty and students engage in internationally-recognized scholarship, producing a significant body of research that contributes to the broad base of knowledge essential for advancing the well-being of the state; and

WHEREAS, alumni from Tennessee graduate schools occupy leadership roles in school systems, institutions of higher learning, health-related institutions, business, government, and politics; and

WHEREAS, Tennessee universities have recognized the strengths and contributions of a culturally diverse student body, and as a result attract student scholars from diverse backgrounds interested in pursuing graduate education;

NOW, THEREFORE, I, Bill Lee, Governor of the State of Tennessee, do hereby proclaim the week of April 1-5, 2024, as

Graduate Education Week

in Tennessee and encourage all citizens to join me in this worthy observance.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the official seal of the State of Tennessee to be affixed at Nashville on this fourth day of March, 2024.

Bill Lee

Governor

Tre Hargett

Secretary of State

Abstracts

College of Agriculture & Human Ecology

School of Agriculture

Agriculture

Undergraduate Students

Impact of Volunteerism on Social Behavior

Primary Author: Tamara Heath, S.L. Officer Endowed Scholarship in Agriculture

Collaborator: Sheridan Roberts

Faculty Advisor: Dennis J. Duncan, Ph.D., Agriculture

Tennessee Technological University students with the School of Agriculture participated in a study abroad trip to Dumfries, Scotland, in the Fall of 2023 to research and contribute to the fight against food insecurity at Summerhill Community Center. Volunteerism was a recurring theme in the operations at Summerhill. This study sought to analyze the culture of volunteerism and its intersection with interpersonal relationships and social interaction. The data collected and analyzed is expected to further promote the mutualistic nature of volunteerism and personal development while exploring a community center that features a synergic structure. Although the Community Center is under the supervision of a manager, the different components are led by each group of individuals involved and given responsibility, creating its unique structure. The students traveled abroad intending to bring back qualitative data in the form of audio-recorded interviews and personal reflections. Based on the research conducted and analysis of the data in this study, there is a positive correlation between the social exposure at Summerhill and the motivation to volunteer. For example, when asked how the community center has impacted her life, one volunteer said, "[Summerhill] has really lifted me." Summerhill is a micro example of community-based social opportunity that promotes volunteerism, boosts mental health, and builds morale between volunteers and participants at the Community Center.

Enhancing Student Behavior through Outdoor Learning: A Cross-Cultural Examination

Primary Author: Sophie Helton

Co-author: William Massey

Faculty Advisor: Dennis J. Duncan, Ph.D., Agriculture

This study examines the correlation between student's behavior and time spent learning outdoors. Two primary schools were studied in the fall of 2023 -- St. Andrews Primary in Scotland and Jere Whitson Elementary in Cookeville, Tennessee. Data was collected through observations, surveys, and behavioral assessments. Jere Whitson has 314 students from pre-k to fourth grade, and nearly 79% are minority students. Gender distribution is 51% female and 49% male. St. Andrew's Primary in Dumfries, Scotland, serves 245 students from Nursery to Primary 7, with 56% male and 44% female students. Both schools offer outdoor learning opportunities. St. Andrew's uses a woodland area; Jere Whitson Elementary's outdoor learning lab features a greenhouse, raised gardening beds, and an outdoor classroom pavilion. Factors such as increased physical activity, exposure to nature, and hands-on learning experiences emerged as pivotal contributors to the observed enhancements in student behavior. For example, students who actively engage in outdoor experiential learning demonstrate greater attentiveness and respect in the classroom environment. They exhibit minimal disruptive behavior and display exemplary conduct compared to their less-engaged peers. Outdoor learning fosters creativity, enhancing students' ability to maintain focus and attentiveness during educational activities. These findings underscore the significance of integrating outdoor learning experiences into educational frameworks.

Agriculture Business

Undergraduate Student

How an Outdoor Learning Environment Impacts Teachers and Students

Primary Author: Jessica Delong

Co-author/Collaborator: Caroline Norris, Biology

Faculty Advisor: Dennis J. Duncan, Ph.D.

In 2023, students from Tennessee Technological University's School of Agriculture traveled across the pond to Dumfries, Scotland, to research how outdoor learning areas are used in Scotland. Information was gathered via personal interviews and qualitative surveys from the teachers at St. Andrew's Primary School. St. Andrew's is a Roman Catholic public school consisting of 245 children located in the heart of Dumfries. This data has provided insight into the usage of their outdoor learning area and how they believe it could be improved. Tennessee Tech students analyzed different aspects of the outdoor learning area, known as the Woodlands, while interacting with the school teachers during school hours. In the Woodlands, the children have access to various learning opportunities. For example, a teacher taught geometry by creating pictures with two lines of symmetry using natural materials. The Tennessee Tech students evaluated how the school utilizes the outdoor learning area by sending a survey to the teachers who would like to improve the space. Based on the data collected from the teachers, there is a desire for outdoor learning opportunities and resources. The data shows ways to implement math, science, and reading into the outdoor learning area, such as measurement, tree identification, and poetry. Tennessee Tech students are currently analyzing the remaining data from the St. Andrew's Primary School teachers.

Agriculture Communications

Undergraduate Student

Critical Thinking Dispositions of Students in the School of Agriculture

Primary Author: Sheridan Roberts

Co-author/Collaborator: Dennis J. Duncan, Ph.D., Agriculture

Faculty Advisor: Dennis J. Duncan, Ph.D., Agriculture

Renowned scientist and Nobel Prize winner Albert Einstein famously said, "Education is not the learning of facts, but the training of the mind to think." Almost all universities would presumably agree with such revelations as they attempt to foster an environment where critical thinking is pursued and prioritized. This study seeks to understand if Tennessee Tech University's school of Agriculture is successful in this attempt. The agriculture department at Tech is strategically designed to prepare students for careers through lecture, lab, and hybrid courses. Conceivably, this data will evaluate the critical thinking practices at universities like Tennessee Tech and contribute to adjustments that will refine such programs. The students reported both on the importance of critical thinking and their individual competencies as related to engagement, cognitive maturity, and innovativeness. At the beginning of the study, students reported both high levels of importance and competency for only one statement: "I strive to be well-informed." The students placed a higher level of importance on the statement "I look for opportunities to solve problems" after three years. The intention behind this research was to discover statements where students place the most importance and feel the most competent before and after their time as Tennessee Tech School of Agriculture students.

Agriculture Education

Undergraduate Student

The Impact of Volunteerism on Mental Health

Primary Author: Briona Agee

Co-author/Collaborator: Kallie Renner

Faculty Advisor: Dennis J. Duncan, Ph.D., Agriculture

The conversation surrounding mental health is slowly becoming less taboo. Moreover, it has become a topic people care about and invest in. In October of 2023, several students from the Tennessee Tech College of Agriculture flew across the pond to Scotland to study food insecurity and agriculture. While there, we volunteered with a local community center, Summerhill. On top of the want to help, we conducted several interviews with participants and volunteers of the community center. We really wanted to answer one key question: what makes people volunteer? Upon extensive interviewing, an interesting discovery was made. We found that many of the volunteers at the community center had struggled with their mental health, and many of them had seen a significant positive impact on their mental health since they began volunteering. For example, one interviewee, who struggled with Post Traumatic Stress Disorder, even referred to volunteering there as his therapy saying, "if my brain is active, I am happy." Though there were many reasons the volunteers of Summerhill gave their time, mental health was certainly an underlying theme amongst many. We wanted to

expand on that discovery within this research project and truly assess the effects of volunteerism on mental health.

Animal Science

Undergraduate Student

The Effects of Biochar as a Litter Amendment in on Broiler Growth Performance and Litter Quality

Primary Author: Antonio Fuentes Garcia, Oliver J. Hubbard Memorial Poultry Science Scholarship

Co-authors/Collaborators:
Pat Sherren, Metzler Forest Products, LLC.
Jerry Stutzman, Bio Carbon Solutions, LLC.
Nelson Peachey, Wakefield Farm

Faculty Advisor: Victoria Ayres, Agriculture

The objective of this study was to investigate the efficacy of biochar as a litter amendment on broiler growth performance. A total of 1,104 Cobb 500 by-product male chicks were obtained from a local hatchery, weighed, and divided into groups of 23 chicks. Each group was then placed in one of 48 floor pens, varying in litter material and biochar application. The six litter treatments were as follows: 1.) fresh pine shavings without biochar, 2.) fresh pine shavings with a single application of biochar (12 yd3/20,000 ft2), 3.) built-up pine shavings without biochar, 4.) built-up pine shavings with a single application of biochar (12 yd3/20,000 ft2), 5.) built-up pine shavings with an application of biochar once per week (1 yd 3/20,000 ft2), and switch grass with biochar premix (0.708 yd3/20,000 ft2). Broiler performance metrics measured included: d0 starting pen weight, d10, 21, and 35 bird weights, bird feed intake (FI), live weight gain/bird (LWG), mortality corrected feed conversion ratio (FCR), and percent mortality. Treatments were arranged in a randomized complete block design. Broiler performance metrics including FI, LWG, FCR, and percent mortality did not differ between treatments ($P > 0.05$). Therefore, the use of biochar as a poultry litter amendment does not affect d0-21 broiler performance.

Environmental Agriscience

Undergraduate Student

Fertilizer N Management Effects on Dry Matter Yield in Mixed Species Hay Production

Author: Ali Bledsoe, 2023 CISE Recipient

Faculty Advisor: Michael Nattrass, Agriculture

Urea is a common fertilizer nitrogen (N) source used in TN hay production. Urea fertilizers are susceptible to environmental loss through ammonia volatilization. Urea stabilized with Agrotain and Environmentally Smart Nitrogen (ESN), a controlled release fertilizer, are alternatives for minimizing N loss, but may delay N availability during early season plant growth. This research aims to evaluate untreated, stabilized, and controlled release urea fertilizer blends for optimizing hay yield. The experiment was designed a randomized complete block containing seven fertilizer N treatments and a control (0 N) (n=8). Fertilizer N treatments were applied at 56 kg ha-1 untreated urea (UR: 100%), UR+Agrotain (AGRO:100%), ESN (100%), UR+AGRO (50%:50%), UR+ESN (50%:50%) AGRO+ESN (50%:50%), or UR+AGRO+ESN (33%:33%:33%) with six replications. At 56 d after fertilization, plots were harvested and dry matter yield (DMY) determined. Treatment means were subject to analysis of variance using PROC GLM a=0.05 (SAS v9.4). The data was pooled and when compared to the control (1709 kg ha-1), fertilizer N treatments increased DMY ($P < 0.0001$) with yields ranging between 2266 to 2715 kg ha-1. Abundant and well distributed rainfall likely minimized the potential for N loss. To maximize DMY, producers should consider applying the UR-AGRO-ESN blend. This research will be continued to further develop optimal fertilizer N best management practices with stabilized and controlled release sources.

School of Human Ecology

Human Ecology

Graduate Student

The Correlation Between Being Raised in a Lesbian Household and Child Development

Author: Sara Steets, HOPE

Faculty Advisor: Rufaro A. Chitiyo Ph.D., Human Ecology

This study will give insight into how children develop when raised by two lesbian mothers rather than a mother and father couple. The purpose of the study is to obtain a better understanding of the difference between growing up with a mother and father, versus growing up with two mothers. I will be exploring

the pros and cons, the discrimination experienced by lesbian families, and the aspects that set lesbian families apart from heterosexual families. Key terms used at Cornell University while researching include lesbian household, LGBTQIA+ discrimination, same sex parents, lesbian stereotypes. The participants included lesbian households with children under the age of 18, and excluded lesbian families without children, or gay (two male) households with children. As the research continues, we continue to see these stereotypes that allude to lesbian parents not living up to the standard being falsified and proven wrong. Findings found in the research include the following: 1.) Lesbian parents tend to be much more nurturing than a heterosexual couple. 2.) Discrimination varies between states and community groups. 3.) Peers tend to be much less judgmental, and mainly just curious about these experiences, while the older generation is just judgmental. It's important that the stereotypes continue to be broken to help alleviate a portion of the discrimination these families feel on a day-to-day basis, and open up more opportunities for inclusivity and access to resources.

Undergraduate Students

Exploring the Correlation between Self-care Practices and Burnout

Author: Lydia Lawen, Soaring Eagle Scholarship

Faculty Advisor: Dr. Rufaro A. Chitiyo, Ph.D., Human Ecology

Burnout among healthcare professionals is a relevant concern, affecting both individual well-being and quality of care. The purpose of this project is to investigate the correlation between self-care practices and overall well-being and job satisfaction, addressing the research question: "What is the correlation between self-care practices and the occurrence of burnout in healthcare professionals?" Articles were selected based on profession and self-care practices, with exclusions for non-English articles. Search terms included self-care, healthcare professionals, burnout, and nursing, searched via Eagle Search and Google Scholar. Participants included palliative care nurses, doctors, child life specialists, and in-patient nurses. Findings suggest that self-care practices allow professionals to manage stress and emotions, crucial for preventing burnout. Additionally, engaging in self-care practices correlates with higher job satisfaction and reduced burnout compared to non-engagers. Researchers should explore specific self-care practices for deeper insights into their relationship with burnout. Research across diverse populations may also provide broader perspectives on healthcare professionals' practices. Recommendations for healthcare professionals include prioritizing self-care practices in the workplace and offering avenues for professionals to engage in them. This project reveals the role of self-care practices in mitigating burnout among healthcare professionals.

The Benefits of Child Life Services on Children in the Hospital and Throughout Their Lifespan

Author: Kayleigh Vaught, Human Ecology Alumni Endowed Scholarship, HOPE Scholarship, Edna Mackie Memorial Endowed Scholarship

Faculty Advisor: Dr. Rufaro A. Chitiyo, Ph.D., Human Ecology

This project focuses on the benefits child life services provide to hospitalized children and throughout their lifespan. The purpose of this project is to evaluate the importance of child life specialist and how the services they provide benefit children. Consequently, the research question is how do child life specialists benefit children in the hospital and throughout their lifespan? Key terms like child life, child life services, and hospitalized children were used to search for articles on Google Scholar and The Institute of Education Sciences. Articles were selected based on their relevance to this topic and articles involving countries besides the United States were excluded. The participants included hospitalized children, their families, and Certified Child Life Specialists to get different perspectives. Findings show the importance of preparation and pain management to reduce the anxiety levels in children and play to normalize the hospital setting. A third finding is that child life specialists benefit both children and adults, focusing on the need for more specialists in the medical setting. Researchers should study specific diagnoses and age groups for clearer information. Child life specialists should advocate for their role in the medical field, this will enhance the hospital experience for children and families by increasing their numbers, benefiting all.

Exploring Children's Academic Success in Relation to the Family's Socioeconomic Status

Author: Kinsley Spears, HOPE Scholorships

Faculty Advisor: Dr. Rufaro A. Chitiyo, Ph.D., Human Ecology

Academic success is a big part of most people's lives and many different things go into being academically successful. The purpose of this study is to compare a child's academic success to their family's socioeconomic status. Consequently, the research question is in what ways does a family's socioeconomic status play a role in a child's academic success? Using Google Scholar, I used the following keywords "academic success, socioeconomic status (SES), and families SES". Articles were excluded because of how in-depth the research was.
The participants were children between the ages of 7-15 and either one or both of their parents, schools, and school districts. Results from reviewed articles showed 1. The better the family's SES, the more supportive parents were of their child's education. 2. A medium to strong SES--achievement correlation. This means the higher a family's SES is the more it benefits the child. 3. A third finding was how involved a family was with their children in school as well as outside. In conclusion, these results point out that the support that parents have for children and their academics sometimes relates to their SES. Support from parents plays a role in children's lives in their academics and how far they take it. Implications for professionals could include providing support and help for these children who do not succeed because of their home lives. Implications for researchers include different forms of samples and groups.

Exploring the Reasons Why Children Defend their Abusers

Author: Avery Swisher, HOPE Scholarship, Human Ecology Scholarship

Faculty Advisor: Rufaro A. Chitiyo, Ph.D., Human Ecology

Children across the world sometimes justify their abusive lifestyles, so how and why do children defend their abusers? Children defending their abusers become acclimated to a life of degradation. The purpose of this study is to investigate why children sometimes defend and side with their abusers. The articles contributing to the study of this research were chosen based on the similarity they had with one another regarding the reasoning behind a child's defense of an abuser. Each article was beneficial because each one focused on abuse associated with children. Because children were each article's main focal point, this lined up with the research needed for this study. Some key terms that were used when seeking to find criteria were children defending abusers, children siding with abusers, and why children defend their abusers.
One key finding is that children side with their abusers because they are emotionally attached to them. Another key finding is that children will defend their abusers because they don't want to risk angering their abuser even more if they are confronted. A third incredibly sad finding is that children may defend their abuser because they blame themselves for the abuse. Based on these findings, professionals can understand that these children don't know how worthy they are and will be better suited to help them feel worthy by giving them the love they deserve.

Understanding the Correlation Between Foster Care and Adolescent's Adjustment to Adulthood

Author: Morgan Braswell, High Flyers, HOPE

Faculty Advisor: Rufaro A. Chitiyo, Ph.D., Human Ecology

How do foster care experiences relate to adolescents and their adjustment to adulthood? The foster care system exists as a last resort for children who would not be in a safe environment if they were to stay with existing family. Because of this, their wellbeing is in the hands of foster care families, some of which are healthy and some of which are toxic. This experience can make the adjustment into adulthood as an adolescent extremely challenging. The purpose of this study is to identify areas of challenge for adolescents who are aging out of the foster care system and transitioning to adulthood. When searching on Google Scholar for information, key words, and phrases such as adjustment to adulthood, foster care, aging out, and adolescent were used. The selected studies were comprised of real-life experiences and longitudinal studies that span a few years post-aging out of foster care for some adolescents. The participants were mostly adolescents and young adults who recently left the foster care system as legal adults. Future researchers should find a diverse compilation of experiences and resources available. Overall, the results seem discouraging, as many adolescents struggle with substance abuse, financial instability, lack of a support system and more. These gaps highlight the disparities in the foster care system and the resources that are available to aid adolescents that are aging out of the system and makes clear the areas in need of improvement.

Reviewing the Correlation Between Food Additives and Health Issues

Author: Jadyn Norman, HOPE, Pell Grant, Mary Verble

Officer Edowed, Purple and Gold

Faculty Advisor: Rufaro A. Chityo, Ph.D., Human Ecology

Food dyes are added to staple foods as appearance enhancers but provide no nutritional value. Certain food dyes may be linked to a variety of things, but in what ways do food additives really hinder the health and lifestyle of the human population? I examined health effects of food dyes from peer reviewed articles, which included participants that were college-aged, children, and rodents. The human participants were selected by ADHD diagnosis, while animal subjects were chosen due to genetic similarity to humans. The purpose of this project is to explore the consequences that chemicals have. Key terms used to find articles included food dyes, tumor, hyperactivity, and ADHD; but excluded humans without ADHD and non-English articles. One finding was in children on food dye elimination diets: over 60% experienced a significant decrease in ADHD symptoms, while individuals who consumed food dyes experienced excessive irritability and anger. Another finding was that certain dyes do not cause tumors in deceased mice but do cause nerve cell destruction. Although these results show that food dye consuming individuals have an increased risk of ADHD symptoms, people that continue consuming dye may not be at risk for developing cancer-causing tumors; but can experience a depletion of nerve cells. The implications of these results are the prohibition of these dyes, not only to prevent health issues, but for convenience when consumers purchase food.

Investigating Types of Sex Education and Their Correlation to Teenage Pregnancy Rates

Author: Bethany Polson, HOPE Scholarship, TSAA grant, Presidential Scholarship, Crossville Inc., Community Chorus, and Rotary of Crossville

Faculty Advisor: Rufaro A. Chityo, Ph.D., Human Ecology

Teenage pregnancy is an ongoing concern in our society with many different sides and views. This study's goal is to determine the relationship between the type of sex education received in schools and teenage pregnancy rates. This issue is very important. With the proper sex education, many young adults will not be risking pregnancy. The difference between comprehensive sex education and abstinence only sex education is vast. The purpose of this study is to determine which type of sex education actually impacts teen pregnancy rates, rendering it more successful. I selected my studies by looking at the results and how they were achieved. I liked to read articles using different types of research methods and seeing how each person's experiments worked differently. All participants in these studies were teens as we are studying the pregnancy rate. Many of these teens were in high school across the states. The results of these studies varied case to case. Some findings said that there were no differences and others said that comprehensive sex education was more effective. This topic is very important to do research on so we can implement these ideas in schools across the United States. I believe these findings show teenage pregnancy rates may rely on different types of sex education but heavily rely on outside factors.

Exploring the Relationship between Postpartum Depression and Social-Emotional Child Development

Author: Abbigail Renner, High Flyers, HOPE

Faculty Advisor: Rufaro A. Chitiyo, Ph.D., Human Ecology

One in eight mothers experience postpartum depressive symptoms annually, which can affect the way mothers interact with children, thereby affecting development. The purpose of this study is to raise awareness of the prevalence of maternal postpartum depression and how it affects child development: what is the correlation between postpartum depression and child social-emotional development? Key terms used on Google Scholar included postpartum depression, maternal depression, child development, and social-emotional development. I determined inclusion by reading the articles' abstract and discussion sections and excluded articles based on race, drug use, and paternal factors. Participants included low-income postpartum women with depression, mothers with a history of childhood-onset depressive disorders, never-depressed mothers, pregnant women, and children from 12 months to 9 years of age. Results from the literature show that postpartum depression negatively impacts child development especially in the social-emotional domain, but stronger social support for the mother indicated protective factors for both the mother and child. Future research should investigate practices that help mothers and children successfully cope and live with maternal postpartum depression; practitioners in the family sciences field should discuss reactive support methods for mothers experiencing postpartum depression and preventative measures for at-risk mothers.

Community Health and Nutrition

Graduate Students

Developing a Food Pharmacy Program in a Rural Community

Author: Sara Hoover

Faculty Advisor: Samantha Hutson, Ph.D., Human Ecology

The intent of this project was to develop a plan to implement a food pharmacy program in the rural community of Sequatchie County, Tennessee. This program would be in partnership with the local health department and serve uninsured individuals who have been diagnosed with a chronic disease. Eligible participants would receive vouchers that they would be able to redeem at the local farmers' market for fresh fruits and vegetables. Participants would also receive nutrition education specific to their disease state and healthy recipe ideas to encourage them to increase fruit and vegetable consumption. The primary goal of this program is to increase the number of individuals with chronic diseases who consume the recommended amount of fruits and vegetables daily. A secondary goal of the program is to improve chronic disease indicators such as HgbA1c, blood pressure, cholesterol levels, and body mass index among participants. Doing so would improve the health and quality of life for participants and empower them to live a healthier lifestyle. This project taught me a great deal about how to develop a community program and all the challenges that come along with the process. This project has culminated in a detailed plan to implement the food pharmacy program. This plan will be presented to community partners and will hopefully be put into action sometime in the future.

Factors Affecting the Incidence of Overweight/ Obesity and Nutrition-Related Chronic Diseases During Incarceration

Author: Hannah Bailey

Faculty Advisor: Darci Bell, Ph.D., Human Ecology

Chronic diseases such as cardiovascular disease, diabetes, cancer, chronic kidney disease, and pulmonary disorders are incurable processes which have many etiologies and cause a socioeconomic burden on individuals diagnosed. Overweight and obesity is a worldwide public health concern. The worldwide prison population represents 10.3 million people, and prisoners are at a higher risk for excessive weight gain and chronic disease development. The purpose of the literature review was to decrease the knowledge gap in health behaviors and risks within the prison population by examining the correlation between incarceration and the risk of overweight, obesity, and nutrition-related chronic diseases and examining factors which may contribute to this risk. Peer-reviewed journal articles from 2013-2023 were located using the TN Tech Eagle Search, Google Scholar, and PubMed with keywords: prison, imprisonment, incarceration, persons deprived of liberty, overweight, obesity, chronic diseases, chronic noncommunicable diseases, cardiovascular disease, hypertension, and nutrition. Results of this study support the hypothesis that exposure to the prison environment may have negative effects on the health status of inmates. It is recommended that interventions be made to improve overweight, obesity, and chronic disease development of inmates and future research be performed to assess the effectiveness of these interventions.

The Importance of School Lunches' Nutritional Value for Educational Performance Among School-Aged Children

Author: Reagan Baker, Janet Roberts Fletcher Scholarship

Faculty Advisor: Samantha Hutson, Ph.D., Human Ecology

When it comes to school-aged children, nutrition plays a significant role in their life. School meals are crucial to promote healthy and sustainable food behaviors among the school community. As children's eating preferences often persist into adulthood, schools can help provide meaningful opportunities to promote and establish healthier diets through access to nutritional foods for breakfast and lunch. Children currently intake more high-energy dense foods rather than foods that are high in nutritional quality. Nutrition is one of the many factors that affect development of the brain and, therefore, the cognitive development of children. Deficiencies in micronutrients, such as, iron, zinc, omega-3 fatty acids, and iodine can alter cognitive development in school-aged children. It has also shown that school lunches can help improve academic performance within specific subjects. The purpose of this literature review is to examine the importance of nutrition among school-aged children, the nutritional value of foods within the school, nutrition and cognitive development,

and the correlation between school nutrition and academic performance.

The Long-term Effects of Plant-Based Diets on Womens' General Health

Author: Alexandra Garcia

Faculty Advisor: Darci Bell, Ph.D., Human Ecology

Vegetarian diets are classified as excluding all meat but allowing the consumption of dairy and eggs, while vegan diets exclude all food that originates from an animal. The differences between the two diets and the normal meat-eating diet can lead to a variance in macro- and micro-nutrient consumption, leaving some people practicing plant-based diets deficient in some of the nutrients needed to maintain overall health and well-being. The purpose of this research is to evaluate the adequacy of vegan and vegetarian diets in providing proper nutrition and supporting overall health and well-being in women, especially by looking at various studies done on this subject. The research found that vegan and vegetarian participants had low blood serum concentration levels of Vitamin D and calcium, lower dietary intake of Vitamin D, Vitamin B12, niacin, iodine, iron, calcium, and selenium compared to omnivores. Vegans and Vegetarians were also more likely to display symptoms of orthorexia nervosa. Lower hormone production of leptin, parathyroid hormone, and bone-turnover hormones were seen in vegan and vegetarian participants compared to the omnivore participants. Lower hormone production of leptin, parathyroid hormone, and bone-turnover hormones were seen in vegan and vegetarian participants compared to the omnivore participants. Lower hormone production of leptin, parathyroid hormone, and bone-turnover hormones were seen in vegan and vegetarian participants compared to the omnivores.

Alaskan Natives: Location and Health Vulnerability

Author: Piper Smith

Faculty Advisor: Darci Bell, Ph.D., Human Ecology

Vulnerable populations are those lacking accessibility to basic needs including quality healthcare, nutrient-dense food, and education. Alaskan Natives represent an example of a vulnerable population.

This population faces several vulnerabilities including higher rates of chronic disease and struggle for food access. Since Alaskan Natives make up smaller numbers of the U.S. population, their vulnerabilities are not widely understood. The purpose of this research is to examine the Alaskan Native community and how they represent a vulnerable population. This research will discuss chronic disease prevalence, food insecurity, and providing cultural competency among Alaskan Natives.

Hypothalamic Obesity Effects on Childhood Outcomes, Risks Factors, and Possible Treatments

Author: Lia Nesbitt

Faculty Advisor: Darci Bell, Ph.D., Human Ecology

The purpose of this review is to determine how hypothalamic obesity (HO) impacts childhood development, HO risk factors, and prospective HO treatment approaches. Hypothalamic obesity (HO) is a treatment-resistant obesity that is prevalent among individuals with hypothalamic and pituitary gland brain tumors, such as craniopharyngioma (CP). The Tennessee Technological University Library Database Eagle Search, Frontiers in Endocrinology, Pediatric Obesity, and more were used to find relevant articles. The findings suggest that HO has a detrimental influence on patients' survival rate, weight development, cognitive status, psychosocial status, and quality of life (QoL).

Moreover, it increases their risk factors for HO and comorbidities that occur as a result of it. Treatments for HO yielded inconclusive outcomes. The dextroamphetamine therapy had an effect on BMI and other HO-related measures, although it was temporary. GLP1RA treatment lowers calorie intake while decreasing energy expenditure. Oxytocin had no influence on body weight or metabolic markers; however, it did have an effect on mood. Despite varied results, all articles presented evidence that supported the significance of further research in all topics discussed in this paper. Ultimately, those who have HO are not impacted in the same manner, which promotes a tailored care plan, collaboration with other healthcare experts, and additional clinical studies that can help reduce or prevent HO from transpiring.

Weekend Nourishment: A Systematic Approach to Alleviating Food Insecurity Among the Homeless

Author: Krissie Miranda

Faculty Advisor: Samantha Hutson Ph.D., Human Ecology

The "Weekend Nourishment" project aimed to tackle the pressing issue of weekend food insecurity among homeless individuals in Cookeville, TN. Despite ongoing attempts to combat food insecurity, many homeless individuals in our community face significant challenges in accessing consistent and nutritious meals, especially during the weekends when traditional food assistance programs and services are unavailable. Through a community-driven approach, this project seeks to utilize a vending machine as the sustainable solution that provides access to meals for homeless individuals throughout the weekends. By offering easily transportable and ready-to-consume food items, such as non-perishable goods and protein sources, the project aimed to alleviate hunger among the homeless. Strategic measures, including grant applications and partnerships with local businesses, were employed to facilitate effective implementation. Surveys, questionnaires, and interviews were conducted with homeless individuals to glean insights and perspectives on the effectiveness of the vending machine intervention. The conducted interviews among the population were responsible for identifying the key criteria for selecting the "ideal" vending machine. Approximately 25 to 35 homeless participants from the Cookeville community were engaged. With the support of community stakeholders and partnerships, including the suppliers, the project demonstrated the ability to transform the idea into an actionable reality.

Design Studies

Graduate Student

Exploring Eco-Friendly Screen Printing Practices that are Practical to Adopt

Primary Author: Hunter Tisdale

Co-author/Collaborator: Kennedy Agee

Faculty Advisor: Hannah Upole, Human Ecology

Screen printing is a popular design method for transferring a picture, words, or logo onto a piece of clothing. It is done by pressing ink through a mess screen that acts as a stencil. This design method is very popular because it is simple and effective, however, it is not the safest design method. The environmental impact of screen printing is high in comparison to other production alternatives. S.M. Hoque states that "The highest difference between RSP and DTP was identified in chemical wastage, as DTP wasted 99.64% fewer chemicals than RSP." (Hoque S.M., 2021). We are seeking a solution that brings the environmental impact of screen printing closer to the standard set by other production methods. When looking into research studies, journals, and books to try to find the best alternative dye methods that could replace the mainstream dyes used in fast fashion we found that small businesses tend to gravitate towards screen printing due to the low start up cost, and large corporations will gravitate towards screen printing due to the decreased cost in bulk. Rotary screen and flat screen printing took up approximately 90% of the market share of textile printing in 2014 (Hoque S.M., 2021). With such a high market share, finding an environmentally beneficial solution to the screen printing process is of utmost importance. Research is being conducted on this topic during the spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

Undergraduate Students

What Does the Future of Government Programs Hold for Clothing Recovery?

Primary Author: Peyton Harris

Co-Author/Collaborator: Philip Hall

Faculty Advisor: Hannah Upole, Human Ecology

Due to excessive textile waste, the textiles industry is the second most polluting industry behind oil and may overtake the oil industry as the most polluting industry within the next five to ten years. With this in mind, we feel that there is a necessary change that must happen in order to combat this problem. A worthy opponent that could fight textile waste is clothing recovery. Clothing recovery is a way to manage post-consumer textiles and clothing by reusing and recycling used clothing. Currently, France is the only country that has adopted a national program for clothing recovery. France uses an extended producer responsibility policy (EPR). An EPR is a program in which producers are held responsible for the environmental impacts of their products after they leave the store's shelves. While France's program is promising, we believe that other nations would have to get involved in order to truly make an impact. With that in mind, we believe that clothing recovery could absolutely make a huge impact in our world if other countries united together in fighting back against textile waste by implementing a clothing recovery program. Research is being conducted on this topic during the Spring 2024

semester and the results will be presented at the 19th Research and Creative Inquiry Day.

Is Kombucha Leather a Viable and Attractive Alternative to Real and Faux Leather Options?

Primary Author: Canaan Jones

Co-Author/Collaborator: Brooke Galan

Faulty Advisor: Hannah Upole, Human Ecology

Due to a mix of overconsumption and the wide usage of synthetic textiles, pollution by way of the fashion industry has become an increasing problem over recent decades. One of the noteworthy aspects of this growing problem is the manufacturing of real and synthetic leather. According to Spinnewijn (2022), chromium is commonly used during the tanning process of animal leather. This chemical is highly toxic to humans as well as the environment; often found in the effluent produced during the tanning process. The alternative, faux leather, requires the use of fossil fuels during its production. Furthermore, the presence of chlorine used in PVC leather can produce toxic chlorinated compounds when disposed of improperly. (Spinnewijn, 2022). In recent years, innovations in science and manufacturing have led to sustainable, ethically made, and biodegradable alternatives to leather as a textile. The most intriguing of which is bacterial cellulose, more specifically kombucha leather. Kombucha leather is produced during the fermentation of tea as a byproduct made from a symbiotic culture of bacteria and yeast (Concord, n.d.). Kombucha leather is ethical and sustainable, however, innovations are still needed to produce a product that is durable and attractive enough as a viable alternative to capture the attention of consumers. Research is being conducted on this topic during the spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

What are the Primary Advantages of using Tensile Fabric Materials in the Construction of Commercial Buildings Compared with Traditional Building Materials?

Primary Author: Shannon Lee

Co-Author/Collaborator: Lucas Ballard

Faculty Advisor: Hannah Upole, Human Ecology

The purpose of this study is to investigate the possibility of utilizing tensile fabric structures in commercial buildings in the Upper Cumberland, as compared to traditional commercial building materials. The design approach used is a research-based study on the behavior of tensile fabrics under particular conditions, the effects of environmental factors on their lifespan, and sustainable aspects of construction. According to the research, Tensile fabric structures offer many advantages. They are constructed with a flexible, lightweight material that is completely sustainable. This material offers fast and easy installation, as well as numerous design possibilities that are not possible with traditional building materials. Research shows that Tensile fabric structures are also very energy efficient due to their "highly solar reflective properties" (Carvalho and Franguero,2016, p. 231). In addition, tensile fabric can be reused, recycled, and produced locally, which could lead to "fewer carbon emissions, less waste, and more efficient resource utilization" (Ortega, 2023, p.68).

The research findings have shown the relationship between tensile fabric structures and traditional buildings, as well as the primary advantages tensile structures offer including versatility, durability, and sustainability. Research is being conducted on this topic during the Spring 2024 semester and the results will be presented at the 19th Research and Creative Inquiry Day.

How Can Wearable Triboelectric Nanogenerators Be Optimized?

Primary Author: Ethan Mayo

Co-Author/Collaborator: Chrystopher Shaward

Faculty Advisor: Hannah Upole, Human Ecology

Nanotechnology may seem small at first, but it has been growing large in terms of use over the past several years. Nanogenerators which draw charge from the triboelectric effect, or energy creation through the building of friction, were created in response to the Global Energy Crisis, the first truly global instance of supply shortages and slowing economies. Through the Internet of Things (IOT), mechanisms such as the triboelectric nanogenerator (TENG) are connected to a network of wireless communication.

In finding wearable applications, TENGs have become a passive energy source that circumvents the need for electronic waste. Newer models are able to be reused in later mechanisms and also have gained abilities such as moisture wicking, non-contact generation, and other forms of resilience. TENGs have effectively

fallen into one of three structural types, but variations on these forms have allowed TENGs to achieve weather resistance and higher output performance. As such, the applications in fields, such as agriculture or healthcare, are becoming more significant as well as more viable while researchers continue to test for the best combination of materials that can generate and store the most energy.

Research is being conducted on this topic during the Spring 2024 semester and results will be presented at the 19th Research & Creative Inquiry Day.

What is greenwashing and how does it affect consumers' perceptions of brands, specifically Nike?

Primary Author: Sarah Kate Miller

Co-Author/Collaborator: Caleb Johnson

Faculty Advisor: Hannah Upole, Human Ecology

Have you ever bought an eco-friendly product? Do you know if it was actually eco-friendly? In recent years many large companies, specifically Nike, have been known to mislead consumers about their green products. Green marketing strategies have been used by companies to help raise their competitive advantage and appeal to ecologically conscious consumers. Unfortunately, not all green marketing claims accurately reflect the company's environmental pledge to consumers. Some exaggerate or claim to be environmentally responsible or green when they are not. This is known as greenwashing and unfortunately, greenwashing claims are becoming more and more prevalent in today's world. Research is being conducted on this topic during the Spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

What is the feasibility of using reusable sterile medical gloves in medical training facilities?

Primary Author: Cael Sumerlin

Co-Author/Collaborator: Raegan Tjon Sien Kie

Faculty Advisor: Hannah Upole, Human Ecology

In the medical field, many consumables get thrown away everyday--more than you think. According to the Journal of Hospital Infection, PPE accounts for 80% of waste within the medical field, with gloves comprising 85% -95% of this statistic (Ashley, Duane, Jamal, & Lyne., 2021). This can be counteracted by enacting sustainable materials and practices that can be used continuously in the medical field. A few questions to consider are what methods can ensure a sterile and clean field, how will these products hold up to everyday use, how can facilities reduce the use of disposable materials, and ultimately what is the feasibility of using reusable sterile medical gloves in medical training facilities. By prioritizing the development and implementation of such reusable alternatives, medical facilities can significantly reduce their ecological footprint while maintaining the necessary standards of cleanliness and safety. Research is being conducted on this topic during the spring 2024 semester and results will be presented at the 19th Research & Creative Inquiry Day.

Advancements in Sustainable Textile Dyeing Techniques for Reducing Water Pollution

Primary Author: Charlie Thomason

Co-Author/Collaborator: Reina Imoto

Faculty Advisor: Hannah Upole, Human Ecology

This literature review explores the essential shift towards sustainable practices in contemporary textile production, focusing on waterless and air dyeing techniques. Traditional dyeing processes are criticized for their environmental impact, especially in water use and pollution. Researchers and practitioners address this by exploring methods of preserving fabric quality while reducing harm. The review delves into sustainable textile dyeing, examining waterless dyeing with D5 and AirDye(R) technology. AirDye(R) in printing machines cuts water usage, energy consumption, and greenhouse gas emissions by 95%, 86%, and 84%, respectively (Mahmud & Kaiser, 2020). Airflow dyeing machines further minimize water use, outperforming traditional methods in energy savings (Khattab et al., 2019). Comparing these techniques highlights their progressive nature and environmental impact. Research on waterless dyeing and air dyeing methods in the textile industry indicates potential benefits and challenges, fostering environmentally conscious manufacturing (Lara et al., 2022; Wang et al., 2019). Research is being conducted in the spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

Would consumers care to buy naturally dyed clothing, home materials, and other goods compared to synthetic dye methods that may be harmful to the environment?

Primary Author: Taylor Vaughn
Co-Authors/Collaborators:
Chloe Richardson
Eman Norris

Faculty Advisor: Hannah Upole, Human Ecology

Sustainable dyeing processes are considerably safer for the environment, but they generally aren't an option due to the mass production rates that would need to happen in order for natural dyes to overrule synthetic dyeing processes as a whole. The emerging interest of natural dyes may allow there to be a balance of natural and synthetic dyes to allow for a healthier environment. Synthetic dyes are unsafe in a multitude of ways that this literature review focuses on.

Synthetic dyes have a wide variety of color options, but after the dyeing process is done, the dye contaminated water is drained through a pipe source into the waterways, streams, and runoffs. "In addition, these waste waters can produce several dangerous problems, namely aesthetic and health problems such as changes in the quality (color and odor) of water and make it toxic, as they can cause allergies, dermatitis, skin irritations, cancers and mutations in humans". (Berradi et.al., 2019 p.6) Thus, leaving some waters unsafe for the public health. Natural dyes may reduce the concerns of water pollution from the textile industry.

The purpose of this study is to present a balance that will exceed the demand for synthetic dyes and progress the use of natural dyes in the textile industry to absorb the environmental shock that synthetic dyes cause. Research is being conducted on this topic during the spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

Sustainable Alternatives for Cotton and Polyester in Our Environment

Primary Author: Teagan Warren

Co-Author/Collaborator: Caleb Maxwell

Faculty Advisor: Hannah Upole, Human Ecology

The textile industry is known for cotton and polyester being the leading fibers within the average consumer products. Consumers are possibly not aware about what effects cotton and polyester have on the environment. This is what leads us to wanting to bring awareness to the sustainable alternatives and if consumers are willing to buy these alternatives if possible. Environmental concerns of the most common fibers currently utilized within the textile industry are easily recognized within the majority of the scientific community as well as individuals from within the industry itself. Although their usage in certain contexts can and will continue to be useful, alternatives must be considered to ensure the longevity of textiles production in terms of resource consumption and their environmental impact. Alternatives such as hemp, bamboo, and an increasingly larger roster of other cellulosic fibers should and must be considered to stave off even further impacts of the over-usage of the other aforementioned fibers. We intend to provide and determine the current levels of awareness, price limitation thresholds, and the general willingness to seek these alternatives within the average consumers of our local community for the sake of gaining better perception into the scope of this region, and of current and future consumption trends and ideals. Research is being conducted on this topic during the Spring 2024 semester and results will be presented at the 19th Research & Creative Inquiry Day.

3D Printed Homes: The Future of Architecture?

Primary Author: Emily Worrell

Co-Author/Collaborator: Andrew Whitehead

Faculty Advisor: Hannah Upole, Human Ecology

3D-printed homes are currently making their way into many countries and neighborhoods. They are cost-efficient, and they save time where regular ways of building homes do not. But where we see growth in the popularity of these homes, we will continue to see growth in how they affect our environment. As architects and engineers continue to use these processes, we must take necessary precautions to lessen the harmful things we are putting back into our air. This study serves to find what we already know about 3D printed homes and measure their sustainability based on several factors: cost efficiency, ecological effects, longevity, and recyclability. Our review of current literature has shown that 3D-printed homes using cement produce greenhouse gases and give less room for mistakes made by the printer. Other materials and different types of 3D printers are currently being experimented with and will allow for more eco-friendly processes while leaving extra room for error. The purpose of this study is to analyze if 3D printed homes have a place

in the future and if they could be a better option than the conventional ways of building. Research is being conducted on this topic during the spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

How had social media turned thrifting into a harmful trend?

Primary Author: Alexys Fallon

Co-Author/Collaborator: Brook Fritts

Faculty Advisor: Hannah Upole, Human Ecology

Social media has brought our generation some positive aspects, but has it brought anything positive for our environment? Thrifting has become a popular trend within the recent years due to Instagram and TikTok. Influencers have posted about what they've found on their thrifting trips, which has impacted consumers because they want follow what their favorite influencers are up to. However, 87% of our unwanted textiles end up in the landfills when 90% of those items are recyclable and can be reused. Even though our generation has been thrifting more than ever, is this trend really helping our environment when social media has negatively impacted it? Thrifted clothes by influencers are either being resold for profit or not even being worn at all, then eventually thrown out. Which defeats the purpose of thrifting to help our environment. Research is being conducted on this topic during the Spring 2024 semester, and results will be presented at the 19th Research and Creative Inquiry Day.

Synthetic vs. Natural: A Study on fabric frequencies and human health

Primary Author: Chloe Maynord

Co-Author/Collaborator: Faythe Martin

Faculty Advisor: Hannah Upole, Human Ecology

Fabrics have a profound impact on human health and well-being, not only through their characteristics but also their frequency interactions with the body. The frequencies of textiles and their effects on the human body have been connected to fabrics' makeup. Synthetic fibers contain many chemicals in their production process, creating sustainability concerns regarding human health and the environment. Unlike synthetic fibers such as polyester and nylon, natural fibers such as linen produce high frequencies when in contact with the human body, thus resulting in higher comfortability, better health and overall well-being. With these findings, it is evident natural fibers are a better alternative in all aspects.

This study presents a systematic review of the available evidence concerning the question of fabric frequencies in the textile industry. The research question investigated: Is the public aware of textile frequencies and their effects on the human body? Research is being conducted on this topic during the spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

How can we change the effect new construction packaging materials have on the environment?

Primary Author: Nathalie Recinos

Co-Author/Collaborator: Amaris Rice

Faculty Advisor: Hannah Upole, Human Ecology

This study is intended to find and evaluate the responses of local contractors when asked if they would be willing to pay more, knowing that the products they are buying are packaged sustainably, and then used at their construction sites. Waste produced at a construction site is at an extremely high rate and is causing a negative impact on the environment around us with little to no environmental regulations on waste. Studies from other countries have been conducted to see how much waste is being produced from construction sites. Katz (2011) describes that about 20% of leftover materials are dumped in landfill sites in Israel because of construction, as well as packaging from purchased materials. Demand for housing and renovations are high which continues the problem of waste. Through calling different contractors in the Upper Cumberland area via phone call we will be able to determine if this idea is worth producing. If there is no demand or want for sustainably packaged products, it would not benefit this area. The limitations to this project would be location since we are only testing the Upper Cumberland area since there are so many contractors and developers in this area. If it would succeed here, then this idea could be further tested in other parts of the state and nation where areas of construction are high. Research is being conducted on this topic during the Spring 2024 semester and results will be presented at the 19th Research and Creative Inquiry Day.

Sustainability of Green Roofs

Primary Author: Peighton Maynord

Co-Author/Collaborator: Matthew Bowling

Faculty Advisor: Hannah Upole, Human Ecology

Imagine a world where we use green roof technology to implement a better future for global warming. Green roof technology is a sustainable and efficient addition that can be accommodated to any commercial or residential building. Implementing a roof style like this has many benefits such as: thermal resistance, buffer stormwater runoff, potential vegetation growth, extremely environmentally friendly, and lowering carbon dioxide concentrations. Depending on the contractor and location of the building in mind, a green roof's materials can differentiate. Some types of green roofs can be constructed with certain plastics or modified asphalt, while others can be made with specific synthetic rubber and coatings. These environmentally friendly solutions must include six layers to correctly construct a durable and long-lasting green roof: the vegetation layer, the substrate layer, the filter layer, the drainage layer, the root-resistant waterproof layer, and the structure layer. Furthermore, there is more than just one type of green roof, there are five main types: extensive, semi-extensive, intensive, solar garden roof solar, and blue-green roofs. Consumers often select extensive green roofs due to the low maintenance that comes with them. Research is being conducted on this topic during Spring 2024 semester, and results will be presented at the 19th Research and Creative Inquiry Day.

Nutrition and Dietetics

Graduate Student

Implementation of a Wellness Grant in a Rural Community

Primary Author: Amber Buckner Watts

Co-author/Collaborators:
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Samantha Hutson, Ph.D., RDN, LDN
Hannah Upole, Ph.D.

Faculty Advisor: Samantha Hutson, Human Ecology

Spring Into Health and Wellness: A Pop-Up Event was a Rural Reimagine grant project developed to assist rural regions in the Upper Cumberland. This objective was achieved by offering take-home wellness boxes to families during upbeat, pop-up events. Our aim for this initiative was to furnish families in rural communities with wellness-related resources that can aid them in developing healthy life skills. These skills include enhancing their understanding of healthy eating habits, improving financial security, and understanding the ways that personal hygiene can impact overall wellness. Stigma often deters individuals from participating in social assistance programs. Therefore, the primary goal of this grant-based project was to reduce that stigma and provide the community with a positive and easily accessible resource.

An additional goal was to pilot this program to gather data, evaluate the program, analyze the obtained information, disseminate findings, and create a sustainable, replicable model on how to provide food and general wellness resources to residents of rural areas in Tennessee.

Undergraduate Student

The Effects of Caffeine on Cognitive Function in Adults

Author: James Medley

Faculty Advisor: Allison Coutinho, Human Ecology

Caffeine is one of the most consumed substances by adults. It has been consistent throughout human history in various forms such as coffee, tea, and chocolates. Caffeine typically affects people by increasing heart & breathing rates, giving them a perceived physical & mental energy increase, and altering their cognitive performance. This literature review aimed to understand more about how caffeine can effect an adults cognitive function. Using various sources for articles & information such as the Journal of the Academy of Nutrition and Dietetics & Google scholar, found 9 articles pertaining to studies that had used caffeine as one of the main focal points, 7 of them looked at in depth in this review and 2 where used for statistics or basic information. Some articles performed tests to examine caffeine's effects on mood, learning, processing speed, memory, and other areas. One study looked at how it can help prevent Alzheimer's Disease. The biggest take aways from this review are that caffeine (most notably in its form of coffee) have been shown to have effects on mood, alertness, processing speed, neuronal protection, and the perception of increased cognitive function. The significance of this information could

help registered dietitian nutritionist in research and recommendations for clients in certain age groups, those with mood imbalances or mental disorders, and potentially help policymakers to have a clear understanding of the effects of caffeine within the brain.

College of Arts & Sciences

Department of Biology

Biochemistry

Undergraduate Student

Computational Docking and Structural Analysis of the Intermolecular Interactions of JNK3 and MKK7 in the MAP Kinase Signal Transduction Pathway

Primary Author: Joshua T. Dean

Co-Authors/Collaborators:
Christian D. Scott
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Derek J. Cashman, Ph.D.

Faculty Advisor: Derek J. Cashman, Ph.D., Chemistry

JNK3, also known as c-Jun N-terminal kinase 3, is a stress-activated protein kinase and a member of the mitogen-activated protein kinase (MAPK) family. Through its interactions with the MAP kinase 7 (MKK7), it plays a role in the signal transduction pathways in the pathogenesis of diseases such as Alzheimer's and Parkinson's. While the 3D structure of these proteins has been resolved by X-ray crystallography, the N-terminal and C-terminal regions are yet to be determined. In an effort to evaluate the function of the N-terminal region (NJ38), the 3D structure was predicted using the artificial intelligence software, Alphafold2 (DeepMind Technologies, Ltd., London, UK), and this structure was added to the X-ray structure of JNK3 using the molecular modeling software, MOE 2022 (Chemical Computing, Ltd., Montreal, Quebec, CANADA). The full JNK3 protein was subsequently docked with the known 3D structure of MKK4 using ClusPro (Boston University, Boston, MA USA), to obtain 30 docked conformations. Each conformation was analyzed based on the proximity and distance between the known active site residues in the protein. The top JNK3/MKK7 protein complexes with bound ATP were then simulated using all-atom molecular dynamics in in NAMD on Tennessee Tech University HPC cluster for further evaluation. The simulations suggested that the docking is stable at equilibrium and the proposed docking sites are being planned for experimental validation by pull-down assay.

Synthesis and Characterization, of New Ligands for Metal-Centered Anti-Cancer Studies

Primary Author: Sarah Beshara, 2023 URECA Recipient

Co-Author/Collaborator: Andreea Cojocaru, Ph.D., Chemistry

Faculty Advisor: Edward Lisic, Ph.D., Chemistry

Thiosemicarbazones have proved efficacy in defense to multiple cancer cell lines by preventing certain cellular processes identified as precursors to cancer. Recently, metal complexes of Cu (II) with tridentate heterocyclic thiosemicarbazone ligands have shown the powerful ability to inhibit the enzyme Topoisomerase II alpha, which is used by the cell to help DNA strand replication and is overexpressed in malignant cancerous cells. By synthesizing metal complexes with unique new thiosemicarbazones, alternative affects to cellular activity may occur to provide a more efficient cancer inhibition pathway. This presentation focuses on a series of new ligands using 2-benzoyloxazole as a substrate with different R groups on the thiosemicarbazones such as methyl, ethyl, and tert-butyl. We have already characterized one of these, BZOX-ETSC, by X-Ray crystallography. The ligands have been characterized by NMR spectroscopy and complexed with Cu (II) and other metals and that information will be presented in this poster.

Expression and Purification of JNK-3 Mutant without the N-terminus

Primary Author: Zac Rush

Co-Author/Collaborator: Kirsten Spradlin, Chemistry

Faculty Advisor: Xuanzhi Zhan, Chemistry

c-Jun N-terminal Kinases (JNKs) are a family of mitogen activated protein kinase (MAPK) which regulates many stress related responses in cells including: apoptosis, cell proliferation, and cell differentiation. There are three JNK subfamilies including two ubiquitous expressed JNK1 and 2, and neuron-specific JNK3. JNK3 contains an extension on the N-terminus, named NJ38 in this investigation.

It's impact on the kinetics of the molecule are yet to be determined. To deepen the understanding of the mechanism and kinetics of NJ38 terminus, we designed and constructed a mutated form of JNK3 that has NJ38 removed to investigate the efficacy of JNK3 without it, referred to as J3DN (JNK-3 deleted NJ38). To unravel the kinetics of J3DN, the protein must be expressed and purified. Here, we report our efforts to express and purify this J3dN mutant. We have optimized the expressing temptation, time-line and IPTG concentration in small scale and purified this JNK3 mutant protein by Ni-NTA chromatography.

Biochemistry - Health Science

Undergraduate Student

Computational Modeling of the Intermolecular Interactions of JNK3 and MKK4 in the MAP Kinase Signal Transduction Pathway

Primary Author: Christian Scott

Co-Authors/Collaborators:
Joshua T. Dean
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Derek J. Cashman, Ph.D., Chemistry

Faculty Advisor: Derek J. Cashman, Ph.D., Chemistry

The c-Jun N-terminal protein kinase, JNK3, is a stress-activated protein kinase that is a member of the mitogen-activated protein kinase (MAPK) family. It is functionally implicated in a wide range of cellular activity and CNS function, and may play a role in the progression of Alzheimer's and Parkinson's Disease. While the structure of these proteins has been resolved by X-ray crystallography, the N-terminal and C-terminal regions remain largely unresolved. To further evaluate the possible function of the unresolved N-terminal region (NJ38), the 3D structure was predicted using the artificial intelligence software, Alphafold2 (DeepMind Technologies, Ltd., London, UK). The full JNK3 protein was subsequently docked with the known 3D structure of MKK4 using ClusPro (Boston University, Boston, MA USA), to obtain 30 docked conformations. Each conformation was analyzed based on the proximity and distance between the active site residues in the protein. The top JNK3/MKK4 protein complexes with bound ATP were then simulated using all-atom molecular dynamics in in NAMD on Tennessee Tech University HPC cluster for further evaluation. The simulations suggested that the docking is stable at equilibrium and the proposed docking sites are being planned for experimental validation by pull-down assay.

Computational Docking and Structural Analysis of the Intermolecular Interactions of JNK3 and MKK7 in the MAP Kinase Signal Transduction

Primary Author: Joshua Dean

Co-Authors/Collaborators:
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Faculty Advisor: Derek J. Cashman, Ph.D., Chemistry

JNK3, also known as c-Jun N-terminal kinase 3, is a stress-activated protein kinase and a member of the mitogen-activated protein kinase (MAPK) family. Through its interactions with the MAP kinase 7 (MKK7), it plays a role in the signal transduction pathways in the pathogenesis of diseases such as Alzheimer's and Parkinson's. While the 3D structure of these proteins has been resolved by X-ray crystallography, the N-terminal and C-terminal regions are yet to be determined. In an effort to evaluate the function of the N-terminal region (NJ38), the 3D structure was predicted using the artificial intelligence software, Alphafold2 (DeepMind Technologies, Ltd., London, UK), and this structure was added to the X-ray structure of JNK3 using the molecular modeling software, MOE 2022 (Chemical Computing, Ltd., Montreal, Quebec, CANADA). The full JNK3 protein was subsequently docked with the known 3D structure of MKK4 using ClusPro (Boston University, Boston, MA USA), to obtain 30 docked conformations. Each conformation was analyzed based on the proximity and distance between the known active site residues in the protein. The top JNK3/MKK7 protein complexes with bound ATP were then simulated using all-atom molecular dynamics in in NAMD on Tennessee Tech University HPC cluster for further evaluation. The simulations suggested that the docking is stable at equilibrium and the proposed docking sites are being planned for experimental validation by pull-down assay.

Biology

Undergraduate Students

Construction of Three-Dimensional Models of the Twenty Amino Acids at Physiological pH as a Biochemistry Teaching Aid

Author: Adriah Scruggs

Faculty Advisor: Derek J. Cashman, Ph.D., Chemistry

This project involved the modeling and printing of three-dimensional models of the twenty amino acids for use as a teaching aid in biochemistry lecture and laboratory classes. The software MOE (Chemical Computing Group, Ltd., Montreal, Quebec, CANADA) was used to model each amino acid, accounting for differences in the protonation states of the carboxyl, amine, and side chains at physiological pH. These molecules were then converted to stereolithography (STL) files and imported into ideaMaker for slicing where the models were scaled and supports were added, creating a gcode file of each of the models for the 3D printer. These gcode files were then imported into the Raise3D Pro2 printer located in the computer modeling laboratory, and the models were printed with polylactic acid (PLA), a biologically-based and biodegradable plastic. Once printing was complete, support structures were removed and each model was painted using the CPK color scheme for each element. Issues surrounding the scaling and durability of the models were resolved, and a model of each of the twenty amino acids was successfully produced, and some of these models were tested in fourth year biochemistry courses in the department.

Modeling the influence of CRSP and EPF2 on Stomatal Lineage in response to CO2 Concentrations

Author: Emma Farley

Faculty Advisor: Hannah Kinmonth-Schultz, Ph.D., Biology

Stomata are pores surrounded by specialized epidermal cells that function as a mechanism to control gas exchange in plants. CO2 regulates the initiation of potential stomatal cells from protoderm through a complex signaling pathway that is controlled by CO2-RESPONSIVE SECRETED PROTEASE and its activation of the pro-peptide EPIDERMAL PATTERNING FACTOR 2. This model is used to predict the formation of stomatal cells versus epidermal cells based on the signaling pathway. This model explores the question: Can CO2 concentration at elevated levels predict the stomatal index in developing leaves based on levels of CRSP mRNA and EPF2 activity? Relative CRSP and EPF2 mRNA levels and EPF2 cleavage rates in relative fluorescence units are collected in vitro from specimens of Arabidopsis thaliana (Engineer 2014). The positive interactions of these mechanisms shown in the data establish the relationship of decreasing designation of protodermal cells as stomata. The increasing concentrations of atmospheric CO2 initiating this signal pathway leads to the creation of less epidermal cell fates than stomatal cell fates. This model encapsulates the overall relationships between CO2 concentration and its impact on stomata. but to refine it, there must be more data collected on the basal and maximum mRNA levels to further define the boundaries of the regulation of stomatal lineage.

Biology - Health Science

Undergraduate Students

Assessing Arthropod Diversity and Aquatic Health in the Bridgestone Nature Reserve on the Cumberland Plateau, Tennessee: A Combined Approach Using eDNA Metabarcoding and Traditional Taxonomic Surveys

Primary Author: Rawan Elsayed

Co-Author/Collaborator: Riley Widdifield, Biology

Faculty Advisor: Carla Hurt, Ph.D., Biology

The Cumberland Plateau in Tennessee is a global center of biodiversity; this region provides habitat for numerous at-risk species of arthropods, amphibians, fishes, mollusks, and vascular plants. The Bridgestone Nature Reserve (BNR) at Chestnut Mountain encompasses 5,700 acres within the Cumberland Plateau. The primary objective of this study was to explore the diversity of arthropod species inhabiting BNR. We employed both eDNA metabarcoding as well as traditional morphological taxonomic surveys to investigate both alpha and beta diversity patterns, shedding light on the ecological richness and community structure within this habitat. In addition, we calculated a Tennessee Macroinvertebrate Index (TMI) score for each sampled stream to assess biological conditions of the aquatic macroinvertebrate communities present on BNR. Results from our study will be used as a baseline inventory for assessing changes in biodiversity at BNR that may result from management practices and climatic conditions. Our assessment of the TMI of ephemeral streams on BNR will be used to assess ongoing management practices on water quality and ecosystem health.

Biology - Pre-Vet/Zoology

Undergraduate Student
A Novel Application of Membrane Inlet Mass Spectrometry to Study Larval Physiology of the Streamside Salamander (Ambystoma barbouri)

Author: Kaitlyn Darnell, 2023 CISE Recipient

Faculty Advisor: Joshua Hall, Biology

Urbanization often causes environmental temperatures to increase due to the replacement of vegetation with heat-absorbing substrates. Thus, the physiology of ectotherms in urbanized areas may be detrimentally affected. The Streamside Salamander (Ambystoma barbouri) in Tennessee is primarily threatened by urbanization, which, in addition to habitat destruction, causes temperature increases in breeding streams around the Nashville metro area. During early development, salamanders are sensitive to temperature increase due to their limited thermoregulatory capacity. To determine effects of rising temperatures on larval physiology, we applied an novel application of a Membrane Inlet Mass Spectrometer (MIMS) to examine oxygen consumption of larval A. barbouri at two temperatures (10 and 20 Â°C). These temperatures span nearly the entire range of environmental temperatures experienced in the wild. Statistical analysis revealed a Q10 of 2.6 based on oxygen levels measured from individual larvae at the two thermal treatments. The Q10 is within the range expected for biological reactions and that observed in other species. Therefore, these data support the hypothesis that larvae function normally within this range of temperatures and warmer or cooler temperatures would be required to induce thermal stress. The results of this study offer crucial insights into the physiological adaptations of A. barbouri and provide foundation for the use of MIMS to study larval physiology in the future.

Flow synthesis and characterization of Prussian blue nanoparticles

Primary Author: Noha Elkeelany, 2023 URECA

Co-Authors/Collaborators:
Nathan Colwell
William Carroll, Ph.D., Chemistry

Faculty Advisor: William Carroll, Ph.D., Chemistry

Well-controlled nanoparticle size can have a tremendous impact on the light blocking and coloration of pigments. The repeatability and consistency between batches of nanoparticles are critical to the usability of their preparations. Many of the more reproducible nanoparticle preparations are based on batch approaches, and continuous preparation has many attractive properties. Here we investigate the use of flow synthesis to control nanoparticle size and optical properties in pigment preparations. This work reports the preparation of Prussian blue of measured particle size and size distribution. Scanning electron microscopy (SEM) measurements determined the particle dimensions and their statistical variances. The transparency and hue of Prussian blue are impacted by its particle size. Pigments prepared in batch and continuous flow were mixed into paint and evaluated for their properties in practice. Small-scale flow reactors have excellent mixing and temperature control and can be used to control the timing of dilution and mixing well.

Botany

Undergraduate Student

Trumpet Lilies in the Southeastern United States

Author: Eveanna Bolich-Sledge, 2023 CISE Recipient

Faculty Advisor: Shawn Krosnick, Ph.D., Biology

Early detection is a challenge in addressing invasive species and their environmental impacts. Species in Lilium section Leucolirion are thought to have begun naturalization in the southeastern United States. Although currently there is no evidence to indicate invasiveness, a more thorough understanding of these species is needed to fully comprehend their potential environmental impacts. Data on their morphology, molecular biology, reproductive mechanisms, and pollinator interactions would provide valuable insights into their expansion and support the creation of identification keys. We visited five sites in the southeastern United States in July and August 2023 to conduct pollinator observations and self-compatibility testing. Flower samples will be collected to observe under UV fluorescence, and leaf samples collected by Cassandra Fink in Summer 2022 will be subjected to molecular analysis.

Environmental Biology

Undergraduate Students

Tennessee Tech Genetics Team eDNA Research: Tennessee Pollinators

Primary Author: Erica Duke, 2023 URECA Recipient

Co-Authors/Collaborators:
Shelby Burke, Biology

William Dunn, Biology
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Faculty Advisor: Carla Hurt, Biology

One of the biggest threats facing pollinators today is diminished availability of viable habitat. Using eDNA metabarcoding analysis, our team is working to better understand how land use across the Tennessee is impacting honeybees, one of the world's most effective pollinators. This information is useful for beekeepers as well as conservationists who work to prioritize the health and availability of pollinator habitat.

In collaboration with the Tennessee Beekeepers Association, we are obtaining honey samples from fifty apiaries across the state. The samples collected represent colonies that rely on different land use categories: urban, rural, agricultural, and forested lands. We will be extracting DNA from the honey samples and use amplification techniques to target three specific genes: rbcL, ITS-2, and COI. Bioinformatic analysis will be performed on the results using Tech's HPC as well as GenBank database to determine prevalent plant DNA. From this information we're able to determine key plant species or groups preferred by honeybees in Tennessee.

Individualized reports summarizing this data will be sent to those who provided honey samples with the aim of providing informative and useful results. Our team will utilize landscape data from the USGS National Land Cover Database and ArcGIS Pro to draw conclusions about how different land use types affect honeybee colonies across the state. This information has implications for various industries and decision makers.

Microbiology

Undergraduate Students

Examining the mechanisms of telomeric position effect (TPE) in Pyricularia oryzae

Primary Author: Justin King, 2023 URECA Recipient

Co-Author/Collaborator: Aidan Thornton

Faculty Advisor: Mostafa Rahnama, Biology

Telomeres, the protective DNA segments at the ends of eukaryotic chromosomes, play a pivotal role in preserving genome integrity. Additionally, telomeres can influence gene expression near chromosome ends (subtelomeric genes) through the telomere position effect (TPE), which involves silencing these genes, often through histone modification. P. oryzae, the causal agent of rice and wheat blast diseases, poses a significant threat to global crop production. For the first time, Rahnama lab demonstrated that P. oryzae uses TPE to silence its subtelomeric genes. Following up on this finding, we aim to uncover the mechanical intricacies of TPE in P. oryzae, focusing on its constituent processes and regulatory genes. We have identified two proteins in P. oryzae that are similar (homologous) to the known regulators of TPE in model organisms. We intend to elucidate the regulatory roles of these two proteins in the TPE and other biological activities of P. oryzae by deleting their coding genes. This research will enhance our understanding of TPE in this fungus and offer insights into telomere dynamics. It may identify novel targets to control crop blast diseases, mitigating the pathogen's impact on agriculture and global food security.

Department of Chemistry

Chemistry

Graduate Student

Synthetic Access to Unsymmetric 1,2,4 Triazole Complexants via Molecular Iodine -Oxidative Cyclization of Carbaldehydes & Heteroaryl Hydrazonimides

Author: Emmanuel Aimiuwu

Faculty Advisor: Jesse Carrick, Ph.D., Chemistry

The search for an effective strategy for separating minor actinides from lanthanides in spent nuclear fuel (SNF) has been ongoing for years. Challenges for expanded use of nuclear energy exist due to the long half-lives of minor actinides. Designing a complexant for separating minor actinides from lanthanides is crucial. Previous research has focused on synthesizing soft-Lewis-N-donor complexants for improved liquid-liquid separations. This research project aims to develop synthetic techniques for unsymmetric complexants and assess potential impacts on liquid-liquid separations. Specifically, experimental effort focuses on oxidative cyclization of carbaldehydes and heteroaryl hydrazonimides to afford the unsymmetric 1,2,4 triazole. Several compounds were produced in good yield using optimized reaction conditions in two pots. Characterization of the isolated product was confirmed using FTIR and 1H & 13C NMR. Method

development and optimization, preliminary substrate scope, and functional group interconversion of important substrates will be presented.

Progress towards the Synthesis of Unsymmetric Tridentate Complexants for Application to Minor Actinide Separations

Author: Racheal Ajibola

Faculty Advisor: Jesse Carrick, Ph.D., Chemistry

Nuclear energy is distinguished for the generation of emissions-free power which is non-polluting to the atmosphere. Despite this pros of nuclear energy, the highly radioactive waste generated from spent nuclear fuel (SNF) as a result of the minor actinides (MA) being present needs to be effectively managed. The formation of an ideal complexant that will selectively separate MA from SNF is essential. Developing unsymmetric complexant scaffolds can be very explorative and has been hypothesized to improve challenges such as solubility difficulties and degradation challenges that have marginalized the efficiency of some symmetric complexants. By harnessing soft-Lewis basic unsymmetric complexants, substituents having different electronic properties can be introduced on both sides of the complexant which can aid the performance in separating MA from SNF. Reaction conditions to develop an unsymmetric complexant having a 1,2,4-triazole synthon have been developed. During the substrate expansion, the reaction conditions have been found to be regioselective based on the substituents and inductive strength of the starting materials used. These conditions make it possible to access unsymmetric complexants having a 1,2,4-triazole and 1,3,4-oxadiazole synthons synchronously. Efforts to obtain a good separation of both regioisomers for appropriate application are currently ongoing. Current synthetic results and future directions will be presented.

Progress towards the total enantioselective synthesis of Hamigeromycin B - Polyketide Synthon

Author: Victor Jonathan

Faculty Advisor: Jesse Carrick, Ph.D., Chemistry

Resorcylic Acid Lactones (RALs), in recent years, have emerged as a group of fungal polyketides with a vast array of therapeutic properties against a number of diseases such as cancer, malaria, and bacterial infections. They possess a macrolide core structure linked to an aromatic ring called resorcinol -- these structural features have proved to be essential pharmacophore in their bioactivity. Since Radicicol was isolated in 1953, more than 200 RALs have been identified; one of which is hamigeromycin B. hamigeromycin B is a natural product with potential for mediating signal transduction in human kinases. It belongs to the hamigeromycin family (A-G) of RALs that consists of 7 14-membered RALs. Studies have shown the druggability of this molecule hence making it a target for synthesis. The retrosynthetic pathway involves two key synthons --a polyketide and a styrene acid synthon. Styrene acid synthon had been previously completed in the Carrick lab hence the goal of this study is to obtain the polyketide synthon in good yields over 5 steps and ascertain the end-game strategy for the macrolide formation. The polyketide synthon's synthetic strategy involves hetero Diels-Alder cycloaddition and 1,4-conjugate addition employing allyl tributyl tin to yield a vinylogous lactone before condensation with the styrene synthon via esterification and ring-closing metathesis. The importance of this molecule, and the peculiar synthetic challenges involved with this study will be discussed.

Telescoped condensation of heteroaryl carbonitriles toward unsymmetric, pyridyl-1,2,4-triazine complexant scaffolds for chemoselective minor actinide separations

Author: Eric Agyei

Faculty Advisor: Jesse D. Carrick, Ph.D., Chemistry

Research efforts in the field of separation science are currently focused on advancing the development of materials that enable effective and selective extraction of minor actinides from spent nuclear fuel (SNF). The development of new methods to synthesize soft-Lewis base structures with efficient separations of trivalent actinides from lanthanides remains the primary goal of research in this lab. In the past, complexant design with soft N-donor properties has mostly been focused on symmetric moieties of the bis-triazinylpyridine (BTP) class of compounds. The introduction of unsymmetric BTP scaffolds is envisioned to have improved solubility, as well as good complexation performance over symmetric BTP scaffolds in process-relevant diluents. In this work, telescoped condensation of heteroaryl carbonitriles with diversely functionalized 1,2-dicarbonyl afforded 22 examples of the proposed unsymmetric complexant scaffolds in good yields. Access to the heteroaryl carbonitrile synthons as starting materials for this transformation was achieved through a metal-free oxidative condensation approach from their corresponding heteroaryl carbaldehydes. Separation

studies of selected unsymmetric BTPs in simulated SNF (241Am3+ vs. 152Eu3+) are currently ongoing. The optimized synthetic method for these scaffolds, as well as comparative solubility analysis data, will be presented.

Developing Cellular Assays to Evaluate the Efficacy and Specificity of JNK3 Isoform-specific Inhibitors with Therapeutic Potential for Neurodegenerative Diseases

Primary Author: Nadia Mireku

Co-Authors/Collaborators:
Kyleen Carver
Lindsey Morgan

Faculty Advisor: Xuanzhi Zhan, Chemistry
The c-Jun N-terminal kinase 3 is a JNK isoform that is mainly expressed in the central nervous system (CNS), and to a lesser extent in the heart and the testis. JNK3 is involved in the regulation of cell growth, cell division, apoptosis and survival. Accumulating data suggest the necessity of isoform-specific JNK inhibitors for therapeutic use to reduce the side effects of pan-JNK inhibition. Because of its CNS-specific distribution and pro-neuron death properties, the JNK3 isoform is an attractive therapeutic target for the treatment of neurodegenerative diseases. The development of a selective inhibitor for one isoform family of c-Jun N-terminal kinase remains great challenge. A series of peptide inhibitors were recently developed which demonstrate great JNK3-isoform inhibition selectivity by targeting the specific interactions between JNK3 and its binding partners. The efficacy and selectivity of these new peptide-based inhibitors in cells must be carefully evaluated. Here, a number of cellular tests are proposed to study the inhibition of JNK3 activation by various cellular stimuli.

Synthesis of pyridyl-1,2,3-triazole complexant scaffolds via an intramolecular DBU-mediated cyclization of n-tosylhydrazones

Author: Orume Edirin

Faculty Advisor: Jesse Carrick, Ph.D.

The continuous search for chemoselective complexants for the selective separation of minor actinides from lanthanides in spent nuclear fuel (SNF) is a crucial step toward closing the nuclear fuel cycle. Although minor actinides comprise just 0.1% of the SNF's mass, they have a significant effect on the SNF's relative radiotoxicity. The minor actinides must first be separated from the SNF, especially from closely comparable trivalent lanthanides, to transition into more stable, shorter-lived isotopes. The primary objective of this study is to identify and produce N-donor complexant scaffolds that incorporate pyridyl-1,2,3-triazoles. The investigation of metal-free techniques has been established. One such technique is the cyclization of Ntosylhydrazones mediated by 1,8 Diazabicyclo(5.4.0)undec-7-ene. With this technique, good yields of pyridyl-1,2,3-triazole complexant scaffolds have been produced. Currently, 25 novel pyridyl-1,2,3-triazoles have been successfully synthesized using the optimized method in good yields. Preliminary substrate scope, functional group interconversion of significant substrates, method development, and optimization will be presented.

Chemical Fingerprinting of Pepper Sprays Utilizing Gas Chromatography

Author: Emma Schrider

Faculty Advisor: Jeffrey Boles, Ph.D., Chemistry

With increased usage of aerosol defense sprays as a weapon coupled with the increased use as personal protection in a riot, we sought to develop a method to chemically fingerprint spray residues using existing and emerging technologies. Various spray residues are often found as evidence and these include personal-protection sprays, wildlife sprays and tear gas. Currently, forensic methods commonly used in crime laboratories only differentiate between a pepper spray and a tear gas at a qualitative level. Since this is limiting as forensic evidence, we sought to provide more identifying information on the various commercial sprays since each manufacturer's product will have a distinctive chemical fingerprint. The method selected is one that utilizes both GC-MS and GC-FTIR, each of which is common to state crime laboratories. Pepper sprays, wildlife sprays and tear gas-enhanced sprays were analyzed and quantified through external calibration. A library database of commercial sprays and standards was initiated in order to differentiate solvent profiles as well as active components.

Optimizing Microwave-Assisted Extraction for Exploratory Analysis of Organic Pollutants in Household Dust

Primary Author: Busola Olope

Co-Author/Collaborator: Oluwasola Ifedayo

Faculty Advisor: Andrew Callender, Ph.D., Chemistry

The detection and quantification of organic pollutants in household dust carry significant implications for human health and the environment. Therefore, it is imperative to develop effective and accurate analytical methods for their analysis. Organic pollutants are carbon-containing chemical compounds that come from a variety of sources, including human activities and natural processes. These organic pollutants have been proven to have carcinogenic, neurotoxic, immunogenic, and estrogenic properties. This study proposes a combined non-targeted and targeted approach using microwave-assisted extraction (MAE) and gas chromatography-tandem mass spectrometry (GC-MS/MS) to analyze household dust samples from middle Tennessee. MAE offers advantages such as reduced extraction time and lower solvent consumption. GC-MS/MS provides rapid chromatographic separation and sensitive detection. Non-targeted analysis identifies pollutants, followed by targeted analysis to quantify specific organic pollutants like flame retardants and phthalate esters. This research significantly contributes to our understanding of the composition, concentration, and potential health risks associated with exposure to organic pollutants in indoor environments. This knowledge is important for policymakers and health practitioners to implement measures to reduce human exposure and protect both human health and the environment.

Undergraduate Students

Gender effects on Item Responses for General Chemistry Exams

Author: Olivia Furr, 2023 URECA Recipient, 2023 CISE Recipient

Faculty Advisor: Chad Rezsnyak, Ph.D., Chemistry

Gender has an impact on many aspects of our society, some more visible than others. In fields related to science, technology, engineering, and mathematics (STEM), individuals who identify as males have dominated these areas for many years. By gathering and statistically analyzing final exam results from general chemistry students at a rural Tennessee university, this presentation plans to analyze the effects a student's gender may have on not only overall test scores, but also on the manner in which these students interact with questions and answer choices. The data will be analyzed to determine if disparities in exam scores exist based on gender, and if so, what factors might be contributing to those disparities. That knowledge will then be used to create exams, questions, and answer choices that are more equitable to all students in order to set up all students for success regardless of gender.

3D Printing and Chemically Activating an Electrode Array

Author: Evie Lawlor

Faculty Advisor: Jonathan Moldenhauer, Ph.D., Chemistry

Electrodes on the small scale can require costly equipment to produce. However, with affordable 3D printing technology, smaller printed electrodes open a world of possibility. Small electrodes can be printed more easily and cost effectively, making it more accessible, which allows for a more varied data pool, as more researchers in different areas can conduct experiments. An electrode is extruded from a 3D printing pen with multiple electrodes forming an array. It is printed from conductive and non-conductive filament, and then is chemically treated with dimethylformamide (DMF). The electrode array is then used in a series of electrochemical tests to test its conductivity and efficiency. The data can be compared to a typical electrode's performance. It is anticipated the data will be comparable to a typical electrode array, with each electrode having the ability to function individually. If successful, this method can be used to easily produce electrodes of different designs and in smaller sizes.

Utilization of APCI-mass spectrometry for field identification of opioids

Author: Claudia McDavid, 2023 CISE Recipient

Faculty Advisor: Jeffrey Boles, Ph.D., Chemistry

In the United States, there has been an increase in illicit opioid use, including heroin, fentanyl, and other Novel Synthetic Opioids (NSOs) such as U-47700, AH-7921, and MT-45. In the past, law enforcement has relied on colorimetric testing to identify illicit substances in the field. However, due to the risk of fentanyl exposure, law enforcement is moving towards the use of portable, definitive laboratory techniques such as Raman spectroscopy or mass spectrometry. Mass spectrometry is considered the gold standard in forensic laboratories for the identification of unknown substances. This project aims to identify opioids with APCI-mass spectrometry. An APCI-mass spectrometry method will be developed using known opioid standards. Further development and optimization will

be accomplished with clandestine samples from local law enforcement.

Synthesis of Supramolecular Macrocycle-Dye Conjugates via Suzuki-Miyaura Cross-Coupling Reactions

Primary Author: Andrew Nguyen, Swindell, Jackson Research Assistantship

Co-Author/Collaborator: Ella Reynolds

Faculty Advisor: William Carroll, Ph.D., Chemistry

The formulation of new colorants that are both inherently colorfast and stable is an active area of research. By using 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) coupling between alkylamine substituted carbazole derivatives and carboxylic acid functionalized dyes, a substituted monomer can be formed. This monomer can then undergo a Suzuki-Imine cross-coupling reaction with a m-dianiline linker, forming a supramolecular macrocycle. The shape of the macrocycle can be controlled by manipulating the length and substitution pattern of the monomer and linker. By covalently bonding the dye to the macrocycle, exposure to various chemical environments can be controlled. With this increase in control, the possibility of photodegradation is reduced, allowing for the addition to plastics for long-lasting coloration. With the substitution of the alkylamine spacer, the conjugation of the dye can be extended into the macrocycle, increasing the maximum wavelength the system can absorb. With the manipulation of the monomer and linker, this work explores the creation of more stable, vibrant reactive colorants for application to plastics and textiles.

Microbially Mediated Redox Cycling of Fe(III)/Fe(II) in Soils: Effect of Glucose on Formation of Floating Fe(III) Films
Author: Luke Overton

Faculty Advisor: Hong Zhang, Ph.D., Chemistry

Iron (Fe) is widespread in soils and waters. Fe is important in many environmental chemical phenomena where Fe (III) is reduced to Fe(II) to become soluble and mobile and Fe(II) is oxidized to Fe(III) to become insoluble. Previous research showed that in the presence of glucose ($C_6H_{12}O_6$) as energy source for soil microbes, Fe(III) oxides in fresh soils can be reduced microbially to Fe(II) and the Fe(II) then can be oxidized to Fe(III) to hydrolyze to form oil-like Fe(III) films floating on water of flooded or inundated soils.

We investigated the role of glucose in the Fe(III) film formation. Our particular research question was: Is there a concentration threshold (minimum level) of glucose required for occurrence of the Fe(III) films in the soils? We collected a number of soils in Cookeville (TN) and used various levels of glucose to test the Fe(III) film occurrence in these soils. Our research showed that for each of all the soils tested, there was indeed a minimum level of glucose required for the Fe(III) films to occur. This provides a further research lead to probe why such a threshold is required and quantify the energy flow (electron transfer) during the Fe(III) film formation.

Improving Upon Topoisomerase Inhibiting Organic Compounds

Primary Author: Daniel Whiteaker

Co-Authors/Collaborators:
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Kate Cooper

Faculty Advisor: William Carroll, Ph.D., Chemistry

Topoisomerase is a protein that is essential to the replication of cancerous cells. Therefore, finding means to inhibit Topoisomerase, can be greatly beneficial to the treatment of various cancers. Our efforts focused on improving recently reported natural products with known cancer fighting activity. Using computational software, such as MOE, we are able to simulate docking these Topoisomerase inhibitors and quantify how well they dock to the Topoisomerase itself. Using this data, we can then theorize improvements upon these compounds, and then simulate these improvements in MOE to see if the changes made a significant difference in the docking efficiency. Once a target with improved docking efficiency is identified we designed a synthesis to produce this molecule and have begun attempts to synthesize it for testing.

Comparison of Heavy Metal Concentrations in Inorganic and Organic Fertilizers Using ICP-OES and XRF Spectroscopy

Primary Author: Sydney Decatur

Co-Author/Collaborator: Michael Natrass

Faculty Advisor: Andrew Callender, Ph.D., Chemistry

The presence of heavy metals in agricultural soil has become a major environmental concern. Identifying

where these pollutants are coming from and the quantity in which they are present can help to better understand the problem and find solutions that avoid health and environmental hazards. One of these sources of heavy metals is fertilizer. This research aims to compare heavy metal concentrations in inorganic and organic fertilizers using X-ray Fluorescence (XRF) and ICP-OES Spectroscopy. Three different fertilizer samples were used, Sta Green Lawn Fertilizer 22-0-4 (+2% Iron), Miracle-Gro 5-5-10, and Milorganite 6-4-0. For creating the samples, fertilizer was taken from the top, middle, and bottom of the collection to ensure the samples were as homogenized as possible. For the XRF machine, samples were ground into a fine mixture, and for the ICP-OES machine, samples were put through a method of acid digestion using a microwave. Metals that were expected to be found are as follows, Zinc, Mercury, Cadmium, Lead, Copper, Nickel, Arsenic, and Chromium.

Synthesis of macrocycles for untangling of nanoplastics

Author: Wesley Gibson

Faculty Advisor: Kyle Murphy, Ph.D, Chemistry

Polystyrene-based nanoplastics are an under-investigated and burgeoning threat to Earth's aquatic ecosystems. Nanoplastics are less-than-microscopically small bundles of polymers, and they have the potential to unravel into individual strands after the permeation of cellular membranes, potentially causing the death of the affected cells.

Fluorene-based macromolecular rings/helicene polymers may serve useful in the capture and removal of nanoplastics from aquatic systems. The potential capture of polystyrene-based polymers should be encouraged by the macrocyclic-polymer interactions that guide the polymer to and then through the macrocycle, as well as the kinetic-favorability of the filling of the macrocyclic cavity.

Extraction Methods for the Analysis of Volatile Molecules in Coal Samples

Primary Author: Bella Cable, Chemistry Academic Scholarship

Co-Author/Collaborator: William Carroll, Ph.D., Chemistry

Faculty Advisor: William Carroll, Ph.D., Chemistry

The chemical composition of coal may help establish the temperatures it has experienced. Recently, the chemical analysis of the char produced by wildfires has provided models to establish the temperature of the fires that produced it. We hope to apply this understanding of the chemical products of wildfires to coal and charcoalified matter. This research focuses on the best extraction methods for volatile small molecule compounds from coal. Extraction methods include using a Soxhlet extractor and direct contact of coal samples in heated solvent. These extraction methods will be compared by using NMR and mass spectrometry to analyze the aromatic content of the solvents. The NMR data will be collected using solution-state carbon NMR with coal samples donated by the Illinois Geological Survey. This data will be used to examine the effects of time and temperature on the aromatic content in coal samples. Analyses of these volatile contents of samples will aid in producing a way to measure the temperature experienced by coal.

N-acyl hydrazone and semicarbazide furfural derivates as novel tools for disrupting microbial biofilm formation

Primary Author: Danielle Ferguson, 2023 URECA Recipient

Co-Author/Collaborator: Iroda Abdullaeva, Chemistry

Faculty Advisor: Kyle Murphy, Ph.D., Chemistry

In America, there is an overuse of antibiotics. The over-prescribed use of antibiotics has caused bacteria to adapt and form into multidrug-resistant bacteria. This research creates a library of pure hydrazone furfural derivatives that can create more opportunities for antimicrobial compounds. The research pertains to the organic synthesis of hydrazone furfural derivatives performed under sustainable and green chemistry conditions. Research is performed under short reaction times, with water as both the solvent and for filtration and purification of products. This project aims to synthesize hydrazones and characterize them via NMR spectroscopy and TLC to determine reaction success and purity. It is generally observed that these products can be synthesized in high yields (>85%). With future work pertaining derivatizing the compounds that have proved most successful against S. aureus and assessing if they are more suitable candidates for reduction of growth in bacteria as well as for biofilm inhibition.

Chemistry - Biology

Undergraduate Student

N-acyl hydrazone furfural derivates as candidates for inhibition of quorum sensing in bacteria

Primary Author: Iroda Abdullaeva, 2023 CISE Recipient

Co-Author/Collaborator: Danielle Ferguson**,** Chemistry, Biology

Faculty Advisor: Kyle Murphy, Ph.D., Chemistry

The diseases resultant from antibiotic-resistant pathogens are reported to result in understated 700,000 annual deaths globally -- a number that is projected to increase at least tenfold by 2050. The resistance in microbial pathogens is selected for naturally, partially as a consequence of misuse and overuse of the present antimicrobial countermeasures. One of the strategies incorporated by microbes to select for the resistances is a signaling network that constitutes a surface-associated assemblage of microbes -- biofilms. The signaling network, known as quorum sensing, imparts genetic activation/inactivation that differentiates communal behavior of microbes. This project intends to create a collection of quorum sensing inhibitors derived from a green chemical furfural and N-acyl hydrazide to negate biofilm formation and mitigate the escalating health crisis. The synthetic scheme is performed under nonthermal conditions, short reaction times, water solvent, and purification by filtration in water. Thin Layer Chromatography (TLC) is used as a preliminary analytical method, followed by Nuclear Magnetic Resonance (NMR) analyses to confirm successful syntheses. The synthesis of several N-acyl hydrazone furfural derivatives in high purity and percent yield has been achieved, and the project is to continue to the testing pertaining to quorum sensing inhibition. The most successful compounds will be derivatized and polymerized to potentially augment quorum sensing disruption.

Chemistry - Custom, ACS Certificate

Undergraduate Student

The Latest Developments in Tennessee Tech's New Fourier Transform Microwave Spectrometer

Primary Author: Mitchell Swann, Skinner Chemistry Scholarship

Co-Authors/Collaborators:
Rusiru Rajapaksha
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Ranil Gurusinghe, GruLab

Faculty Advisor: Ranil Gurusinghe, Chemistry

Fourier Transform Microwave (FTMW) spectroscopy is a powerful rotational spectroscopic tool that is used for probing gas phase chemistry. Rotational spectroscopy can provide the precise three-dimensional geometry of polar molecules, making it a popular technique in the fields of radio astronomy, combustion chemistry, photochemistry, and fundamental science. The Gurusinghe Lab (Gru Lab) at Tennessee Tech University has designed and custom-built a FTMW spectrometer that combines two popular rotational spectroscopic techniques: Cavity and Chirped-pulse FTMW spectroscopy. This new spectrometer combines a high vacuum system, pulsed supersonic molecular beam source, Fabry-Perot microwave cavity, microwave circuit, and Python interface. We will present the most recent progress in instrument development and the first molecular rotational signals we recorded.

Chemistry - Forensics

Undergraduate Student

Comparing the effectiveness of varied conductive 3D-printing filaments

Author: Cayden Cravener, Presidential Scholars

Faculty Advisor: Jonathan Moldenhauer, Ph.D., Chemistry

This research compares multiple conductive 3D-printing filaments and aims to determine which is the most efficient electrode. The only filament type being tested is polylactic acid (PLA). The information as to which is the most effective filament will allow for much cheaper and more precise fabrication of electrodes through 3D-printing rather than standard production methods which often require rare earth minerals and highly specialized machinery. Our specific approach is to compare the suitability of different commercially available brands of filament. This comparison will be done by taking repeated

measurements of each filament using a potentiostat to determine their sensitivity and how effective each is at electron transfer.

Environmental Chemistry

Undergraduate Students

Microbially Mediated Redox Cycling of Fe(III)/Fe(II) in Soils: Effect of Organic Acids/Ligands (acetate and oxalate) on Formation of Floating Fe(III) Films

Author: Danner Keeton

Faculty Advisor: Hong Zhang, Ph.D., Chemistry

Iron (Fe) is ubiquitous in the environment, with ferrous Fe (Fe(II)) being soluble and mobile, while ferric Fe (Fe(III)) is typically insoluble. Redox cycling between Fe(III) and Fe(II) plays a vital role in soil and water chemistry, occurring through both abiotic and microbial processes. Previous studies have demonstrated microbial reduction of soil Fe(III) oxides to Fe(II), followed by oxidation back to Fe(III), resulting in the formation of floating Fe(III) films.

Our research in Cookeville (TN) aimed to investigate the impact of organic acids/ligands, such as acetate and oxalate, on the formation of Fe(III) films. Our findings suggest that these acids alone failed to induce Fe(III) film formation, indicating that soil microbes may not directly utilize them as an energy source for microbial reduction of soil Fe(III) oxides. Moreover, higher concentrations of these organic ligands impeded film formation by binding to Fe(III), making it soluble and thus hindering Fe(III) film formation. Notably, oxalate exhibited a stronger effect than acetate, consistent with its higher binding affinity to Fe(III). Future research will delve into the effects of additional organic acids/ligands on Fe(III) film formation in soils.

Organic Chemistry

Graduate Students

Synthesis of Esteroxy-Substituted Symmetric Bis-(1,2,4)-Triazinyl Pyridine (BTP) Complexants towards Minor Actinide Separations of Spent Nuclear Fuel (SNF)

Author: Samiat Olayiwola

Faculty Advisor: Jesse Carrick, Ph.D., Chemistry

As an established source of electrical power, Nuclear energy has shown several advantages including carbon free emission, but a barrier to the expansion of this power source is the disposal of this radioactive by-products of nuclear fission. Spent Nuclear fuel (SNF) after separation contains residual substances which are a mixture of 241Am, 244Cm, lanthanides and other isotopes. Separation of An (III) from Ln (III) is challenging due to the physical properties between the two groups. Prior work in our lab has afforded unsymmetric, and symmetric mono-triazinyl pyridine (MTP) and bis-(1,2,4)- triazinyl pyridine (BTP) scaffolds with promising results for minor An (III) separation. This research project is centered on enhancing the performance of these scaffolds by adding an ester functional group to symmetric BTP scaffolds which could potentially improve the performance of this tridentate ligand and allow for enhanced solubility. The experimental work involved a telescoped pathway acylation with 3,3-dihydroxyl benzil and acyl chlorides upon condensation with bis-hydrazonamide to afford the esteroxy-BTP complexants. Subsequently, a series of ester functionalized BTPS were obtained. Characterization studies using NMR spectroscopy ensured the successful synthesis of the desired compounds. Solubility tests were performed in extraction solvents. Current synthetic results, characterization data, acid contact data, and solubility studies of this complexants will be presented.

Pure Chemistry

Undergraduate Students

Low Barrier Quantum Tunneling in the CIS and Trans Conformer of 3-Methylsytrene probed using FT-Microwave Spectroscopy

Primary Author: CadenceMiller, 2023 URECA Recipient, 2023 CISE Recipient, James Powell and Willie Rush Jewell Endowed Scholarship

Co-Authors/Collaborators:
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Faculty Advisor: Ranil Gurusinghe, Chemistry

Rotational spectroscopy is unique because of its sensitivity to small mass and conformational changes

leading to highly accurate structure determination. The sensitivity of the technique also allows for the study of quantum tunneling associated with a methyl rotor, and subsequently how conformational changes impact the methyl rotor. This is what we have done with the first recorded pure rotational spectrum of 3-methylstyrene (3MS). The rotational spectrum (10-22 GHz) was recorded using the cavity molecular beam Fourier transform microwave spectrometer at Kent State University. The cis- and trans-conformers have been differentiated through computational geometry optimizations on Gaussian-09, at the B3LYP-GD3BJ/Def2TZVP level of theory. The low dipole moment and low methyl torsional barrier result in weak and widely split rotational lines for both conformers. We used BELGI-Cs and XIAM internal rotor fitting programs for both the cis and trans conformers. We have fit 115 transition frequencies of cis-3MS, up to J=11, to obtain its torsional and rotational parameters. Our fits show a low barrier to methyl torsion in cis-3MS, V3 = 30.35 (5) cm-1, aligning with the behavior observed in toluene and its derivatives lacking significant steric hindrance. We fit over 60 transitions of trans-3MS (up to J=10) in the 10-22 GHz range to obtain vibrational ground state torsional and rotational parameters. This research can provide fundamental insight into more complex molecules.

Analysis of Metal Cations and Vitamins Through ICP-OES and HPLC

Author: Sean Wheat

Faculty Advisor: Andrew Callender, Ph.D., Chemistry

Quality control is a critical element in any company's process in manufacturing. The area in question by this project are vitamin companies. The goal of this project is to determine whether or not these companies are producing vitamins with their claimed quantity of supplements. Various vitamins and supplements were gathered containing metals such as zinc, iron, and magnesium, as well as multivitamins containing B series vitamins as well as other important metals for the body. These vitamins were then crushed and microwave digested with nitric acid, and then diluted before being analyzed with the ICP-OES. B series vitamins underwent extraction with dilute methanol before being analyzed by the HPLC.

Department of Earth Sciences

Earth Sciences

Undergraduate Students

Assessing Contaminant risks in streams adjacent to landfills and farmland in Rutherford County Tennessee

Author: Matthew Carmichael

Faculty Advisor: Joseph Asante

Leachate, illicit discharge, remnants of farming activities, and landfill operations are potential sources of deleterious contaminants. Environmental contaminants can pose a significant threat to aquatic ecosystems, human well-being, and the overall socioeconomic landscape. The objective of this study is to determine the exposure and potential risk from harmful contaminants in streams close to landfills and farmlands in Rutherford County, Tennessee. Water quality data were collected at three locations along the streams Lytle, Wades Branch, and West Stone to facilitate a comparative analysis of water quality. These three streams were analyzed for field parameters, metals, and anions. The preliminary results indicate elevated levels of copper (Cu), chromium (Cr), nickel (Ni), cadmium (Cd), and lead (Pb) at Lytle and Wades Branch compared to West Stones. While most metal concentrations fall within acceptable limits for freshwater ecosystems, this data highlights potential sources of pollution originating from agricultural runoff and waste disposal sites, as evidenced by the relatively high levels of heavy metals. The relationship between stream ecological status, land use, and water quality will also be assessed.

Environmental Geology

Undergraduate Students

Relationship Between Land Use and Quality of Rivers in the Falling Water River Watershed, Cookeville, Tennessee

Author: Gage Lineberry

Faculty Advisor: Joseph Asante, Ph.D., Earth Sciences

Modern societies are growing increasingly concerned about anthropogenic influences on the chemical composition of rivers due to health and environmental concerns. The research objective is to evaluate how land uses impact stream quality in the Falling Water River watershed. The hypothesis was that water quality is lower for more developed and agricultural watersheds. For this research, the parameters that were measured to determine water quality are pH, Dissolved Oxygen (mg/L), Electrical Conductivity

(ÂµS/cm), Temperature (Â°C), and Alkalinity. The data were collected each day of the field visit at three field sites, with each site within the sub-watersheds Cane Creek, Falling Water River, and Taylor Creek. The physicochemical parameters of 21 samples were measured during the data collection campaign. To correlate the results with land use, watersheds were created for each data collection site using ArcGIS Pro, and the dominant use of each watershed was determined using the NLCD land cover data. The preliminary results show Falling Water River, the most urbanized watershed, had the lowest dissolved oxygen, the highest electric conductivity, and the highest alkalinity. Taylor Creek, the most agricultural watershed, had higher dissolved oxygen and alkalinity. The study results suggest a correlation of the physicochemical parameters with their geographic land uses and the City of Cookeville's negative impact.

Geology

Undergraduate Students

CXRD Illite Crystallinity Technique: Developing Laboratory Standards and Testing of Appalachian Shales

Primary Author: Robert Moore, 2023 CISE Recipient

Co-Authors/Collaborators:
Riley Mansell, Earth Sciences
Gourab Bhattacharya, Earth Sciences
Mike Harrison, Earth Sciences

Faculty Advisor: Gourab Bhattacharya, Ph.D., Earth Sciences

X-Ray Diffraction (XRD) analysis of illite crystallinity is an established technique for determining the peak burial temperatures experienced by sedimentary rocks rich in clay minerals. Currently, at Tennessee Tech, we are spearheading the development of nine international clay mineral standards based on Paleozoic mudrock. These standards will serve as essential reference points for our laboratory dataset and facilitate comparisons with similar datasets from other research facilities. By establishing the clay mineral standards, we aim to not only enhance collaboration within the broader scientific community but also provide a benchmark for future intra-department research projects that focus on burial temperature assessments.

The Appalachian Basin, an archetypal petroliferous basin, developed and evolved in response to four key Paleozoic mountain building episodes, and over hundreds of millions of years, maintained the thermal conditions necessary to generate and store hydrocarbons. Our research objective is to ascertain the maximum depositional temperatures of the mudrocks comprising the Cumberland Plateau. We will present preliminary XRD results from the Appalachian mudstones and shales, offering insights into the thermal regimes associated with sediment burial in the region. Understanding these thermal conditions will also enable us to investigate the variations in upper crustal temperatures across the Cumberland Plateau in response to the Appalachian-Ouachita orogeny.

Geoscience

Undergraduate Students

Using GIS Modeling to Address the Issue of Chronic Absenteeism in a Rural Tennessee County.

Primary Author: Sierra Alexander

Co-Authors/Collaborators:
Michael Harrison, Ph.D.
Peter Li, Ph.D.

Faculty Advisor: Michael Harrison, Earth Sciences

Using GIS Modeling to Address the Issue of Chronic Absenteeism in a Rural Tennessee County.
Chronic absenteeism, defined as missing 10% or more instructional days, is a multifarious problem affecting millions of students each year. According to a 2023 report from the Tennessee Comptroller of the Treasury, the chronic absenteeism rate increased by 7% between 2019 and 2022, affecting most school districts in Tennessee. According to the National Association of Elementary School Principals, common barriers to attending school include family challenges, limited transportation, illness, aversion to academics or school climate, and misconceptions about why attendance matters. In this study, the issue of limited transportation was addressed for a rural Tennessee school district. Geospatial modeling was used to develop more efficient bus routes for a district with high rates of chronic absenteeism. In this district, only students who lived outside a 1.5-mile radius from a school were initially eligible for bus transportation. The modeling identified prime locations for new bus stops within the school's 1.5-mile radius that targeted areas of high absenteeism; also, it allowed the redesign of existing routes to increase efficiency. Preliminary attendance data from the school district

after these route changes were implemented indicate attendance improved at the elementary and middle schools, however attendance decreased by 2% at the high school. There are many causes of chronic absenteeism; improving access to bus transportation is just one factor in this complex problem.

Comprehensive Analysis and Report of Cedar Crest Camp Watershed

Author: Raley Hendrix, 2023 URECA Recipient

Faculty Advisor: Evan Hart, Earth Sciences

Water-based recreation is a prevalent part of summer camp curriculum. Because of this, it's important that camps have knowledge of the health of any water systems part of their programming. The goal of this research is to create a comprehensive analysis of the water systems located at Cedar Crest Camp in Hickman County, Tennessee. This analysis will provide camp staff with insight into the health of their camp property, as well as provide additional information to be used as part of their environmental education program.

The study focuses on the Barren Fork stream and Cedar Crest Lake systems within the camp's watershed, and consists of three main stages:

- Chemical analysis of water quality, assessing pH, turbidity, hardness, conductivity, common compounds, and bacteria through field and laboratory tests.
- Biodiversity census of invertebrates in the Barren Fork stream using a kick-net and sieve bucket.
- Creation of several maps, including soil and land use cover, topography, and a bathometric model of the lake bottom based on field measurements.

Chemical analysis from both sites will be compared to identify potential sources of pollution that could differentiate between sites. Sample collecting is still ongoing, but preliminary results of the chemical analysis show that both systems are within EPA regulations, apart from the presence of E. Coli. Final analysis will provide camp staff with the proper knowledge to plan for healthy water-recreation activities for their campers.

Upper Cumberland Oral History Project: Preserving Weather History by Interviewing Long-term Residents

Author: Theodora Kline, 2023 CISE Recipient

Faculty Advisor: Meagan Atkinson, Volpe Library Archives

The people of Appalachia have a remarkable perspective on weather marked by its impact on their culture. While valuable, this perspective has rarely been preserved. Other notable projects have recorded the oral histories of similar regional communities, though it has never been done for Upper Cumberland. Therefore, we sought to preserve the weather-related oral histories for this region. To do this we sought out people who have lived in Upper Cumberland for more than 30 years to tell us notable weather events and how each affected them.

It is vital that these statements be preserved and collected before researchers lose this generation to the ailments that come with old age. Researchers must also understand the Appalachian dialect and interpret the unique phrases used.

Each interview was recorded and preserved digitally through transcription and uploaded on the Tennessee Tech Archives website. These can be used for future research into weather, agriculture, culture, or the Appalachian accent.

Capybara Distribution Analysis: An Exploration of South American Capybara Populations

Author: Peyton Brewer

Faculty Advisor: Jeannette Luna, Ph.D., Earth Sciences

Understanding the distribution of different wildlife species is important to do any conservation efforts. In this project we use capybara data collected from users on the iNaturalist app to analyze the distribution of capybara in South America over the years of 2010 to Feb. 26, 2024. iNaturalist is a useful tool that allows citizens to report species sightings, allowing the use of the platform for ecological research. We analyze this data and overlay it over population data to understand the effect urbanization has on this species. Additionally, because iNaturalist users often enter data on portable devices, we analyze the effect that cell towers have on data accuracy, as well as if capybaras are displaced by infrastructure built. Preliminary analysis done for the area of Sao Paulo, Brazil suggests that capybara are found in cities as well as in less urban areas; however these capybara in cities are primarily found in park areas or along water features like canals. Additionally, the overall

distribution of the capybara data suggests that the data is limited to the areas in which people had already lived.

Department of English

English

Undergraduate Students

A Tragic Resemblance: The Satirical Tale of Romeo and Juliet

Author: Shannon Long, Tennessee HOPE, Tennessee Tech High Flyers

Faculty Advisor: Kristen Deiter, Ph.D., English

In this analysis of Shakespeare's Romeo and Juliet, I study the actions of his characters alongside common societal norms of sixteenth-century England. Shakespeare based his characters' actions, behaviors, and beliefs on true personalities of the time and portrayed them in a satirical style, using exaggeration and often humor. This research gives readers insight on how Shakespeare organized and structured his writing based on his surroundings. The ideas of marriage, family, religion, and the roles of men and women are topics included in Shakespeare's play that center on beliefs in sixteenth-century England. The research connects the Montagues and Capulets to Queen Elizabeth I and Mary, Queen of Scots. The relationships correlate between their mannerisms and actions. This analysis views the romantic relationship between Romeo and Juliet to be one that is defiant of societal pressures on young couples during this time. The roles of young men and women are examined and then compared within Shakespeare's text. The acts of the young lovers are written to portray the overwhelming pressures of society's push toward marriage. The research indicates that Shakespeare's use of intentional yet discrete satire in Romeo and Juliet addresses important issues regarding society while entertaining readers with a tragic romance.

Richard, Duke of Gloucester: Ruthless Ruler or Product of His Environment?

Author: Hailey Reagan

Faculty Advisor: Kristin Deiter, English

In The Second Part of King Edward IV by Thomas Heywood, Richard, Duke of Gloucester, is a cruel and ruthless ruler due to the environment that he was raised in. The environment that a person inhabits has an impact on the person's character and temperament, and Richard is no exception to this rule. In the 15th century, rulers used merciless tactics that would help them achieve their goals. By using Machiavellian tactics, Richard achieves his goal of becoming king. Richard eventually meets his quest for significance, gaining the approval of those surrounding him, but he is not sure what to do once he has achieved it. I explore the use of Machiavellian tactics, and I compare them to Richard. I, also, consider the idea of Richard's physicality, and how the other rulers viewed him due to his disabilities.

By considering the characters who surround Richard and the Machiavellian traits portrayed by him and other characters, I demonstrate Richard's true quest for significance. I seek to prove that Richard's true quest for significance is not just the crown but also the idea of approval. Through this search for approval, Richard can be viewed as a product of the environment he grew up in. I wrote this paper for the course - Topics in British Literature to 1667: Sixteenth-century English Literature.

Department of History

History

Undergraduate Students

Understanding Victorian Culture Through the Lens of Women's Fashion

Author: Olivia Howell, 2023 Marion Hood Langlois Endowed History Scholarship

Faculty Advisor: Elizabeth Propes, History

Fashion is one of the biggest ways that people express themselves today, and clothing can tell a lot about a person and their culture. During the Victorian Era this was no different and women's fashion and Victorian ideas about fashion can tell historians a lot about their culture. Analyzing fashion as a source to understand history provides a unique view of the topic. Using clothing held in museum collections, fashion plates, women's magazines, Victorian books on fashion, and modern sources about fashion I found that fashion reflected the changes women experienced in the Victorian Era from changes in technology to changes in freedoms.

Tennessee Death Penalty

Author: April Riley

Faculty Advisor: Troy Smith, Ph.D, History

Creating digital tools to research and understand history can change the perspective of historical topics and reveal new trends and information unseen before. With the rapid increase of technology, we are starting to see more and more software and hardware being developed to explore new ways of handling information. This brings in a different way of viewing information and discovering unseen biases, misinformation, and missing data that has not been seen or noticed during the collection of the data opening new views and opinions.

For our project we chose to research the Tennessee death penalty cases and create a digital tool to view the data. The death penalty is an under-researched topic in the state of Tennessee and by creating virtual tools such as an interactive map with points showing where each case has happened with sources, it is possible to create a new way of viewing a complete data source of the Tennessee death penalty cases that was previously unavailable. Having a compiled source of data about the penalty can allow researchers to find new trends in the data that could sway public opinion on the legality and ethics of capital punishment such as being able to notice the rise in types of execution, the race involved, the crime committed and the time it took to carry out the execution.

Department of Mathematics

Mathematics

Graduate Students

Utilizing RNN for Real-time Cryptocurrency Price Prediction and Trading Strategy Optimization

Author: Shamima Nasrin Tumpa

Faculty Advisor: Kehelwala Dewage Maduranga, Ph.D., Mathematics

This research embarks on the exploration of leveraging Recurrent Neural Network (RNN) for real-time cryptocurrency price prediction and optimization of trading strategies. Amidst the volatility and unpredictability of cryptocurrency market, traditional forecasting methods and trading strategies often fall short of delivering desired outcomes. This study aims to bridge this gap by harnessing the power of RNN, renowned for their proficiency in capturing long-term dependencies and trends in time-series data.

The project starts with a comprehensive literature and collection of datasets encompassing historical price data, trading volumes and sentiment analysis. The subsequent works are data preprocessing, feature engineering, iterative development and refinement of the RNN model to accurately predict cryptocurrency prices. These pave the way for the formulation of dynamic trading strategies that are rigorously backtested to assess profitability and risk, culminating in an evaluation phase where the model's efficacy and the trading strategies' performances are thoroughly analyzed.

The anticipated outcome of this research is a robust RNN-based predictive model that not only surpasses traditional forecasting methods in accuracy but also empowers traders with optimized strategies. Through this study, we aim to set a precedent for future research in integrating advanced machine learning models with financial trading systems to navigate and profit from the digital currency ecosystem.

Response Surface Methodology Based Hyperparameter Optimisation of Actuarial Neural Networks

Primary Author: Belguutei Ariuntugs

Co-Author/Collaborator: Kehelwala Dewage Maduranga, Ph.D., Mathematics

Faculty Advisor: Kehelwala Dewage Maduranga, Ph.D., Mathematics

The field of Data Mining plays a pivotal role in today's data driven landscape where terabytes of data are generated every moment. To tackle this problem, numerous data mining algorithms have been proposed and used in the last few decades. These algorithms require user-defined hyperparameters that need to be set before the training process begins. For example, learning rate or number of layers for Feed Forward Neural Network, etc. As machine learning algorithms grow in complexity; optimizing their hyperparameters for efficient resource use is a crucial task. In the realm of actuarial science, where precision and accuracy are paramount, the integration of advanced computational techniques has become increasingly indispensable. One such technique, neural networks, has emerged as a powerful tool for predictive modelling, offering the potential to enhance risk assessment, pricing

strategies, and decision-making processes within insurance and financial sectors. In this paper, actuarial deep learning algorithms like Combined Actuarial Neural Networks (CANN) and Combined Explainable Actuarial Neural Networks (CAXNN) are chosen due to their embedded safety percussions for tasks such as mortality forecasting and pricing. We will be using Factorial Arrangement Design of Experiments for sampling the hyperparameters then, by leveraging Response Surface Methodology, we will fit quadratic surface over the hyperparameter space to find the optimal or near optimal set of hyperparameters.

Department of Physics

Physics

Undergraduate Students

Using Factor Analysis to Explore the Structure of a Vector Assessment

Author: Mateo Cacheiro, NSF DUE1852045

Faculty Advisor: John B. Buncher, Ph.D., Physics

Vectors are tools that all physics students use, and the ability to perform vector operations is essential to student success. Students frequently struggle with the simplest of operations -- vector addition and subtraction. Our research group is investigating student difficulties with these skills. We are developing a vector skills assessment to quantify the type, frequency, and relationships among student mistakes when graphically adding vectors. This presentation specifically focuses on a factor analysis conducted on a preliminary version of the instrument. We used prior results from the literature to propose factor structures that depend on the vector operation and orientation. Using both exploratory and confirmatory factor analysis, we found a factor structure that begins to justify our assessment's ability to capture a student's comprehension of vector addition and subtraction. As we continue this research, we also intend to publish this assessment as a resource for physics educators to assess students' skills in graphical vector addition and subtraction.

Measurements of the 134Xe Neutron Capture Cross-section Between 0.43 and 5.5 MeV

Author: Luke Parsons, 2023 URECA Recipient, 2023 CISE Recipient

Faculty Advisor: Mary Kidd, Physics

In the study of rare event physics, such as neutrinoless double beta decay, it is important to understand potential background events. Events such as cosmic rays and stray alpha particles can lead to neutron-induced events even in experiments deep underground. Experiments that study neutrinoless double beta decay of 136Xe use material enriched in 136Xe. However, a substantial fraction of the enriched material is 134Xe. One neutron-induced event of interest is neutron capture on 134Xe, which can emit gamma rays that have the potential to Compton scatter into the Q-value region of interest for double-beta decay of 136Xe. In this study, we investigate neutron capture on 134Xe by looking for gamma rays emitted from both the de-excitation of resultant metastable excited states of 135Xe, and the subsequent decay to 135Cs. Highly enriched xenon gas was irradiated in the neutron beam at Triangle Universities Nuclear Laboratory, and the resultant decays were counted in the low-background counting facility located in the Duke Physics Building. We will report our results for the neutron capture cross-section for incident neutron energies of 0.43, 0.8, 1.5, 2.0, 4.2, and 5.5 MeV.

Data Analysis of 35Mg

Author: Zeke Vespie, 2023 URECA Recipient
Mr. and Mrs. Robert L. Shannon, Jr. Endowed Scholarship in Physics

Faculty Advisor: Mustafa Rajabali, Physics

An experiment was conducted at TRIUMF laboratory using the GRIFFIN spectrometer to study the decay of 35Mg. Isotopes in its decay chain include 35,34,33Al, 35,34,33Si, and 35,34,33P, which are populated via beta decay, beta-delayed neutron emission, and beta-delayed twoneutron emission. Analysis was done on the full data set, including tagging with a new OGS detector to cleanly separate out the beta-delayed neutron emission daughters. By setting up a gamma-gamma coincidence spectrum, with the coincidence gating being within 300 ns, new energy level transitions for certain isotopes down the decay chain can be discovered. Through this method, new energy level transitions for both 35Al and 35P were discovered.

Specifically, we believe we've found 7 new transitions for 35Al and 5 new energy levels.
The same is true for 35P, with 7 new transitions and 2 new energy levels. We're also working on determining the branching ratios and half-lives of 35Mg and 35Al by obtaining a fit of the data through the use of the

Bateman Equations. The goal of the fit is to extract the beam intensity which would then give an absolute decay rate to help determine the decay feeding intensity. The current state of the analysis will be presented.

College of Business

Accounting

Graduate Student

Fee-Free Future? Analyzing the Effects of Overdraft Legislation on Community, Regional, and Large Banks
Author: Aidan Wagner

Co-Author/Collaborator: Axel Rodriguez, Accounting

Faculty Advisor: Sid Bundy, Accounting

In 2022, consumers paid $7.7 billion in overdraft/NSF fees. Trends in overdraft fees have been closely monitored by the CFPB (Consumer Financial Protection Bureau). Studies have shown that there are banks that heavily rely upon Overdraft/NSF income for overall profitability. Now in 2024, the CFPB is amending the Truth in Lending Act to require financial institutions to limit their overdraft fees. The House of Representatives has introduced a bill that limits how many overdraft fees banks can charge. The main objective of this research is to analyze how banks will be affected by new rules and legislation regarding overdraft/NSF fees. The data being analyzed has been pulled from the FFIEC's UBPR's and Call Reports. A time series analysis was then performed using revenue, net of interest expense as the base figure in a common size income statement. As a percentage of the base figure, overdraft revenue, EFF ratio, and ROA were compared among banks. A projection analysis on reduced overdraft fees documented changes in ROA, and then compared to other banks. Preliminary results suggest that certain banks heavily reliant on overdraft fees may face significant challenges if new regulations are enacted, thus prompting a need for adaptation in income practices among affected banks. This research sheds light on the evolving landscape of banking practices and regulation, highlighting the necessity for strategic adjustments to ensure financial stability and compliance.

Business Administration

Graduate Students

Historic Lows to Rapid Highs: How Interest Rate Changes Impact Banks' Cost of Funds

Author: Kailey Wood

Faculty Advisor: Sid C. Bundy, Accounting

The dramatic interest rate changes from early 2022 have profoundly impacted banks of all sizes. One of the critical determinants of a bank's success is its ability to control its funding costs, a metric directly influenced by the Federal Funds (FF) rate. Similarly, the Net Non-Core Funding Dependency (NNCFD) ratio can be an indicator of the cost of funds, as non-core funding sources are often more costly. Non-core funding became increasingly vital to banks as the FF rate increased due to new-found liquidity strains. The elevated use of non-core funding to bridge liquidity gaps has caused funding costs to increase dramatically. The FF rate experienced the most significant fluctuations from Q1 2022 to Q4 2022, with growth beginning to taper in 2023. Interest expense as a percentage of total deposits demonstrated the most significant spikes in growth from Q1 2023 to the present. This data indicates that the rise in rates has an approximate 1-year lag effect on interest expense at banks, primarily attributable to the timing of repricing deposits. The dramatic impact of FF rates on funding costs has not only widened the gap between banks' profitability across various sizes. Reliance on non-core funding sources, which has become a serious disadvantage when accounting for overall interest expense, is a crucial concern. Banks already disadvantaged in their profitability before FF rate movements are now at an even further disadvantage, a trend likely to continue into 2024.

Economics, Finance and Marketing

Undergraduate Students

Promoting Sustainability through Eco-Friendly Business: Developing a Profitable Business Model

Author: Chance Hale, 2023 CISE Recipient

Faculty Advisor: Nikki Panter, Ph.D., Biology

The need for sustainable business models has become increasingly apparent in response to the pressing global challenges of climate change and environmental degradation. This project, undertaken as part of the Creative Inquiry Summer Experience

(CISE), aimed to address this need by developing a profitable business model centered around eco-friendly products and packaging.

This project sought to identify sustainable product lines with high demand and profit potential, drawing on market analysis and product research. The target market and purchasing behaviors were determined through online research and competitor analysis in the Upper Cumberland region. Throughout the product development process, attention was given to factors such as quality, cost-effectiveness, and sustainability. Furthermore, the project focused on creating a sustainable and profitable business model that could be scaled for continued growth and expansion. Strategies for reducing production costs and increasing revenue were incorporated into the model.

Ultimately, the project aimed to create a mock startup that promoted environmental sustainability and contributed to the global sustainability movement. The project's success was measured by the design of a hypothetical business aligned with these goals. This endeavor aimed to inspire positive change and contribute to a greener future by integrating business and sustainability principles.

Marketing

Undergraduate Students

Pen to Picket: Unraveling the Economic Impacts of Writers and actors strikes in the Entertainment Industries

Primary Author: Justin Woods

Co-Author/Collaborator: Shaye Carter, Psychology, College of Education

Faculty Advisor: Melissa Creek, College of Business

The meta-analysis investigates the multifaceted effects of the Writers Guild Association (WGA), and the Screen Actors Guild/American Federation of Television and Radio Actors (SAG-AFTRA) strikes on the economy by integrating the data from diverse sources. While writers' and actors' strikes are often rooted in industry-specific disputes, they have far-reaching consequences that extend beyond the creative realm. This study systematically reviews and analyzes the economic repercussions of the strikes, considering factors such as employment rates, GDP fluctuations, and industry-specific trends. Key variables explored in this meta-analysis include the duration and scale of the strikes, economic changes, and impacts on related industries. By pooling data from various sources, including labor reports, economic indices, and industry analyses, this research aims to provide a nuanced understanding of the systematic impact of the writers' and actors' strikes on the overall economic landscape. By incorporating findings from congruent studies, this research contributes to a more comprehensive understanding of the intricate relationship between these strikes and economic dynamics, offering insights that can inform industry stakeholders, policymakers, and researchers alike.

College of Education

Department of Counseling and Psychology

Graduate Students

Strive vs Thrive: The Power of One Caring Adult in Foster Youths' Trajectory to Success

Author: Tammy Knipp

Faculty Advisor: Mark Loftis, Counseling and Psychology

Shifting to adulthood from adolescence can be a challenging developmental benchmark. Success in leaving home, pursuing college or career goals, and learning to navigate socioeconomic constructs as an adult often requires caregiver support. Older foster youth remain in foster care longer than younger youth, yet seldom have caregiver support past age 18 (Kids Count, 2022, Dec.). This presentation will explore the role of positive childhood experiences in foster youths' utilization of available extension services.

Conceptualizing the Play Therapy Dimensional Model with the Multidimensional Grief Theory

Primary Author: Mason Hale

Co-Author/Collaborator: Tony Michael, Ph.D., Counseling and Psychology

Faculty Advisor: Tony Michael, Ph.D., Counseling and Psychology

The Play Therapy Dimensional Model (PTDM) exhibits four approaches along the directiveness and the child's consciousness continuums (Yasenik & Gardner, 2012). The Multidimensional Grief Theory has been developed into an operationalized therapy (Hill et al., 2019) to increase adaptive grief reactions, decrease maladaptive reactions, and to promote positive developmental progression (Kaplow et al., 2013) by strengthening the caregiving system (Alvis et al., 2022). Research continues to be conducted supporting the efficacy of nondirective and directive interventions for therapeutic healing of bereaved children (Boelen et al., 2021).

Undergraduate Students

Existential Freedom
Author: Nicholas Wilford

Faculty Advisor: Matthew Zagumny, Ph.D., Counseling and Psychology

Experimental existential psychology is a branch of Psychology that explores the five major concerns all humans face, death, meaningless, isolation, identity, and freedom. The existential concern over our freedom arises from the many choices we make in life and our responsibility for the outcome of those choices. Existential guilt can arise when an individual reflects on life choices and considers alternate pathways or unrealized potential. Currently, there is a limited amount of research on the concern of existential guilt. This lack of research has also led to a lack of measures. Five to ten participants will be recruited and asked a series of five access questions in interview format. This study would answer the research question, "How is existential guilt experienced and what are the trends in the lived experience of existential guilt". One example question is, "Describe a time when you were faced with a multitude of compelling choices and could choose only one". This question is expected to evoke feelings of guilt or regret. These experiences will be further examined to develop a scale intended to measure the concern of freedom.

Counselor Education & Supervision

Graduate Students

The Relationship Between Alexithymia and Highly Sensitive Persons: A Literature Review

Primary Author: Lara Strate

Co-Author/Collaborator: Regina Beach, Counseling & Psychology

Faculty Advisor: Tony Michael, Ph.D., Counseling and Psychology

The purpose of this literature review is to examine the relationship between levels of alexithymia and highly sensitive persons (HSPs). Using multiple search engines and databases, manuscripts were analyzed based on the variables of alexithymia and HSPs. Higher levels of alexithymia are associated with adverse clinical outcomes and other mental and physical health problems (Leweke et al., 2011). Recent research has also investigated the relationship between alexithymia and the construct of highly sensitive persons (Liss et al., 2008; Maroti et al., 2018). About 15-20% of the population are considered to be highly sensitive persons (Aron, 2022). Researchers have indicated a relationship between the two constructs that may lead to the predictability of alexithymia based on sensitivity scores (Jakobson and Rigby, 2021). While these results have implications for most professionals working with individuals showing signs of alexithymia and sensitivity, special attention is given to the implications for college counselors working with students and supervisees presenting with high levels of both. Exploring how these concepts relate to each other and how they apply to the work of college counselors and supervisors is important to provide effective training and counseling to students.

Promoting Campus Wellness Through the Lens of Mental Health Counselors

Primary Author: Mason Hale

Co-Authors/Collaborators:
Tony Michael, Department of Counseling and Psychology
Brittney Phillips, University Counseling Center

Faculty Advisor: Tony Michael, Ph.D., Counseling and Psychology

Pressure to perform academically, financial stress, and accessibility of entering higher education institutions are common factors that impact the mental health of college students (Flatt, 2013). Findings have suggested the mental health needs of college students worsened due to the COVID-19 pandemic

(Lee et al., 2021). The purpose of this presentation is to provide a conceptualized mental health counseling perspective for promoting campus wellness with a growth-oriented philosophy that emphasizes how to support college students through SAMHSA's wellness model (SAMHSA, 2016). The SAMHSA wellness model addresses the eight domains of: emotional, environmental, intellectual, occupational, physical, social, financial, and spiritual. Each domain will be explored with practical strategies for faculty and higher education leaders to implement across a campus setting.

Equipping Collegiate Clinicians: Treating the Effects of Transgenerational Trauma from Natural Disasters

Primary Author: Ravi Patel

Co-Author/Collaborator: Katherine Hermann-Turner, Ph.D., Counseling and Psycholgoy

Faculty Advisor: Tony Michael, Ph.D., Counseling and Psychology

Innovative and current counseling protocol services are highly sought within university counseling centers. Proper assessments are imperative for effective treatment modalities, implementation of services, and a reduction in psychological distress for college students due to unwanted experiences on college campuses (Irish, 2020). Trending research within transgenerational trauma explores parents' post-traumatic stress disorder (PTSD) symptoms, the dyadic relationship to their children with PTSD symptoms, and exposure to natural disasters (Zhou & Zhen, 2021).

A recent report from the Center for Collegiate Mental Health (2022) indicates a notable increase in traumatic event experiences, which were more likely to have occurred within the past five years. Current research explores how generations of individuals exposed to natural or human-caused natural disasters affect the transgenerational transmission of traumatic symptoms. Clinicians are seeking postvention methods to reduce symptom transmission and psychological issues that interfere with personal and academic development (Irish, 2020).

This presentation investigates trending research in narrative therapy and trauma-focused cognitive behavioral therapy as therapeutic modalities to use with a college-aged population. Demonstrating this synthesis can significantly impact clinical practices with college student populations and direct effective treatment decisions with guidance in quality care.

The Intersection of Attention-Deficit/Hyperactivity Disorder and Internet Gaming Disorder

Author: Jennifer [Paige] Seymour

Faculty Advisor: Tony Michael, Ph.D., Counseling and Psychology

Attention Deficit/Hyperactivity Disorder (ADHD) and Internet Gaming Disorder (IGD) have gained increased recognition within modern society among children and adolescents due to the prevalence of video game use among this population. Although distinct disorders, current trends and data indicate statistically significant correlations between ADHD and IGD, particularly in measures of impulsivity and behavioral disturbance. This poster will detail the complex relationship and potential bidirectionality between the two disorders in key aspects of gender differences, social functioning, behavioral and emotional dysregulation, and neural effects including on the dopamine reward system. CP/Clinical Mental Health

Department of Curriculum and Instruction

Applied Behavioral Analysis

Graduate Students

Existential Isolation

Author: Gracie Conlon, Tennessee Tech Pride Transfer Scholarship

Faculty Advisor: Matthew Zagumny, Ph.D., Counseling and Psychology

In the study of existentialism, there is a focus on five big concerns - death, meaningless, freedom, identity, and isolation. Some scales look at the existential concerns separately, however, there is no scale that looks at the five together. Existential Isolation (EI) is the "unbridgeable gap between oneself and any other being" according to Irvin D. Yalom. Existentialism's primary emphasis on death and meaninglessness often results in existential isolation research being understudied. To better study existential isolation, we propose a phenomenological study. We expect to ask 10-15 participants five access questions to trigger an indirect EI response. An example access question states, "How has COVID-19 affected your social relationships before and after? We will use participant responses to construct a description for the lived experience of existential isolation. With

this, we intend to develop a conceptually valid scale to measure existential isolation, along with the four other existential concerns.

Special Education Teachers' Perceptions of the Importance of Early Interventions for Students with Exceptional Needs

Author: Eseoghene Oderhohwo

Faculty Advisor: Larissa Rector, Curriculum and Instruction

The importance of early interventions for students with exceptional needs is being examined through the interpretive lens of special education instructors' perspectives. This comprehensive case study delves into how educators view the importance of timely interventions for students requiring specialized support. By exploring the insights and experiences of these professionals, the study aims to shed light on effective strategies that can positively impact the educational journey of students with exceptional needs, setting a foundation for their long-term success. This interpretive case study focused on Special Education Teachers' perspectives on the significance of Early Intervention for students with exceptional needs in three Middle Tennessee elementary schools. This study highlights the challenges special educators encountered during the implementation of stated policies on meeting the needs of students with special needs through interviews with three special education teachers, observations on classroom practices, and a document analysis of lesson plans and progress reports. Findings were interpreted using inductive analysis, which classified the results, themes, and patterns. The findings provided a better understanding of special education instructors' perspectives on early interventions and how they influence the requirements of students with exceptional needs. Keywords: Early Interventions, Individualized Education Program (IEP), Every Student Succeeds Act (ESSA) Early Childhood Education

Existential Meaninglessness Phenomenology

Author: Nick Woods

Faculty Advisor: Matthew Zagumny, Ph.D., Counseling and Psychology

The field of existential psychology has proposed five ever-present existential concerns that all people must manage. One of these concerns is the concern of meaninglessness: the concern that life and its difficulties lack meaning. Currently, no measures for the concern of meaninglessness exist, and previous measures of meaning in life have been criticized for poor concept validity. This study proposes phenomenological methods be used to systematically develop a conceptual definition for the experience of the concern of meaninglessness. This study seeks to answer the research question: "How is meaninglessness experienced, and how does that experience compare to conceptual meaning in life models?" Ten participants are expected to be recruited, and five access questions will be used in a structured interview. An example question states "Describe a time when you were unsure of why you were dedicated to completing a difficult and timely task. Describe what you felt and how these feelings affected performing the task". Themes of purposelessness, insignificance, and value obfuscation are expected to be found. The results of this study will guide item generation for an instrument measuring the concern of meaninglessness.

Undergraduate Students

Existential Death

Author: Joshua Thomas, Tennessee Tech Transfer Pride Scholarship

Faculty Advisor: Matthew Zagumny, Ph.D., Counseling and Psychology

The field of existential psychology has proposed five ubiquitous existential concerns that everyone must cope with. There are currently no measures for all five existential concerns that has complete validity and reliability. The existential concern of death is the fear, anxiety and dread that comes from the innate knowledge that all humans will inevitably die. This study proposes the use of phenomenological methods to systematically develop a conceptual definition for the experience and response to the concern of death. This study seeks to answer the research question: "How is the concern of death experienced, and how does that experience compare to existing death models?" There will be ten participants recruited to answer five access questions in a structured interview. Two example access questions ask, "What thoughts and feelings come to mind when you imagine yourself bungee jumping or skydiving and how it would make you feel?"and "Do you think you will still feel the same about life as you will when you are 80 years old?" There is expected to be themes of worldview defense, anxiety, and increased self-esteem as per Terror

Management Theory. The results of this study will be used to form questions for a quantitative existential concern scale.

Early Childhood Education

Graduate Students

Understanding the Perceptions of Elementary Educators Regarding Their Ability to Educate Children with Autism Spectrum Disorder within Mainstream Classroom Environments

Author: Nyasha Dzenga

Faculty Advisor: Holly Anthony, Ph.D., Curriculum and instruction

The exponential increase in the number of children diagnosed with autism is concerning all over the United States and globally. This calls for an increased demand for teachers to ensure they are well-prepared to teach children with autism spectrum disorder (ASD). Although the Individuals with Disabilities Education Act reauthorized (2004) requires children with disabilities to receive their education in the least restrictive environment, a large body of literature suggests that general education teachers are not adequately prepared to teach children with ASD in an inclusive environment. The number of children diagnosed with ASD in the southern part of the US is increasing at an almost similar rate to the national level. This qualitative study aims to understand the perceptions and experiences of elementary teachers regarding their preparedness in teaching students with ASD in general education classes. Keywords: teacher preparedness, inclusion, autism spectrum disorder, effective instructions, perceptions.

Exceptional Learning

Graduate Students

Relationship Between Students' Test-Taking Motivation and Performance on Critical Thinking Assessment Test (CAT)

Author: Gideon Eduah

Faculty Advisor: George Chitiyo, Ph.D., Curriculum and Instruction

More than before, critically assessing information from different sources has become essential (Saunders, 2012). Especially in these times of advanced information technology, people are faced with making judgments about the influx of information on their electronic gadgets daily. Critically assessing information is a skill that can be developed in schools. Educators and psychologists around the world perceive critical thinking as a skill that can be achieved through training (Shaw et al., 2020). Research has shown that critical thinking successfully helps students address social, scientific, and practical issues (Snyder & Snyder, 2008). The Critical-thinking Assessment Test (CAT)--developed at Tennessee Tech University with support from NSF--is among many instruments developed to assess students' critical thinking skills (Stein et al., 2007). However, many students taking these tests consider them low-stakes tests, and, therefore, their performance on the tests is affected. This study aims to examine the relationship between student test-taking motivation and their performance on the CAT. The total word count and total response time are used as proxies for test-taking motivation. Data obtained from the Center for Assessment and Improvement of Learning at Tennessee Tech were analyzed. The findings suggest 28% (over a quarter) of the student's performance on the test (CAT) can be predicted by the student's test-taking motivation.

Exceptional Learning - Literacy

Graduate Students

Interpreting Student Perspectives: A Qualitative case Study on Self-Advocacy Development for a student with a Physical Disability participating in academic coaching in Higher Education

Author: Hannah Willis

Faculty Advisor: Holly Anthony, Ph.D., Curriculum and Instruction

This qualitative interpretive critical case study examined self-advocacy development in college students with physical disabilities at a rural Tennessee state university. Focusing on a single participant, the study investigated the participant's narrative regarding self-advocacy development through participation in academic coaching. The researcher aimed to understand how academic coaching, alongside potential factors such as campus environment, university policies, and faculty inclusivity, contributed to self-advocacy development. The study applied inductive analysis, utilizing open coding to identify concepts and categories in the data,

followed by axial coding to group related codes into overarching themes. This process revealed themes related to the participant's self-advocacy strategies, academic experiences, and disability perception. The study highlights the need for flexible academic programs, enhanced faculty disability awareness training, and collaborative workshops. This analysis further contributes to better understanding self-advocacy development in students with physical disabilities, informing the development of supportive interventions and student support services within higher education.

Exceptional Learning - Program, Planning and Evaluation

Graduate Students

Preservice Teachers' Confidence to Teach Students of Diverse Backgrounds: Differences by Student Major and Sex

Primary Author: Brandi Kriebel

Co-Author/Collaborator: George Chitiyo, Ph.D., Curriculum and Instruction

Faculty Advisor: George Chitiyo, Ph.D., Curriculum and Instruction

This study was created to focus on the preparedness of graduating senior students in Tennessee Tech's pre-service Education program on entering the classroom to instruct classes of diverse learners. This study evaluated the students and their feelings of preparedness in instructing students of culturally diverse backgrounds as well as those with different learning abilities. With this study being conducted at a mostly white university and having that demographic be represented in the pool of participants, it was important to show the views and opinions on how these predominantly white participants approached and felt about being in a classroom beginning their career with a diverse student body. The sample consisted of 125 students in the Teacher Education Program at Tennessee Tech University. A survey was developed by the researchers and administered to the pre-service teachers in Spring 2023. This presentation focuses on candidates' confidence to teach students of diverse backgrounds. This study provides an important insight not only into the attitudes surrounding diverse instruction, but also the evaluative process needed to ensure such pre-service programs are successful and producing well-rounded future teachers.

Exceptional Learning - School Aged Children and Adult Population (ABAS)

Graduate Student

Experiences of Tennessee Tech International Students on their Ability to Manage Anxiety while Studying

Author: Vandyck Adade-Yeboah

Faculty Advisor: Holly Portia Anthony, Curriculum and Instruction

The purpose of this phenomenology study was to examine the experiences of Tennessee Tech international students on their ability to manage anxiety while studying. Data obtained from Open Doors (2009) indicated that about 1,095,299 came to further their studies at universities in the U.S. It was also recorded that the United States recorded the largest number of international students who gainfully got admission into their universities. To solicit the experiences of how international students manage anxiety while studying, open-minded questions were asked; relevant documents were also obtained from international students, lastly, international students also provided journals about how they managed anxiety while studying. Data were analyzed using inductive analysis. The results suggested that international students manage anxiety through available campus resources like counseling services, international student office, and gym centers. The results also suggested that they can manage anxiety through advice from their advisors and other international students or peers who have been in the United States for a while and have gone through the program successfully.

Psychology - Pre-Med

Undergraduate Students

Scale Development Within Existential Phenomenological Research: Existential Identity

Author: Kevin Ho, Golden Opportunity Grant

Faculty Advisor: Matthew Zagumny, Ph.D., Counseling and Psychology

The five recently proposed and identified existential concerns that all individuals face--meaninglessness, identity, freedom, death, and isolation-- are not defined thoroughly in existing literature. Hence, a valid, operationalized measurement for these constructs is required to further explore and understand the phenomenon. Existential identity is an area that has little to no existing literature, further underlining the importance of understanding and describing the phenomenon. This study aims to discern how existential identity is viewed; how do individuals view their own identity in the context of existence, and how do individuals' decisions adhere to said identity? We expect to recruit 10 participants to ask specific access questions intended to provoke ideas of existential identity. An example question may be: "describe a time when you felt as though you were unsure if whether your beliefs coincided with your decisions", or "tell me in detail exactly who you are without giving information that is on a driver's license. We anticipate that participants will respond with ideas that align with identity formation, identity adherence (self-authenticity), and identity dissolution/identity crisis--as well as answers surrounding the idea of the absurdity of existence. We will evaluate participants' responses of these access questions to guide the construction of a valid scale of measurement for existential identity.

Department of Exercise Science

Physical Therapy Concentration

Undergraduate Student

An Introduction to Plyometric Training

Author: Omari Nesmith

Faculty Advisor: Ajit Korgaokar, Exercise Science

Plyometric training is a form of training that focuses on rapid and explosive movements and is used in sports to increase performance in activities such as sprinting, jumping, change of pace, and change of direction. The primary goal of plyometric training is to enhance the neuromuscular system's ability to generate maximal force in a short amount of time. The main objective of this presentation is to acquaint the audience with the advantages of this form of training, aiming to promote awareness regarding its significance among athletic populations. This endeavor extends beyond merely enhancing athletic performance; it seeks to foster a comprehensive understanding of what it takes to develop into a well-rounded athlete.

Sport Specialization

Author: Eva Kilgore

Faculty Advisor: Bobbi Severt, Exercise Science

Youth athletes all over the country are choosing to specialize in throwing sports at an early age. Those who compete for eight months or more per year with no breaks are considered specialized. The potential risks from this behavior can have a tremendous impact on the athlete's future health. A review of relevant literature describing the differences between multi-sport and specialized athletes was synthesized producing information on the effects from being specialized in a throwing sport. From the research three major themes arose, which include identifying the risk factors, assessing the overall health in their throwing arm, and analyzing overuse injuries specific to the type of position the athlete plays. The findings conclude that specialized athletes have an increased risk of injury compared to multi-sport athletes. They also exhibit poor throwing arm health and an increased prevalence of overuse injuries, especially in those who are pitchers and field players. Shoulder injuries are the most common overuse issues sustained from this lifestyle. Most of the data was taken from softball and baseball athletes because of the greater amount of participation compared to other throwing sports. The main goal of synthesizing this research is to enable health care providers, especially athletic trainers, to educate youth athletes about the potential negative effects of sport specialization.

Exercise Science - Pre-Occupational Therapy

Undergraduate Student

Vibration Plates: The Benefit of Motor Development in Children with Cerebral Palsy

Author: Olivia Bradford, Presidential Scholarship

Co-Authors/Collaborators:
Elle Jae Frazier, Exercise Science
Ajit Korgaokar, Ph.D., Exercise Science

Faculty Advisor: Ajit Korgaokar, Ph.D., Exercise Science

Vibration plates are a form of technology that allows one to stand, sit, or lean on a machine that delivers vibrations through the body. These vibration plates can be adjusted by the force and frequency depending on an individual's needs. While the use of vibrations of the body can be traced back to the ancient Greeks, the use of vibrations with specific relation to motor skills can be seen in the mid to late 20th century by the Russians. It was at this time that vibrations of the body were used to treat muscular atrophy in astronauts and speed up the process of rehabilitation after Olympic athlete injuries. From these forerunners of vibration technology more knowledge has been gathered about the benefits of vibration therapy with regard to motor development. Today, the widespread use of vibration therapy, in the form of vibration plates, is in therapeutic settings such as physical and occupational therapies.

The main objective of this presentation is to demonstrate the multitude of ways that training on vibration plates can improve motor development among children with cerebral palsy. Such improvements include increasing gait speed, improving walking, running, and jumping (motor function dimension E), increased bone density, and muscle hypertrophy. It is from this research that one can conclude that the use of vibration plates in a pediatric therapeutic setting for children with cerebral palsy can be extremely beneficial in both their motor skills and motor development.

Exercise Science - Pre-Athletic Training

Undergraduate Student

Pitching Mechanics and Their Effects on Ulnar Collateral Ligament Injuries in Major League Baseball Pitchers

Author: Garrett Gardner

Faculty Advisor: Bobbi Severt, Exercise Science

There has been an increase in the incidence of Ulnar Collateral Ligament (UCL) injuries in Major League Baseball in recent years. This requires a procedure known as Tommy John surgery to repair. In this review of literature, effects of arm slot/pitching mechanics on UCL injuries were examined. As a pitcher, one can land in one of two positions: extended or flexed. Both positions have different effects on the UCL during the throwing motion as a pitcher. There are also several other factors that will be discussed that play a key role in the diagnosis of UCL injuries. In conclusion, one of these pitching styles has a higher injury rate on the UCL than the other. This issue is important to athletic training because ATs are having to diagnose too many UCL injuries due to this reoccurring problem.

College of Engineering

Department of Chemical Engineering

Graduate Students

Engineering Massively Arrayed Fibrous Media for Microfluidic Multiphase Flow Systems using Computational Fluid Dynamics (CFD)

Primary Author: Oluwaseyi Ayeni, Kandy Thevar Graduate Student Summer Scholarship

Co-Author/Collaborator: A. Vasel-Be-Hagh, Ph.D., University of South Florida

Faculty Advisor: H.A. Stretz, Ph.D., Chemical Engineering

Fibers are widely encountered in both natural and engineered environments, exhibiting distinct characteristics suitable for diverse applications. In the natural realm, the arrangement of fibers in bird feathers serves to insulate and maintain warmth. In industrial settings, fiber arrays play pivotal roles in filtration systems, textile yarns, and nanotextured surfaces. Within the chemical process industry, microfluidics is utilized in mixing of multiphase flows to benefit extraction attributed to the finer control of mass and heat transfer. However, the challenge lies in engineering an array of microchannels with higher throughput. A novel approach involves clustering thousands of fibers in a vessel creating network of clearances for fluid and mass transport. It facilitates intimate fluid contact, resulting in high interfacial area for enhanced mass transfer and increased throughput. Employing finite element analysis, CFD was used to examine the impact of inter-fiber distance, wettability, and flow rates on phase structures, specific interfacial area, and pressure drops. Results reveal that the presence of numerous fibers leads to more intricate flows, generating higher specific interfacial areas. Three distinct phase structures were observed that were neither microfluidic nor pipe flow. Flow rates exhibited minimal effects on specific interfacial areas

within a specific packing geometry. Tighter clearances between fibers generated higher interfaces.

Lithium Harvest: Transforming Desalination Byproducts into EV Power

Author: Mohammad J Seyed Sabour

Faculty Advisor: Bahman Ghorashi, Ph.D., Chemical Engineering

This study provides a comprehensive evaluation of top desalination methods, highlighting their advantages and limitations in the context of mineral recovery from saline water. A notable finding is that conventional desalination processes often return the byproduct water, enriched with minerals, to its original source without exploiting its potential value. Among the diverse minerals present, lithium emerges as a critical component due to its significant role in the manufacturing of electric vehicle batteries. Our investigation quantifies the concentration of minerals in the rejected water streams and assesses their economic viability for extraction purposes. We specifically explore crystallization as a promising technique for the efficient and effective recovery of minerals, with a focus on lithium. This approach not only offers a sustainable solution to resource recovery from desalination byproducts but also contributes to the circular economy by providing essential materials for the burgeoning electric vehicle industry.

TiO2--CdS Based UV/Visible Light Photocatalysis for Carbamazepine Degradation and EOP Coupled Foundry Model for Sustainable Engineering: A Hybrid Research with Technological & Educational Applications

Primary Author: Dipendra Wagle, 2023 URECA Recipient

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Faculty Advisor: Pedro E. Arce, Ph.D., Chemical Engineering

This innovative research includes the efforts on contributing the hybrid model studies of using AOP for water cleaning from CBZ and the application of the EOP model for guiding students in an environmentally driven sustainability framework. Therefore, the research plan includes the integration of two key aspects: (I) synthesis and feasibility of Vis/UV catalysts to degrade pollutants from water and (II) development of a pedagogical approach guided by the RFM to incorporate the EOP framework on training students to acquire skills relevant for the understanding and application of the environmental sustainability. Development of TiO2-CdS catalyst with UV/Vis activation potential: Preliminary results in our ECRL indicated that it is possible to develop TiO2-CdS catalyst to degrade CBZ pharmaceutical using UV/visible light. The integration of EOP framework guided by the Foundry for Sustainable Engineering: Leading organizations and foundations including ASEE, VentureWell, Lemelson, and KEEN are strongly supporting the incorporation of sustainability principles in engineering. The EOP framework as an organizational tool of the Foundry is one of the leading models for guiding the incorporation of sustainability elements. The framework, however, lacks a pedagogical engine to guide students systematically for an environmentally-driven learning challenge. Coupling two models provides a structured approach to identify a wicked problem and develop it into an effective prototype.

Role of Magnetic Field Assisted Pore Alignment in Polyacrylamide Gel Nanocomposites for Protein Electrophoresis

Author: Adeleke Abayomi

Faculty Advisor: Robby Sanders, Ph.D., Chemical Engineering

Native polyacrylamide gel electrophoresis (native-PAGE) is a powerful technique for the separation of proteins based on their size, shape and charges. This technique also enables subsequent assessments of protein function (such as through Western blotting). Past efforts have aimed at improving the separation efficiency of native-PAGE and improving mechanical durability of the hydrogel. For example, the introduction of nanoparticles into PAG has been shown to have direct influence on both the protein mobility and the mechanical properties of gel; however, the nanoscale interaction responsible for these behaviors is yet to be fully explored and understood. Therefore, in this contribution, we attempted to first, theoretically investigate the implications of the irregular pore domains, resulting from the introduction of nanoparticles into hydrogels, on the electrostatic potential applied to the gel. Secondly, we attempted to investigate the underlying nanoscale interactions in polyacrylamide gel nanocomposites using two model proteins: Carbonic Anhydrase and Ovalbumin. Electrophoresis of the two

model proteins was performed in a nanocomposite gel with bentonite nanoparticles. Electrophoretic mobility was used to probe the nanostructure while a dynamic rheology study was used to probe the nanoscale interactions between the polymer chains and nanoparticles. The final nanostructure was then investigated using SEM. Results indicate that increasing the nanoparticle concentration results in the agglomeration of nanoparticles in the matrix of the gel. This is significant because it provides a basis for magnetic field anisotropy in polyacrylamide gel nanocomposites that can be explored for magnetic assisted self-assembly of pore in polyacrylamide gel nanocomposites.

Role of the Renaissance Foundry Model in Guiding Experiential Learning in the Systematization of Species Mass Conservation

Primary Author: Shanae Tyree

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Pedro Arce, Ph.D., Chemical Engineering
Andrea Arce-Trigatti, Ph.D., Chemical Engineering

Faculty Advisor: Pedro Arce, Ph.D., Chemical Engineering

In chemical engineering, scaling is a concept that challenges student learning, particularly when applied to species mass conservation. Traditional formats that communicate theoretical concepts generate confusion. When different presentations of the same principle are in textbooks, it's important to get a better understanding of the principles to build on the concepts provided and offer clear vocabulary in more advanced courses so that complex applications can occur. Experiential learning strategies are helpful to address this confusion as they help students make connections to learning via reflection and application. In this proposal, we investigate how the Renaissance Foundry Model fosters experiential student learning through reflection by presenting a systematization of the concepts involved in conservation principles in species mass within an Advanced Reactor Kinetics course. We aim to answer the following: How did presenting the systematization process improve student learning as applied in species mass conservation? As a preliminary study, we present the interventions and the design of curricula that aligns with experiential learning principles and the Foundry model to help students better understand systematization. Understanding student learning through the use of systematization and the Foundry model holds implications for facilitating student learning in advanced engineering courses and offers lessons learned for pedagogical strategies in engineering education.

Integrating Cradle-to-Cradle Design Principles with a Focus on Soil and Water Treatment by Phytoremediation: Towards Sustainable Environmental Solutions

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Using a local Water Treatment Facility as a case study for heavy metal contamination (HMC), this presentation highlights the importance of selecting native plant species in Tennessee for ecosystem balance and environmental impact mitigation. Using the Renaissance Foundry Model and critical thinking, we applied a design thinking approach to investigate combining phytoremediation with Cradle to Cradle (C2C) design for sustainable handling of HMC. HMC in Tennessee communities, stemming from industrial activities and mining, poses significant risks to human health and the ecosystem. One possible approach towards the elimination of heavy metals from soils is the integration of phytoremediation processes with C2C design philosophy. Phytoremediation, the eco-friendly and cost-effective use of plants to clean contaminants, gains popularity. When coupled with C2C principles like material health, renewable energy use, and waste elimination, it achieves enhanced efficiency and sustainability. Phytoremediation's ability to absorb heavy metals from the environment into plants presents promising strategies. Interdisciplinary collaboration and innovative solutions, like using plant waste as an eco-friendly construction material, address challenges in the field. The implications of this project include initial insights with respect to the integration of phytoremediation with C2C design for sustainable management of heavy metal and chemical contamination for local businesses and industries.

Assisting Students in Defining Fluid Velocity Profiles: An Investigation on the Influence of Fluid Flow Kinematics in a Foundry-Guided Learning Session

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Faculty Advisor: Pedro Arce, Ph.D., Chemical Engineering

Engineering modeling aims to focus on the role of geometry, flow dimensions, and mass conservation in constraining the shape of fluid velocity profiles before their actual calculation by the application of momentum conservation. To guide the implementation of momentum conservation equations, the understanding of the velocity shape is critically important. A systematization of this guidance is notably absent in the literature, although scattered elements of a possible strategy can be found in textbooks. To bridge this gap, we used Renaissance Foundry Model to explore the role of fluid flow kinematics and total mass conservation in a chemical engineering curriculum. The Foundry is a six-element based, innovation-driven learning platform that leverages Organizational Tools as a guiding element to help students better understand a student-centered challenge. For this case study, 10-step based on the kinematics of fluid flow is used as the platform's Organizational Tool to help students better understand the determination of the functionality of velocity profile. Centering on this 10-step Organizational Tool, students able to review of fundamental concepts of particle kinematics (Knowledge Acquisition), and identify Resources suitable for the strategy before Transferring this Knowledge towards the Prototype of Innovative Technology (identification of the functionality of the velocity profile). Implications include student's feedback and engagement.

Microplastics in Aquatic Environments: A Review about Sources, Transport, Separation, and AOP-Based Degradation Approaches
Author: Shafieh Karami

Faculty Advisor: Pedro Arce, Ph.D., Chemical Engineering

Microplastics (MPs) are minute plastic particles, normally less than 5 mm in dimension, that their presence has been widely reported in aquatic and terrestrial environments, sediments, air, and even food items. These particles are discharged into the environment through various sources and can pose significant destructive impacts on both the environment and human health. The overall threats caused by MP pollution are severe and growing ever since; however, limited studies on MPs elimination have been conducted and this status leads to knowledge gaps in the current understanding of the issue. Furthermore, as several investigations reported that conventional methods are not reliable in the complete elimination of MPs, researchers have recently examined other approaches for far-reaching MPs separation and degradation, including Advanced Oxidation Processes (AOPs). The present review focuses on summarizing recently reported treatment techniques for degradation of MPs based on AOPs. Furthermore, the review discusses the efficacy, advantages, and challenges associated with currently used MPs removal trends from water and wastewater, alongside the damaging effects of MPs on the environment. Particularly, this contribution aims to (i) introduce MP particles occurrence, fate and transport (ii) illustrate conventional MPs separation methods, and (iii) discuss the current research status of MP treatment based on AOP methods.

Understanding How Electric Fields Affect Solute Transport in Poiseuille Flows: An Algorithm-Based Approach to Area Averaging

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Area-averaging is a powerful up-scaling method employed to derive macroscopic equations in mass, momentum, energy, and charge transport processes. Utilizing a defined process, it reduces variables, facilitating the creation of a macroscopic equation for the entire control domain. However, a "closure" condition is essential to finalize the up-scaled transport equation. While literature offers information for up-scaling, a systematic approach is lacking. Our research group has recently developed an algorithmic-guided method, streamlining area-averaging implementation in various transport processes. This contribution explores the algorithmic-based approach's application to axial and orthogonal applied electric fields influencing solute transport in Poiseuille

flows. The approach facilitates deriving "effective" transport coefficients from the solute species continuity equation. Examining three scenarios--(1) a single field parallel to fluid flow, (2) a single field perpendicular to the flow, and (3) a combination of both--the analysis provides comprehensive insights into dilute, noninteracting solute transport dynamics. This research advances the understanding of area-averaging approaches' role and establishes it as a powerful tool for deciphering the complex interplay between electric fields and solute behavior in diverse fluidic systems. The findings hold promise for optimizing separation processes, including electrostatic aerosol classification systems.

Wastewater Treatment Facilities: Fate and Transport in the Cookeville Wastewater Treatment Plant and Literature Review

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Pollution due to the presence of microparticles in water has significantly impacted our lives and is found in various environments, including oceans, rivers, and food. Water and wastewater treatment plants are pathways for microplastics introduction into the environment. In general, these particles are designed for commercial and household use and they usually require specialized laboratory tools for identification and characterization. This project is a combination of literature review and research, focused on exploring methods that are used for the characterization and quantification of MPs from wastewater treatment plants. Also, we explore other aspects, including comparing the results of the number of particles found in each respective study in addition to the types of the different treatment methods previously implemented. Furthermore, in the present study, samples from different treating units of Cookeville's Wastewater Treatment Plant have been taken to be analyzed for the presence of MP particles. Experimental procedures were followed based on previous studies to isolate possible MP particles from the samples

and characterize them by using microscopic and the FTIR methods. The results of these experiments are discussed, as well as other possible new techniques that could enhance the detection and characterization of MP in future studies on the topic.

Undergraduate Students

Degradation of Per- and Poly-fluoroalkyl Substances (PFAS) - Preliminary Review

Primary Author: Claire Myers

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Faculty Advisor: Robby Sanders, Ph.D., Chemical Engineering

Per- and poly-fluoroalkyl substances (PFAS) are a large group of organic compounds with numerous product applications. These chemicals have been common components in a wide variety of consumer goods since their discovery in the 1930s due to their sought-after properties, including hydrophobicity and thermal stability. The widespread use of PFAS and their inherent properties have made their persistence in the environment notable. For example, varying concentrations of PFAS have been found in different waterways, drinking water supplies, and human blood serum samples. This is concerning especially given the correlation between exposure to PFAS and health issues in humans, including liver damage, cancer, and birth defects. Research indicates that certain populations have experienced higher exposure to or have been overlooked in the systematic testing of waterways for PFAS. These issues have made the detection and regulation of PFAS contamination as well as research regarding the degradation of PFAS a priority for regulatory bodies like the EPA. This work will review the literature related to current methods for the degradation of PFAS to offer a potential structure and systematization to the body of knowledge. A complementary goal will be the identification of gaps in current research efforts that could guide the development of future research.

Magnetic Anisotropy in Polyacrylamide Gel and Its Applicability in Assisted Self-Assembly

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Robby Sanders, Ph.D., Chemical Engineering

Magnetic field assisted self-alignment of polymer pores has given rise to novel polymer materials used for membrane separation. Little exploration has been done on the applicability of this pretreatment to polyacrylamide gels to enhance its properties and separation efficiency. In this study, the effects of a magnetic field on protein separation via polyacrylamide gel electrophoresis (PAGE) were examined to determine whether there is magnetic anisotropy in unadulterated polyacrylamide gel material. Two different gel concentrations relative to volume of the gel solution were tested: 6% and 9%. The resolving gels were allowed to set for 30 minutes in the presence of a magnetic field at two different orientations. Control samples were also prepared and cured in the absence of magnetic field to allow for a direct comparison of both samples in isolation of the magnetic field effect. Post-processing the results of the SDS-PAGE, using ImageJ software would reveal the macroscopic effect of magnetic field on the polyacrylamide gel. The effect of the orientation variations will also be investigated. This work seeks to lay groundwork on the investigation of the presence of magnetic anisotropy in polyacrylamide gels and how such property can be harnessed for material engineering applications.

Convergent Domains as Irregular Cavity Models for Convective-Diffusive Transport: An Algorithm-based Approach coupled with Lubrication Approximation

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Understanding convective-diffusive transport in small diameter capillary and porous domains is crucial in various biotechnology applications which include blood-flow in arteries and flow of solutes within porous materials such as hydrogels and tissues. This analysis illustrates a large class of problems where convective-diffusive transport dominates the motion of solutes through the domain. The irregular geometry of these capillary or pore domains is represented by rectangular, cylindrical, or spherical coordinates while deviations from these well-known geometries arise either by manufacturing of the materials or by naturally occurring processes such as atherosclerosis. To address these complexities, simplified geometrical assumptions are made. These "non-regular" domains allow for the use of these simplifying assumptions to solve the hydrodynamic equations and the convective-diffusive transport equations and determine their deviations. Under the stated conditions, the lubrication approximation can be used to determine velocity profiles analytically and these solutions are then used to solve the convective-diffusive transport equation. In this project, we focus on a rectangular convergent domain where we use an area-averaging approach to determine concentration profiles and effective transport coefficients. Furthermore, a recent algorithmic methodology is used in this upscaling approach. Details and illustrations will be discussed.

Developing Software for the L-Shaped FT/MW Spectrometer with Chirped Pulse and Cavity Configurations

Author: Marton Varga

Faculty Advisor: Ranil Gurusinghe, Chemistry, College of Arts and Sciences

The L-shaped Fourier transform microwave spectrometer with cavity and chirped pulse configuration is being developed in the research lab led by Dr. Gurusinghe. The primary goal behind the spectrometer is analytical applications founded in rotational spectroscopy. The design, engineering, and use of the spectrometer is ongoing and considered a novel development rooted in the extraction of information fundamental to the understanding of chemical molecules, bonding, Van der Waals complexes, reaction intermediates, interstellar species, dipole moments and combinations thereof. Multiple devices, including pulse drivers, signal mixers, frequency synthesizers, oscilloscopes, actuators, and wave generators, are utilized thus requiring overarching Python software controlling the devices simultaneously. Key components controlled include a Zaber actuator manipulating mirror distance, Valon synthesizer reducing signal noise, SRS pulse generator triggering other components, and two Tektronix oscilloscopes collecting signal data. Automatically computed mirror position calibration for effective signal generation is accomplished by probing continuously acquired binary data from an oscilloscope for a maximum peak in a frequency range as the mirror actuator is moved to determine a position most optimal for signal acquisition. External operation of the spectrometer/calibration system, more sophisticated graphics user interface, and other features are in development.

More Efficient Inhibition of Topoisomerase II Alpha with (1E,4E)-1,7-Bis(4-hydroxyphenyl)Hepta-1,4-Dien-3-One

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Faculty Advisor: William Carroll, Ph.D., Chemistry

Topoisomerase enzymes play a vital role in DNA strand management. Topoisomerase IIa in humans is known to promote the untangling of DNA and to be active in cell replication. Selectively inhibiting Topoisomerase in actively replicating cancer cells is a method of potential interest for the chemotherapy of cancer. This approach stems from research on naturally occurring inhibitors of Topoisomerase II that can be further altered and synthesized to better bind to the enzyme and hamper its function. This work started with a recently reported naturally occurring chemotherapy lead (1E,4E)-1,7-bis(4-hydroxyphenyl) hepta-1,4-dien-3-one, referred to as DHDK, found in mistletoe. This lead molecule was optimized to have molecular parameters that are more consistent with known median drug values as a correspondent for its physiochemical properties. The alteration of this chemical was evaluated for its docking with Topoisomerase II ? using MOE-2020 computational site and the best added candidate was chosen for synthesis and testing. Here we report on the progress of synthesizing the altered lead molecule.

Processes (AOPs) for Treatment of Emerging Pharmaceutical Contaminants in Wastewater: A General Review
Primary Author: Chinar Ali

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Faculty Advisor: Pedro Arce, Ph.D., Chemical Engineering

A demand for an access to a pristine water for various purposes such as domestic, business, agricultural, and industrial among others are growing ever than before. Several different types of organic contaminants such as pharmaceuticals, microplastics, dyes, endocrine disruptors, insecticides, etc. that are getting discharged into the environment due to rapid industrialization has reduced the availability of a clean water. This poses a potential health hazard to human life and environmental ecology such as plants, and aquatic habitats. In aquatic environments, the pharmaceutical contaminants (PCs) are found in the concentrations ranging from ng/L to Âµg/L. As a sustainable practice for protecting and preserving our water environment, various methods have been employed to eliminate the emerging PCs. In this contribution, we will highlight a brief overview of the key literatures on the various types of advanced oxidation processes (AOPs) such as ozonation, hydrogen peroxide, Fenton, photo-Fenton, electro-Fenton, electrochemical oxidation, UV-Visible photolysis, and a more promising photocatalytic method used to remove wastewater pharmaceuticals. In addition, we will synthesize a systematic classification of the AOP methods based on the mechanistic pathways by which hydroxyl radicals are generated. The summary will also highlight the removal effectiveness, extend of mineralization, and degradation mechanisms of a typical pharmaceutical by titanium dioxide based photocatalysis.

Chemical Engineering - Biomolecular

Utilizing Mistletoe-based Natural Derivatives to Combat Cancer through Topoisomerase II pathways

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DNA topoisomerase enzymes are found in throughout all life on earth and are an essential part of DNA strand management of living beings. This unwinding is essential to ensuring continuous DNA replication of the strand, which cannot occur if one of the following is restricting said DNA replication. Seeing as these enzymes play a crucial role in a DNA's continuance, inhibiting cellular/DNA replication in cancer cells while limiting other cellular exposure has been the driving force for finding chemicals that can properly dock and prevent the function of topoisomerase enzymes. This project involves the use of naturally occurring inhibitors of topoisomerase II a, optimize

their physiochemical properties, evaluate their simulated chemical docking in topoisomerase II a enzymes, synthesis target the target molecule, and test their ability to inhibit topoisomerase II a. Current synthesis targets are based on a natural product isolated from mistletoe, (1E,4E)-1,7-bis(4-hydroxyphenyl)hepta-1,4-dien-3-one. This natural product was evaluated for its interactions with topoisomerase II a using the MOE-2020 computational suite. A series of candidates was evaluated and the best binding of them was undertaken as a synthetic target. Here we report on the design and synthesis of these candidates in advance of their testing.

Soil Microbial CO2 Respiration Testing, Effect of Concentration Gradient

Author: Shaina Larsen, Robert & Gloria Bell Scholarship, Odom Family Prospective Student Scholarship

Faculty Advisor: Holly Stretz, Ph.D., Chemical Engineering

As the need for more sustainable and efficient agricultural operation develops, a more real time and finer grained mapping of the influence of soil quality and composition on crop production and properties is necessary. Few real time tools are available for farmers to profile their soil, particularly on a molecular level, where microbial decomposition synthesizes the nutrients required to grow crops. Thus, this overall research project focuses on the development of wirelessly powered subsurface soil sensors categorizing soil quality by profiling the gaseous byproducts of organic decomposition within the soil. As a subproject, the present report details the qualification of PTFE hydrophobic membrane compatibility for passive transport of CO2 to the sensor chamber. A larger scale prototype has been constructed to test the membrane, which will later be scaled down. The device has been designed and assembled in its initial form in Spring 2023, utilizing an Isco high-pressure syringe pump(s), Matheson flow controllers, and high-pressure steel tubing. For calibration purposes, flows of a specific N2/CO2 were fed from the pump to a high-pressure acrylic vessel while N2 serves as a countercurrent carrier gas.

Transfer Learning Approach for Flood Forecasting using Deep Learning-Based Models
Author: George Fordjour

Co-Author/Collaborator: Alfred Kalyanapu, Ph.D., Civil and Environmental Engineering

Faculty Advisor: Alfred Kalyanapu, Ph.D., Civil and Environmental Engineering

Flood disasters continue to impact lives and properties significantly. Deep learning (DL) in hydrology for flood forecasting has shown promise, especially in well-monitored watersheds with ample data for training DL models. However, DL models require extensive data to learn effectively. Their performance drops in situations with scarce or non-diverse data, limiting their effectiveness in new scenarios. This challenge highlights the need for methods that enable DL models to generalize across varied tasks, particularly predicting beyond their training data. Transfer learning emerges as a solution, allowing a model trained on a data-rich source domain to be applied to less-documented target domains. This study presents a DL model using Long Short-Term Memory (LSTM) architecture, implementing transfer learning from the data-abundant Lower Cumberland watershed to the Lower Kentucky watershed for flood water level prediction. The findings demonstrate that transfer learning significantly reduces prediction errors, offering a significant advantage in scenarios where the target dataset is limited in size. This approach underlines the potential of transfer learning in enhancing DL model adaptability and performance in flood forecasting across different hydrological contexts.

Department of Civil and Environmental Engineering

Graduate Students

The Effects of Anisotropy on Entry and Exit Conditions of the Phreatic Surface for Unconfined Flow Using Analytical and Numerical Methods

Primary Author: Henry Asamany

Co-Author/Collaborator: Daniel Vandenberge, Ph.D., Civil and Environmental Engineering

Faculty Advisor: Daniel Vandenberge, Ph.D., Civil and Environmental Engineering

The permeability of earth dams is crucial for stability analysis and seepage calculations, influenced by factors like soil type, particle size distribution, and void ratio. Anisotropy, caused by irregular soil particles, results in varying hydraulic conductivity in different directions. Understanding the position of the phreatic line, especially at entry and exit

points, is vital for assessing stability, piping, and soil weakening. Current models simplify entry and exit conditions by assuming isotropic conditions through transformations, but these may not accurately represent real-world scenarios. This study aims to model the phreatic surface considering anisotropy in entry and exit conditions, comparing results with Laplace transformation-based methods. By analyzing differences between numerical and analytical models, the study seeks to refine existing models to better account for anisotropy. It is expected that entry and exit conditions will be influenced by the permeability ratio in different directions, potentially leading to new models for more accurate assessments. This research aims to enhance understanding of anisotropy's effects on phreatic surfaces and improve stability assessments.

Development of Ultra-High Performance Concrete with Locally Available Materials

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Faculty Advisor: Benjamin J. Mohr, Civil and Environmental Engineering

Ultra-high performance concrete (UHPC) is a self-consolidating concrete known for its exceptionally high mechanical and better durability properties. In the Accelerated Bridge Construction technique, UHPC is used for rapid, efficient construction to minimize traffic impact while maximizing construction safety. Previously, UHPC was utilized as a prefabricated bridge structural element, overlay, joint connector or repair material. The compressive strength of conventional concrete is typically 3000 psi at 28 days, whereas, for UHPC, it is more than 17500 psi at 28 days, with superior durability performance. Existing literature indicates that commercial proprietary UHPC costs three times higher than non-proprietary UHPC. This research aims to develop low-cost, non-proprietary UHPC with locally available materials for the Tennessee Department of Transportation. Based on availability and applicability, six types of binder (i.e., cement and supplementary cementitious materials), two types of sand and steel fiber have been selected to find optimal UHPC mixes. This experimental study adopted the 'Trial and Error' and 'one-factor-at-a-time' approach with appropriate ASTM standards to develop UHPC. A minimum of eight mechanical and durability properties, including compressive strength, flexural strength and drying shrinkage will be evaluated. Preliminary results indicate that UHPC can achieve a compressive strength of more than 3700 psi and 10000 psi at 8 hours and 7 days, respectively.

Evaluation of Maturity Method for the Tennessee Department of Transportation (TDOT) Concrete Mix Classes

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Recently, the application of the maturity method to concrete has been growing among state departments of transportation due to its relatively simple technique. The maturity method involves correlating the internal concrete temperature to the compressive strength of concrete under laboratory conditions. Once a correlation relationship is developed, the compressive strength of the same concrete mix under field conditions can be estimated by only monitoring the concrete temperature. This eliminates the need for destructive testing and allows for the early age prediction of later concrete strength. Thus, the main goal of this study is to develop the strength-maturity correlation for two classes of concrete mixes (TDOT Class A and D) following ASTM C1074 procedures. To investigate the impact of variability, two different aggregates from different regions of Tennessee (east and west) were considered. Cylinder specimens were prepared according to ASTM C192, and compressive strength was measured at the prescribed ages for each of the mixes. A thermocouple data logger has been used to measure the temperature of concrete while curing at a temperature of 23 0C. Results show that higher compressive strength can be achieved with the aggregate of the west region for the class A mix. However, for the class D mix, compressive strength with the aggregate of the east region is higher. Maturity-strength correlations also varied for each class of mixes.

A Temporal Analysis of Travel by the Urban and Rural Elderly and Their Implications for Transportation Planning

Author: Samuel Asare-Duah

Faculty Advisor: Daniel Badoe, Ph.D., Civil and Environmental Engineering

US federal law requires that states and metropolitan regions develop transportation plans to address the long-term mobility needs of their resident populations. An increasingly important segment of the national population is the elderly, that is, persons aged 65+. US Census data showed that between 2010 and 2020, the population of the elderly grew by 38.6% while the national population grew by just 7.4%. Concomitant with the growth in their population has been the growth in the number of trips they generate daily while participating in a variety of activities. Clearly, the opportunity to participate in activity is unlikely to be the same for the rural and urban elderly primarily because of the differences in accessibility.

There is therefore a compelling need to better understand the changing demographic characteristics of the rural and urban elderly and the socioeconomic activities they engage in so appropriate transportation plans can be developed to meet their future mobility needs.

This research makes use of data collected in three Surveys conducted by the Federal Highway Administration in 2009, 2017, and 2022 to address the following objectives: (1) the changes in the demographic and travel characteristics of the urban and rural elderly; and (2) the temporal transferability of models of their trip generation. The findings of the analysis will inform the development of policies that enhance the mobility of the elderly while providing for their safety in travel.

Investigating a Small Water Treatment Plant's Water Chemistry and Source Water Blending Capabilities

Author: Kalei Hair

Co-Author/Collaborator: Julia Avera, Ph.D., Civil and Environmental Engineering

Faculty Advisor: Julia Avera, Ph.D., Civil and Environmental Engineering

The City of Lafayette Water Treatment plant serves a small municipality in Macon County, Tennessee, and receives water from two nearby springs (Spring Creek and Adams Spring) and a river in Kentucky (Barren River). Spring Creek is utilized as the plant's primary water source and Adams Spring and Barren River are its supplemental sources. The study aimed to determine if the water treatment plant's water chemistry significantly changes during its treatment processes and if the plant can utilize blended ground water and surface water sources full-time. To understand its water chemistry, we assessed fifteen water quality parameters at four locations across the plant, and sampling occurred every two weeks from July 2023 to September 2023. Jar tests were also conducted for four blended influent scenarios, with differing ratios of spring water to river water in each scenario. The optimal coagulant dosages of the scenarios were utilized to determine if there is a significant increase in chemical doses when treating blended influents. Based on the collected data, it was determined that there were significant changes in water chemistry across the plant, and that the plant could blend its influents more frequently without incurring substantial increases in chemical doses. This research may illustrate the value of analyzing a small municipality's water treatment plant and evaluating blended influents to reduce stress on source waters.

Undergraduate Students

AASHTO Soil Types in Tennessee

Author: Gracie Gore

Faculty Advisor: Daniel Vandenberge, Ph.D., Civil and Environmental Engineering

In order to determine the commonality of soil types based on American Association of State Highway and Transportation Officials (AASHTO) classification by county in Tennessee, the United States Department of Agriculture Web Soil Survey (USDA WSS) was used to find the area of each county's surficial soil that contains each classification. This project was completed in fall of 2023 as part of larger research on chemical subgrade stabilization for the Tennessee Department of Transportation (TDOT). For each county, the areas of each soil type that contain soil of an AASHTO classification were compiled and summed to find a total percentage of area of the county of that AASHTO classification. Thus, each county had data for the percentages of area of each of twelve AASHTO classifications that could sum up to more than 100%. From these data, maps were generated using an online map creation tool (mapchart.net) to display the likelihood of encountering each of the

twelve classifications in the surficial soil types of Tennessee. These maps enable the data to be easily conceptualized by visually showing the counties with more of a classification as darker shades of the same color. The final products of this project are a worksheet with the soil area percentages of each classification by county and a set of maps presenting the findings.

Transportation Engineering and Construction Managment

Undergraduate Students

Easier Said Than Done: Understanding and Promoting the Value of Constructability Experience in Transportation Design

Author: Tanner Keck

Faculty Advisor: Eric James, P.E., Civil and Environmental Engineering

In the construction industry, the saying "looks good on paper" has been referred for many generations. However, what if those constructing our roads were inspired to become design engineers who provide construction-friendly plans, ultimately enhancing the efficiency of transportation projects? The idea of constructability can be a great tool to the engineer. According to the Tennessee Department of Transportation (TDOT), the average timeframe for delivering a transportation project is 15 years, with 11 years in design and 4 years in construction. TDOT projects delivered using traditional methods see a 40% increase in costs compared to their original value. These contribute to lengthy design work, shortages in materials and labor, inflation, and plan revisions. While traditional delivery methods will still be utilized by TDOT, there can still be ways to accelerate project delivery. In this report, several means of constructability considerations will be highlighted based on literature review regarding previous research on constructability for transportation projects, present challenges in transportation project delivery, lessons learned on-site, and conclusions of the report.

Computer Science

Graduate Students

Deep Learning Applications for Image Recognition

Primary Author: Chern Chao Tai

Co-Author/Collaborator: Kehelwala Dewage Maduranga, Mathematics, College of Arts and Sciences

Faculty Advisor: Kehelwala Dewage Maduranga, Mathematics, College of Arts and Sciences

In this digital era, image recognition has become more necessary than ever due to the extremely rapid growth of data. Image recognition is important due to its ability to enable machines to interpret visuals and perceive the world as we do. This technology finds applications across a wide range of fields such as healthcare, robotics, video surveillance, and autonomous vehicles. For instance, advanced vehicles have built-in autopilot mode which requires object detection system to identify obstacles and other vehicles on the road. This paper explores deep learning applications for image recognition in which the CIFAR-10 and CIFAR-100 datasets will be used as benchmarks for comprehensive experimentation. The CIFAR-10 dataset was chosen because of its more diverse and challenging nature compared to the MNIST database. The research will explore various architectures of Convolutional Neural Networks (CNN) and You Only Look Once (YOLO) object detection algorithms for image classification tasks. To further enhance the robustness of the models, data augmentation techniques will be incorporated into the models. Data augmentation is a necessity to improve the diversity of the training dataset. Finally, this paper will evaluate the performance of each model with respect to image classification. The primary goal of this research is to investigate the efficiency and accuracy of each model in recognizing images and classifying objects.

Predictive Analytics for Airline Departure Delays Using Machine Learning

Author: Anurag Dwivedi

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Faculty Advisor: William Eberle, Ph.D., Computer Science

As population increases tremendously and time is everything for many individuals, air travel has become an important component of a modern transportation system, playing a key role in the movement of people over long distances. However, one of the important modern life challenges of airports and airline agencies is flight delay; as of 2019, the amount of airline delays has increased significantly, prompting

the need for effective predictive models to manage flights departure delays. This research presents a detailed analysis of a Kaggle competition dataset focused on airline departure delays during the year 2019. The core focus of our study involves developing a binary classification model aimed at predicting flight departure delays. Utilizing a range of flight and airport-specific variables, our models are crafted to help airlines, airport authorities, and passengers anticipate and effectively manage potential delays. By leveraging machine learning and data science techniques, our models seek to enhance the efficiency of flight operations and improve the overall travel experience. Through comprehensive analysis and model development, this research contributes to the advancement of predictive analytics in the aviation industry, offering valuable insights for stakeholders to make informed decisions and optimize their operations.

2023 Google Decimeter Challenge

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Faculty Advisor: William Eberle, Ph.D., Computer Science

In today's world, the integration of smartphones and other cutting-edge technology has become critical in obtaining precise location metrics. From the navigation provided by digital maps to the futuristic development of self-driving cars, the utility of location accuracy knows no bounds. Current devices return data with limited accuracy from their Global Navigation Satellite System (GNSS) receivers, which poses several challenges. This leads to many issues, such as inaccurate arrival times, incorrect directions, and crashes in self-driving cars and aircraft alike. Our project dives into data science research based on data provided by the Google Decimeter Challenge, hosted on Kaggle. The challenge seeks to refine GNSS data accuracy to levels below the meter or centimeter range of accuracy. Our data spans from Dec 2020 to Sept 2023, but we focused specifically on the 2023 data to subset our data to a manageable size. We engaged in extensive data exploration and cleaning. Moreover, our team identified important features through visualization techniques, such as box plots and pair plots. To map the data on a global scale, we transformed Earth-Centered, Earth Fixed (ECEF) coordinate data to a Geographic Coordinate System (GCS) format. By employing tools like Pandas, NumPy, Plotly, Seaborn, and Matplotlib, we were able to manipulate and visualize data for model development through advanced artificial intelligence and machine learning frameworks, such as TensorFlow and PyTorch.

Real time monitoring and detection of FDM 3D printing

Author: Kase Johnson

Faculty Advisor: Kehelwala Dewage Maduranga, Mathematics, College of Arts and Sciences

3D printing has become more common in the past decade. Manufacturers, designers, and hobbyists that undertake 3D printing in their homes and shops often have no time for monitoring their day-long, or sometimes even longer, prints. FDM printing in particular, is subject to many kinds of print failures that can go undetected for many hours if no person or system is monitoring them, which can lead to wasting filament and time. The real-time monitoring and detection of FDM-3D printing failures is an important step towards ensuring process efficiency and reducing the waste associated with 3D printing. This paper introduces an approach to get over this hurdle, leveraging Data Mining and Machine Learning for real-time analysis of 3D printing processes. We explore the application of image-based data mining techniques for real-time monitoring and detection of various types of 3D printing failures. The methodology involves image processing through data mining techniques. Using feature extraction, this study will isolate important visual indicators of printing failures, such as irregular layer formations, warping, stringing, spaghetti prints, and others. Advanced data mining algorithms, focusing mostly on pattern recognition and anomaly detection are then applied to these features. The studies objective is to develop a model capable of real-time-analysis of 3D prints to analyze and detect signs of failures in their early stages.

Utilizing Data Mining Techniques for Early Heart Disease Detection

Author: Ida Fanny Mittagadapa

Faculty Advisor: Kehelwala Dewage Maduranga, Mathematics, College of Arts and Sciences

The increasing global rate of heart disease demands fresh approaches for early identification and

mitigation. The key topic of this study is: How can real-time health monitoring data be used to discover early warning symptoms of heart disease using data mining techniques? An unbelievable amount of real-time health data has been accessible with the introduction of wearable technologies, offering a singular chance to revolutionize the diagnosis and treatment of cardiac disease. The purpose of this project is to use sophisticated data mining techniques to uncover early signs of heart disease by utilizing this data, which includes blood pressure, heart rate, and other physiological measurements. Real-time health data from wearable devices is collected, preprocessed, and analyzed as part of this research. The study uses advanced data mining techniques, such as machine learning and pattern recognition algorithms, to find anomalous patterns and correlations that may indicate a higher risk of heart disease. Creating a prediction model that can analyze data in real-time and deliver timely risk assessments to enable early intervention is the main goal of this project. The implications of this research are profound, offering a pathway to improved health outcomes, reduced healthcare costs, and enhanced quality of life for individuals at risk of heart disease.

Machine Learning-Based Workflow Classification of Network Traffic

Author: Sahaya Jestus Lazer

Faculty Advisor: Susmit Shannigrahi, Computer Science

Network operators seek to identify individual applications and associated traffic flows to comprehend traffic patterns and detect anomalies. But scientific networks often carry heavy traffic, which makes discerning individual workflows challenging. We aim to solve this problem using Machine Learning (ML). Our initial efforts focused on classifying network traffic generated by four transfer tools: aria2, axel, curl, and wget. We observed that each tool generated distinct traffic patterns. Our setup involved capturing traffic generated while downloading 14 files from the National Library of Medicine database using each of the four tools. After filtering out acknowledgment packets from the traces, we extracted flows characterized by tuples (source IP, destination IP, source port, destination port). We segmented the flows into five parts based on the timestamps of the packets. For each of the flow segments, we collected six statistics: number of bytes, number of packets, bytes per second, packets per second, average packet size, and average delta time between packets. We represented each flow as a sample in our ML dataset, using the flow statistics as features, and the tool's name as the target variable. A Decision Tree ML model and Logistic Regression with feature scaling achieved 95% and 100% accuracy, respectively. Our work lays the groundwork for future research into more complex workflows and the applicability of other ML models in scientific workflow classification.

Credit Card Fraud Detection with Generative Adversarial Networks

Primary Author: Farhat Barsha

Co-Author/Collaborator:
Kehelwala Dewage Maduranga, Mathematics, College of Arts and Sciences

Faculty Advisor: William Eberle, Ph.D., Computer Science

The utilization of credit cards has been increasing due to their convenience, yet ensuring security remains a significant concern in today's world. The risk of credit card fraud is increasing, necessitating more emphasis on fraud detection. A significant drawback in credit card fraud detection techniques is the issue of the data imbalance nature of the credit card fraud dataset. Utilizing a balanced dataset can optimize the training process of machine learning models in accurately detecting fraudulent transactions.

Generative Adversarial Networks (GANs) have received significant attention in this field because of their ability to tackle the problem of class imbalance. A GAN is an artificial intelligence model developed specifically to produce synthetic data that resembles real data by simultaneously training a generative and discriminative model using adversarial training. This study evaluates the efficacy of AdaGAN, VEEGAN, WGAN, and Unrolled GAN in detecting credit card fraud across datasets with varying distributions, including both synthetic and real-world data. The goal is to evaluate and compare different models to choose the most efficient one. I will conduct a more thorough analysis of the generated samples by utilizing t-SNE visualization. Additionally, I will analyze the behavior of the generator and discriminator loss and utilize distance measures to evaluate generated data quality.

Fast and Accurate Anomaly Detection in Dynamic Graph Streams

Author: Anthony (Ocheme) Ekle

Faculty Advisor: William Eberle, Ph.D., Computer Science

Given a large graph stream with dynamically changing structures over a given timestep, it is crucial to detect the sudden appearance of anomalous patterns, such as spikes in IP-network attacks or unexpected surges in social media followers. However, this task presents several challenges, such as the lack of label data, the difficulty in modeling the evolving edge interactions in graph networks, and the rapid structural patterns in the graph. Therefore, it is crucial to develop algorithms that can learn inductively and promptly identify sudden changes in the network. Current techniques are limited in their ability to address these challenges.

In this research, our goal is to design a real-time, inductive, unsupervised anomaly detection method for detecting anomalous nodes and edges in a dynamic graph. We will achieve this by utilizing advanced and lightweight data structures that exhibit constant-time memory and continuous update time in streaming graphs. The performance of our model will be evaluated based on accuracy, AUC metrics, and scalability, comparing it against state-of-the-art methods through intensive experiments with a real-world dynamic graph dataset.

Undergraduates

Early Detection of Alzheimer's Disease

Primary Author: Haley Burnell

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Liezl Laurel, Computer Science
Joshua LaJuett, Computer Science

Faculty Advisor: William Eberle, Ph.D., Computer Science

Research and detection of Alzheimer's disease (AD) is becoming more necessary than ever, as an estimated 6.7 million Americans have this specific type of dementia. Misconceptions about the disease such as it developing from not using the brain enough highlight the more complex nature of developing AD, which has both genetic and environmental factors. Early detection is key as the current therapeutic treatments do not cure Alzheimer's, but can help slow the mechanism of action of the disease. To address this, the current research aims to explore and develop a multimodal model for the early prediction of Alzheimer's. The model takes into account a patient's genetic data, brain scans (MRI), and various other medical assessments. The data comes from the Alzheimer's Disease Neuroimaging Initiative (ADNI), populated by a multi-phased longitudinal study. Specifically, the current research intends to develop a 3D convolutional neural network (CNN) which will process the three modes of data to aid in early detection.

RSNA Screening Mammography Breast Cancer Detection

Primary Author: Amy McCaughan

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Faculty Advisor: William Eberle, Ph.D., Computer Science

With breast cancer being a prominent and deadly disease that will probably never go away, we want to find a way to automate the detection of breast cancer as early as possible. Therefore, this problem is something that we solved by using multiple machine learning algorithms called a Support Vector Machine, and a Convolutional Neural Network. These algorithms both support the use of image data and can help aid in the classification of malignant or benign tumors. The use of an algorithm that supports image classification is a necessity since our data is primarily mammograms. Through these algorithms, we trained the models that are being used to classify if cancer is found or not. From these models, we look for specific statistics that show that the models are accurate. An F1 score is one of our main interesting statistics to look for since this tells us how accurate the model was across the entire dataset, including wrong classifications. This is very important since we are dealing with cancer, because incorrect classifications could mean someone's life is at risk. The other main statistic that we are interested in is accuracy. This is because accuracy gives us a general percentage of what was correctly predicted from the model. With F1 being the most important, accuracy can give us a quick oversight into how well it is performing with just correct classifications, making this a good statistic for us to consider.

Flu Shot Learning: Predict H1N1 and Seasonal Flu Vaccines

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Faculty Advisor: William Eberle, Ph.D., Computer Science

In this study, we aim to predict individuals' vaccination status for the H1N1 and seasonal flu vaccines using data collected during the National 2009 H1N1 Flu Survey in the United States. Our approach involves developing a predictive model that considers individuals' backgrounds, opinions, and health behaviors. Understanding the importance of this issue is critical, as influenza and H1N1 collectively contribute to a significant annual death toll, with tens of thousands of deaths attributed to flu-related complications each year in the United States alone. To achieve this, we are incorporating advanced machine learning techniques, specifically logistic regression with a MultiOutputClassifier for handling multiple outputs simultaneously and a Random Forest classifier. We evaluate model's performance using metrics such as predictive accuracy, multi-class confusion matrix, and ROC AUC. By addressing this problem, we contribute to understanding vaccination behavior and potentially improving public health strategies.

Water Resources

Graduate Students

Flood Early Warning Systems Using Machine Learning Techniques: The Case of the Cumberland River at Ashland City, Tennessee

Primary Author: George Fordjour

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Faculty Advisor: Alfred Kalyanapu, Ph.D., Civil and Environmental Engineering

Flood disasters continue to be significant type of natural disasters worldwide, with their scope varying from neighborhood scale to continental scale. Effective flood mitigation increasingly relies on advanced warning systems. Traditionally, these systems have utilized physically-based hydrologic and hydraulic models, such as HEC-HMS and HEC-RAS. However, the integration of Machine Learning (ML) techniques, either supplementing or replacing traditional models, offers new potential for early warning systems. This study introduces a ML-based flood warning system applied to the Lower Cumberland-Sycamore watershed near Nashville, TN, within the Cumberland River Basin, aiming to predict water levels at the Ashland City USGS gauge station. The model incorporates Long Short-Term Memory (LSTM), Random Forest (RF), and Support Vector Regression (SVR) techniques, trained using water level data from 12 USGS gauges from 2017 to 2021. Comparative analysis highlights that SVR and LSTM methods surpass RF in predicting floodwater levels with Nash-Sutcliffe Efficiency (NSE) values of 0.761, 0.733, 0.724, and 0.598 for LSTM 1, LSTM 2, SVR, and RF, respectively. These findings underscore the effectiveness of LSTM and SVR in flood prediction, showcasing their potential in enhancing the accuracy of flood early warning systems. When equipped with extensive datasets for training and testing, these ML models show promise in improving flood preparedness and response efforts.

Department of Electrical and Computer Engineering

Graduate Students

Optimizing Airfare Forecasting: A Comprehensive Analysis of Machine Learning Techniques

Author: Abhijeet Solanki

Faculty Advisor: Kehelwala Dewage Maduranga, Mathematics, College of Arts and Sciences

Flight ticket prices can fluctuate significantly due to factors such as fuel prices, government regulations, airline policies, seasonal variations, etc. Our research evaluates different Machine Learning (ML) algorithms to address these challenges, including Random Forest, Decision Tree, Linear Regression, and K-Nearest Neighbors (KNN). Each technique provides unique approaches to handling the intricate factors influencing flight prices. Our research aims to determine the most effective method for accurately forecasting airline ticket fares, which can offer valuable insights to airlines for optimizing their pricing strategies while balancing revenue generation with customer satisfaction. The analysis comprehensively evaluates the algorithms' performance by leveraging extensive datasets encompassing a wide range of

variables. The research outcome is expected to enhance the understanding of dynamic pricing in the airline industry and offer a robust tool for price prediction, benefiting both airlines and consumers. Keywords - Airline Ticket Fare Prediction, Machine Learning, Random Forest, Decision Tree, Linear Regression, K-Nearest Neighbors (KNN), Predictive Analytics, Dynamic Pricing

Towards Securing Autonomous Ground Vehicles' Camera Sensors: A Zero-Trust Approach to Mitigate Laser Threats

Author: Abhijeet Solanki

Faculty Advisor: Syed Rafay Hasan, Ph.D., Electrical and Computer Engineering

The rapid advancements in Autonomous Ground Vehicle (AGV) technology have heavily relied on camera sensors for navigation and perception. However, this reliance also exposes them to laser spoofing and blinding attacks, which can compromise their safety. Motivated by these challenges of camera sensors in AGVs, this research paper proposes a comprehensive framework to analyze and mitigate laser-based attacks on AGVs' camera sensors, thereby enhancing the safety and reliability of autonomous grounded vehicles. The framework delves into physical attacks via environment-to the sensors (PAvES) attack and investigates how attackers may exploit camera sensor's vulnerabilities via laser spoofing. A comprehensive defense system, following the zero-trust pillar, will be developed. We plan to achieve this by combining constant sensor monitoring with advanced algorithms to detect anomalies. This work will strengthen the knowledge base on understanding the solutions to defend AGVs against spoofing attacks in general and laser attacks in particular, towards achieving the eventual goal of creating safer and more reliable AGVs.

Keywords: PAvES- Physical Attack via environment to the sensors, AGV-Autonomous Ground Vehicle

Decomposition of Quantum Controlled Permutation Gates

Primary Author: Joshua Adams
Co-Author/Collaborator: J. W. Bruce, Electrical and Computer Engineering

Faculty Advisor: J.W. Bruce, Ph.D., Electrical and Computer Engineering

Overcoming noise is the predominant obstacle faced by quantum computers. Maximum environmental isolation is required to preserve meaningful information storage. This isolation regularly involves qubit-to-qubit isolation. Practical quantum computers often adopt nearest neighbor architectures to restrict the interaction of qubits. Nearest neighbor quantum computers necessitate the decomposition of all quantum operations into a series of 1-qubit and 2-qubit gates. The CSWAP gate is an essential tool used to compare quantum states, generate entangled GHZ states, and build classical logic circuits in a quantum setting. The CSWAP gate can be viewed as a controlled permutation gate. Larger controlled permutation gates are an extension of the CSWAP gate with n>2 data qubits and m=1 control qubits. Controlled permutation gates have applications in superdense coding and entangled state generation. This work presents an optimal nearest-neighbor decomposition of the CSWAP gate along with nearest neighbor compliant controlled permutations of n=3 qubits. The quantum cost and gate count of each circuit is compared to the existing material.

Low Cost IoT for Water Level Monitoring in Remote Regions

Author: Grace Dadzie

Faculty Advisor: J.W. Bruce, Ph.D., Electrical and Computer Engineering

Stream monitoring plays a pivotal role in flood prediction and watershed management. Traditional monitoring devices come with a significant cost barrier, rendering them inaccessible for local counties with limited budgets. This project introduces a cost-effective solution with IoT technology, developing efficient flood sensors. The project tackles cellular connectivity issues in remote regions through a dual-network approach, employing both Long Range (LoRa) and cellular technologies. Four use cases outline the project's versatile sensor network: 1) direct cellular transmission in areas with robust connectivity, 2) LoRa to cellular relay in zones with variable cellular quality, 3) adaptable nodes switching between LoRa and cellular based on connectivity strength, and 4) a mesh network of LoRa sensors ensuring data reaches a node with cellular access. Prototypes for direct cellular transmission and LoRa-to-cellular relay have been developed, with field tests demonstrating LoRa's efficacy over distances up to 1500 feet. Preliminary results show an average Received Signal Strength Indicator (RSSI) of -113dBm and a Signal-to-Noise Ratio (SNR) of 2.96dBm, alongside a Packet Delivery

Ratio (PDR) of 0.99. These findings highlight the project's potential to offer a scalable, cost-efficient solution to stream monitoring challenges, promising significant improvements in flood prediction and watershed management.

Analytical Design of Rectangular Electromagnetic Pads for Optimized Wireless Charging

Author: Taiye Owu

Faculty Advisor: Mahajan Satish, Ph.D., Electrical and Computer Engineering

Two major goals in Wireless Power Transfer (WPT) systems are maximizing the mutual inductance and minimizing the stray field. This article proposes an analytical method to carry out a mutual-inductance optimization on a rectangular electromagnetic pad structure to achieve maximum coupling and minimize stray field. The proposed optimization first uses analytical methods, Finite Element Analysis (FEA), including experiments. From the optimized pad design, it is shown that more power can be delivered even under misalignment conditions. Results further show, that preliminary designs for a mutual inductance optimized pads WPT system with tolerance to misalignment can be done using an analytical approach.

Game-Theoretic Distributed Reinforcement Learning Based MIMO Optimal Control Design for Building HVAC Systems

Primary Author: Junaid Anwar

Co-Author/Collaborator: Syed Ali Asad Rizvi, Electrical Engineering

Faculty Advisor: Syed Rafay Hasan, Ph.D., Electrical and Computer Engineering

Buildings remain to be the key consumers of electricity in the US accounting for roughly 76% of energy usage. A major contributor to this energy consumption are the building's heating, ventilation, and air conditioning (HVAC) systems, and therefore, there is a significant room for improving the energy utility by optimizing the controls of these systems based on modern optimal control theory. However, owing to the challenges of modeling large-scale building HVAC systems, traditional model-based optimal control approaches become increasingly difficult to employ. This has led HVAC researchers to explore recent AI based control theoretic tools, in particular, reinforcement learning (RL). RL based optimal control techniques have recently demonstrated some success in HVAC applications. We present a new formulation for distributed optimal control design for building HVAC systems using a two-player non-zero-sum cooperative game. A new data-driven and completely model-free Q-learning algorithm is proposed that solves a quadratic game optimization problem online without invoking any knowledge of the building dynamics. Mass flow rate and supply air temperature are considered to be the key decision variables that serve as the two players in the game. The building HVAC zone serves as a game environment for these players, whose dynamics are assumed to completely unknown to the players. The algorithm is shown to learn the optimal game solution and associated control policies for each player.

A Cooperative Economic Dispatch Scheme using Mobile-Aware Electric Vehicles

Author: Yang Zheng

Faculty Advisor: Nan Chen, Ph.D., Electrical and Computer Engineering

With the high integration of intermittent renewable energy sources and rapidly increasing load demand in the smart grid, the smart grid faces critical challenges in energy balancing under high stability and reliability constraints. Existing literature considers stationary energy storage and infrastructure upgrades to address the aforementioned challenges. While effective, these approaches could be costly as ramping more generation capacity or building more bulk generation require high expenditure.

Meanwhile, as the market penetration of electric vehicles (EVs) increases, their potential as mobile energy storage could be utilized by the smart grid. EVs could be used as energy buffers to compensate for insufficient power generation incurred by intermittent renewable energy and stochastic loads. This paper proposes a cooperative dispatch of mobile EVs and generators to achieve cost-efficient energy balancing. First, the mobile EV-assisted economic dispatch problem is formulated to minimize the generation dispatch cost considering on-demand charging and discharging of mobile EVs. A rolling horizon window algorithm is developed to efficiently solve the problem considering the stochastic properties of renewable energy generations and loads. Simulation is conducted on the IEEE 14-bus system to demonstrate the effectiveness and cost-efficiency of the proposed scheme compared to existing benchmarks.

Developing an Electric Vehicle Driving Dataset to Analyze Driving Behavior

Author: Weston Beebe

Faculty Advisor: J.W. Bruce, Ph.D., Electrical and Computer Engineering

Electric vehicles (EVs) present a number of advantages over conventional internal combustion engines. Overall cost of ownership is lower, and they have higher efficiency and reduced emissions. As EV become more popular and infrastructure continues to develop, it is important to understand how EVs specifically are utilized as personal vehicles. This work presents an EV dataset with data collected from various vehicles driven in various conditions and locations. Data is logged from the vehicles on OBD-II loggers. The raw data is normalized, collected, and processed. Data is collected on a per second basis and includes various fields such as vehicle and motor speeds, high voltage battery voltage and current, temperature, and state of charge. Data collected per drive includes energy consumed and distance driven. Data continues to be collected, but the dataset contains data from 116,508 driven miles at the time of writing. This dataset can be useful in data-driven modeling and can provide a better understanding of how electric vehicles are utilized as personal vehicles, providing insight in infrastructure planning or smart grid applications.

Analysis and Evaluation of LSTM and CNN-based short-term load forecasting

Primary Author: Nabil Bin Shahadat Shuva

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Faculty Advisor: Satish M. Mahajan, Ph.D., Electrical and Computer Engineering
Load forecasting plays a crucial role in power systems for optimizing power generation and enhancing energy management. Precise short-term load forecasting improves resource allocation & grid stability and reduces unnecessary costs associated with power generation. The load demand depends on multiple factors including consumer behavior, weather conditions, and economic activities. Conventional statistical models such as time series analysis and regression have been performedover the years to forecast power consumption using historical load data and weather data. Due to the non-linear characteristics of electricity demand, the calculations of the forecasting model become more complex. To mitigate this, various machine learning algorithms have been introduced. In this study, two distinct neural network models such as Long Short-Term Memory (LSTM) and Convolutional Neural Network (CNN) will be employed to forecast 1-hour and 24-hour ahead load demand by utilizing hourly load data from Electric Reliability Council of Texas (ERCOT) and weather data of the coastal region of Texas from the National Renewable Energy Laboratory (NREL). LSTM and CNN models outperform traditional statistical methods by demonstrating increased efficiency and accuracy in acquiring complex patterns for improved forecasting. This study aims to evaluate the accuracy of LSTM and CNN models using different metrics such as Mean Absolute Percentage Error (MAPE) and Root Mean Squared Error (RMSE).

Undergraduates

Reinforcement Learning Based Adaptive Cruise Controller for Autonomous Vehicles

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Faculty Advisor: Syed Ali Asad Rizvi, Electrical and Computer Engineering

Automatic cruise control is considered as one of the foundational building blocks in vehicle autonomy that has been widely accepted in the automative industry. Its primary objective is to maintain the vehicle speed without user intervention even in the presence of varying road conditions and/or loading of the vehicle itself. Higher-level vehicle navigation algorithms rely on this fundamental block to achieve their desired vehicle trajectories. Traditionally, mainstream implementations of cruise controllers used to be primarily based on the classic proportional-integral-derivative (PID) algorithm. However, recent advances in adaptive control theory have paved the way for controllers that have self-adaptation capabilities to cater for wider scenarios without requiring much tuning with respect to the underlying vehicle dynamics and environmental conditions. Optimality of the cruise controller has now become a key design consideration particularly for electric vehicles that are subject to battery and range constraints. In this work, we present a cruise controller that not only is adaptive but it meets a linear quadratic optimality criterion

without requiring any knowledge of the vehicle dynamics or external disturbances. It is shown that the cruise controller is able to learn the optimal control parameters online in real-time as established by its convergence and asymptotic vehicle speed tracking is maintained under different road conditions.

Decay of 34Mg and Its Daughters

Author: Dakota Moye, 2023 CISE Recipient

Faculty Advisor: Mustafa Rajabali, Physics

34Mg sits near the island of inversion near the magic number N=20. Its decay includes both beta-delayed one and two neutron emissions and a long decay chain of mass 34, 33, and 32. To understand its decay feeding, there are several hurdles that must be overcome. Along its decay chain, 34Si is known to have a low-lying state that decays via an E0 transition, which hinders the beta-particle tagging and must be accounted for when counting the beta-electrons. Also, the beta-delayed neutron branching ratios from Mg and Al are not well known.

An experiment was conducted at TRUIMF Laboratory using the GRIFFIN spectrometer, which included the use of HPGe detectors, plastic scintillator detectors, and new OGS neutron detectors to observe the decay of 34Mg, its decay chain, and beta-delayed daughters. From this data, the goal is to extract branching ratios for beta-delayed neutron one and two emissions along with detecting any new energy transitions in the decay chain of 34Mg. Utilizing the Bateman Equations to fit the decay chain, we can narrow down the ranges for the beta-delayed branching ratios and confirm predetermined half-lives. From this fit, we also need the beam intensity which would then give an absolute decay rate to help determine the decay feeding intensity.

Wireless Power Through Soil Efficiency Calculator

Author: Erlind Boraj

Faculty Advisor: Van Neste, Ph.D., Electrical and Computer Engineering

Wireless power transmission (WPT) is vital in the industry for its ability to enhance operational flexibility, safety, and efficiency, ultimately driving innovation and productivity.

Tennessee Tech is developing a currently functional WPT system using the soil as the medium and inverter propagating a pulses at 50kHz in order to power sensors over an area. A well is used to install two electrodes underground as the positive/negative terminals. Sensors are being developed at State University New York, Buffalo and tested at UTK. This research will be about calculating the power loss while using the "Through the soil" system. The intent of this research is to create a mathematical model to predict the power loss through soil in different ranges and frequencies. The model will involve weather variability and soil structure. Thus, creating an efficiency model so we can expand the usage of the "Through the soil" system beyond just farming equipment but also in industries such as sports, geology, etc.

As of right now, the system is already built and set up at the Tech farm where I have put several rebars at range, equally spaced to be used as testing points. Current and Voltage will be measured at different distances, frequencies, weather conditions. Finally, will create a user-friendly software which will output the power needed for desired range and efficiency of any device. This will facilitate current Tech work on "Through the soil system" and utilize it in other industries.

Data Science and Artificial Intelligence

Undergraduate Students

Impacts of Color on Convolutional Neural Network Classification

Primary Author: Ethan Owens

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Faculty Advisor: Doug Talbert, Computer Science

Convolutional Neural Networks (CNNs) are a staple in modern image classification modeling, drawing inferences from color, texture, and shapes from images. While the significance of texture and shapes on classifications is well documented, the importance of colors for classification is much less of a focus in the literature. Through empirical investigation on album covers we will explore the significance of

color on genre classification. Through this we can gain insights into whether the model's predictions are driven by genre characteristics or potentially irrelevant color patterns. If applying a filter drastically changes the predicted genre, it might suggest that the model is capturing superficial features rather than deep, meaningful aspects of the music that truly define its genre.

Department of Manufacturing and Engineering Technology

Mechatronics

Undergraduate Students

The Development of Knowledge Blocks for Producing the Remanufactured filaments for the Material Extrusion Processes

Author: Robert Officer, 2023 URECA Recipient, 2023 CISE Recipient, Ned McWerther Scholar

Faculty Advisor: Ismail Fidan, Manufacturing and Engineering Technology

As additive manufacturing continues to gain traction across various industries, the demand for sustainable materials has escalated. Among these materials, the concept of creating custom and recycled filaments has become incredibly popular. This research study presents a systematic investigation of the categorization and characterization of filaments created by home use extrusion by their quality as well as determining what parameters affect color, quality, strength and ductility. This study also seeks to analyze how the presence of additives affects the quality of the filament and the parameters needed to create quality filament. By synthesizing existing literature, this study aims to provide a comprehensive understanding of the diverse types of recycled and virgin filaments, their properties, processing techniques, and applications. Additionally, the study examines the key properties of filaments, like the mechanical and thermal strengths as well as analyzing the dimensional accuracy of the created filaments. Furthermore, it highlights the emerging trends and challenges in the field, including the need for standardized testing protocols and the integration of recycled materials into industrial-scale additive manufacturing processes. Through this assessment, the project seeks to provide a frame work for how specialty filament creation as well as at home recycled filaments can be created with quality in mind and how each form of filament can be assessed and categorized.

Department of Mechanical Engineering

Graduate Students

A Numerical Study on the Impact of Turbulators in Enhancing the Thermal Performance of Parabolic Solar Collectors with Various Heat Transfer Fluids

Author: Mohsen Pourfallah

Faculty Advisor: Ethan Languri, Ph.D., Mechanical Engineering

Solar energy represents a pivotal solution to address the world's growing energy needs while mitigating the environmental impact of traditional fossil fuel-based power generation. Solar energy systems can be deployed on various scales, from small residential rooftop installations to large-scale solar farms, making them versatile and adaptable to diverse energy requirements. Parabolic solar collectors are sophisticated devices designed to concentrate sunlight onto a focal point, where the concentrated solar energy can be utilized for various applications, such as electricity generation or heating. In this numerical study, three novel configurations of fin-spiral turbulators are introduced to enhance the convection coefficient inside the absorber tube. Moreover, three different nanofluid compositions, including baseline water and water-based Single-walled carbon nanotubes (SWCNT), cupric oxide (CuO), and a hybrid SWCNT-CuO at concentrations of 1%, 3%, and 5%, compare in terms of their heat transfer coefficients and friction factors. The turbulators with 4, 7, and 10 blades are evaluated by ANSYS-FLUENT under steady state and turbulent flow conditions.

Thermal Performance Analysis on Copper Metal Foam and PCM Composite in a Rectangular Chamber

Author: Mohsen Pourfallah

Faculty Advisor: Ethan Languri, Ph.D., Mechanical Engineering

Phase change materials (PCMs) have a crucial role in the enhancement of heat transfer in the design of many systems in the power and energy industries. The high heat capacity in a small amount of PCMs has made them an ideal candidate for application in

compact devices and systems. Moreover, PCMs are able to maintain a constant temperature during the phase change, therefore, they would be excellent for applications needing uniform temperature distribution such as batteries, microprocessors, and fuel cells. On the other hand, PCMs suffer from low thermal conductivity and complete release of the absorbed heat causing a low heat transfer rate and a sharp drop in heat dissipation capacity. Porous materials such as metal foam have the potential to improve the thermal specification of the PCMs in different applications. In this study, the effect of embedding copper metal foam with different PPI (porous per inch) is investigated in a rectangular chamber with paraffin wax. Constant temperatures and constant heat fluxes are employed as boundary conditions in a wall to analyze the melting time and temperature distribution on metal foam and PCM composite.

Experimental and Numerical Analysis of a Novel Metal Casting Process: Lost-PLA Casting

Primary Author: Mohammad Alshaikh Ali, 2023 URECA Recipient

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Faculty Advisor: Ismail Fidan, Manufacturing and Engineering Technology

Metal casting is one of the oldest manufacturing techniques dating back five thousand years. With advancements in Additive Manufacturing (AM), specifically Material Extrusion (MEX), multiple methods of integrating AM into metal casting have been proposed. In this research, a novel process is developed to exploit MEX filaments with foaming agents to use as direct expendable patterns. Three materials are considered, and all three are thermally characterized, including Thermogravimetric Analysis and Differential Scanning Calorimetry, to identify the best candidate for the casting process. In addition, the flow and density characteristics of the materials are explored. The pattern is then fabricated, coated, and placed in mechanically bonded sand. The molten Aluminum is poured at a temperature of 780 C, with the flask being filled with 35 Grain Fineness Number mullite sand. Material characterization results indicate one of the MEX filaments has a lower Volumetric Expansion (VE), at around 200%, which yields heavier components compared to the other two materials which exhibit a VE of around 250%. Simulation is run to identify shrinkage locations based on the pattern developed. The simulation results exquisitely match the experimental results. In conclusion, the preliminary results indicate that the process proposed has significant potential to be adopted by industry due to the success observed.

Enhancing the Mechanical Properties of Additively Manufactured Carbon Nanotube Integrated Components: A Simulation-Based Approach

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Additive Manufacturing (AM) is becoming an attractive production technology due to its ability to produce complex shapes and reduce raw material usage. However, its strength isn't as good as traditional techniques. To address this, fillers like carbon nanotubes (CNT) are increasingly being introduced in AM processes, especially in Material Extrusion (MEX) processes. CNTs have strong mechanical characteristics that could improve the parts printed of PLA or ABS materials. The objective of this study is to explore how the mechanical properties of 3D-printed parts improve by incorporating CNTs. Using both experimental and simulation methods, this study explores the influence of CNTs on the mechanical properties of 3D printed parts and demonstrates how simulations replicate real-world processes. Different simulation tools such as Material Designer and Explicit Dynamics within Ansys software were used in the simulation. Material Designer was used to incorporate CNT filler at varying percentages into PLA and ABS matrices and the strength analysis was carried out using Explicit Dynamics. It appears from preliminary results that 0.5% and 1% additions of CNT result in an increase in material strength, while 2% addition leads to CNT agglomeration with adverse effects. These findings suggest that polymers reinforced with CNTs show potential for strengthening materials in AM applications thus enabling engineers to develop more effective designs and benefiting the industry going forward.

Numerical Modeling of Industrial Thermal Management Systems for Energy Efficiency Improvements

Primary Author: Spencer Jones

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Manufacturing processes produce a significant thermal load in industrial sites. Three main cooling methods exist to remove this heat load: evaporative, spray-assisted, and dry cooling. Evaporative and spray-cooling systems both use the latent heat of water in the heat exchange. The difference is system orientation, evaporative is open, while spray-assist systems are closed loop. In dry cooling, a closed loop heat exchanger is used to transfer the thermal load from the process to the outdoor air. Each of these systems uses electric energy for a fan to control load on the cooling system and a pump to control process water flowrate. For evaporative and spray-assisted cooling, the system load and flowrate directly relate to a volume of water lost through evaporation. It is common for all three resources to be used inefficiently in any cooling system. However, the projects that can increase resource efficiency are difficult to analyze. In this study, a numerical model was further developed and validated to quantify the energy and water savings associated with various efficiency projects on each cooling system. Using TMY3 weather data, a cooling system's operation can be simulated for the ambient conditions through a year. This model combines heat transfer and thermodynamic models to create a resource that can be used by industry to inform decisions related to implementing efficiency projects for their evaporative, spray-assisted, and dry cooling systems.

A Review of Engineering Applications for Daytime Radiative Cooling

Author: Spencer Jones

Faculty Advisor: Ethan Languri, Mechanical Engineering

As the average temperatures of the planet increase, cooling systems become more important. Whether these are air conditioning or process cooling systems in industry, the increase in ambient temperatures means an increased need for cooling. Since most cooling systems require electric energy that has been generated by the combustion of fossil fuels, their operation also causes the higher temperatures that necessitate the greater demand for cooling. The problem here indicates the need for passive cooling systems, such as radiative cooling, that require no energy input to achieve a cooling effect. Radiative cooling refers to an object's ability to reduce its thermal load primarily by radiation heat transfer to deep space. Specifically, radiative cooling has been expanded recently to include daytime radiative cooling. This extension allows an object to still achieve a net cooling effect even in full sunlight. Due to the solar irradiance experienced in full sunlight, a daytime radiative cooling material must exhibit high reflectivity in the solar spectrum and a high emissivity in the atmospheric window, a region of the infrared spectrum where the Earth's atmosphere is transparent to thermal radiation. In this study, a review of radiative cooling materials and applications is completed to better inform the decision-making process for the engineering applications where radiative cooling would be viable.

Optimizing Defect Detection: MetaFixture Testbed for Indirect Electromechanical Impedance Based Non-Destructive Evaluation

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This paper introduces a pioneering method for non-destructive evaluation (NDE) and quality control (QC) of engineered structures, leveraging an indirectly bonded electromechanical impedance (iEMI) technique integrated with a metamaterial fixture. Conventional NDE approaches often encounter challenges such as high costs, limited accessibility, and sensitivity issues with complex geometries. In contrast, iEMI presents a cost-effective solution by utilizing a piezoelectric element affixed to a fixture instead of directly to the part, thereby eliminating the need for individual part instrumentation.

However, conventional iEMI configurations may be susceptible to interference from fixture dynamics, potentially distorting the impedance signature of the test specimen. To overcome this hurdle, this paper proposes the utilization of a metamaterial fixture characterized by broad bandgap properties. By strategically preventing wave propagation within specific frequency ranges, this innovative fixture accurately reflects the intrinsic characteristics of the part under examination. The study focuses on the development of a chiral metamaterial fixture tailored

to control mechanical wave propagation, with a particular emphasis on achieving bandgap formation within targeted frequency ranges.

Digital Twin Technology in Manufacturing

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In the past years, the integration of Digital technologies has started taking place in the field manufacturing. In that specifically Digital twin is very popular technology. A Digital Twin can be defined as an AI-based virtual representation of a physical entity, process, or system that replicates its behavior, characteristics, and performance. In the context of manufacturing digital twin can be created to represent equipment, workers, production lines, products, and more, simulating processes to enhance decision-making.

The literature lacks a review of the digital twin concept in Manufacturing. This paper conducts a review of the current state-of-the-art in digital twin (DT) technology for manufacturing facilities. The review approach is to examines various technologies used in creating DTs and a systematic analysis of the methods, technologies, algorithms, and approaches used in digital twin experiments also, it will present the new methods for predictive maintenance to identify and address problems in production line or a system.

This study's results provide insight into the factors that influence production, methods, help to expedite identifying equipment malfunctions and point towards potential solutions, leading to more sustainable and energy-efficient buildings.

Keywords: Digital Twin (DT), Digital Replica, Energy Efficiency, Sustainable Process, manufacturing operations, Digital Technology

A Molecular Modeling Approach to Estimating Engineering Additive Thermal Properties

Author: Miles Nevills

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Functionalized nanodiamond (fND) particles present a potentially novel solution to issues of fluid heat transfer -- use of engineered additives for the overall improvement of heat transfer characteristics in a host fluid. Estimation of particle properties, however, is difficult with more commonly utilized strategies, often producing significantly varied results. Molecular modeling, also sometimes referred to as quantum modeling, grants a unique approach in the forms of Green-Kubo method and Non-Equilibrium Molecular Dynamics (NEMD). Through the use of loose thermostating, an approximation of a typical engineering heat flux problem can be simulated and analyzed. This thermostating involves the selection of atomic groups on either side of the particle and designating a "hot" side or "cold" side. GROMACS, typically used for protein simulation, has enough present capabilities to perform this analytical approach. These capabilities allow for the calculation of both isochoric specific heat capacity and thermal conductivity, granting a more detailed understanding of the functional groups affects on the diamond core, and more appropriate values to be used in Maxwell's solution property equation

Characterization of the Functional Nano Diamond Enhanced Phase Change Materials: Electronic Thermal Management

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Thermal management of the electronic devices is one of the very important aspects. According to the survey almost 53 % of the electronic devices fails due to increased temperature. Currently a lot of research is happening on the phase change materials in order to improve the thermal management of the electronic devices because of high latent heat of fusion possessed by them.

To boost up the thermal performance of the PCM they are being doped with the various types of the nanoparticles. In present work two different types of the PCM are synthesized with the Functionalized Nano Diamond Particles. Both the PCM are enhanced and characterized with the 1% Wt., 2% Wt. and 3% Wt. functionalized nanodiamond particles. To examine the various properties of the composite PCM some characterization tests are performed like measurement of thermal conductivity with KD2 Pro, Differential Scanning Calorimetry (DSC) for specific heat and

latent het of fusion, Viscosity measurement with AND SV-10 Vibro Viscometer and X-ray diffraction (XRD). In addition to this a statistical tool Response Surface Method (RSM) is deployed to achieve optimum Wt.% of the FND to be used for maximum value of the thermal conductivity.

It has been found that the addition of the FNDs to the PCM enhanced the thermal conductivity of the PCM.

Keywords: Phase Change Material (PCMs), Functionalized Nano Diamond (FND), Differential Scanning Calorimetry (DSC), X-ray Diffraction (XRD), Thermal Conductivity

Undergraduate Student

Development and Evaluation of an Insole-based Foot Impact and Force Sensing System

Author: Tyler Kinchen, 2023 URECA Recipient

Faculty Advisor: Steven Anton, Ph.D., Mechanical Engineering

A smart building is one with intelligent features that monitor the structure, its occupants, and its environment to adaptively control the systems in said building. Tech is developing one of these structural dynamics smart building systems (SDSBS). This system is vibration-based and uses floor-mounted accelerometers to determine the source of vibrations in the building. The smart building system could result in a less intrusive tool to monitor building occupants. Vibration-based localization algorithms typically use a time-based approach, energy-based approach, or both. The time-based methods rely on time-difference-of-arrival (TDOA) calculations and can have large errors due to the variability of the wave velocity through the floor. Precise data on the exact timing of the impact being measured by the system would contribute to the improvement of the system's accuracy. The goal of this project will be developing and validating a wireless insole-based system that can be used in any shoe to accurately record when a footstep impacts the floor and the duration of contact. This system will be used by the SDSBS team for occupant tracking studies as a data collection tool. Once completed, the system can be adapted for gait analysis, pressure mapping and force analysis.

College of Interdisciplinary Studies

Biology

Undergraduate Student

Phylogeography of the Tennessee Woodrat

Author: Gabriela Barrett, 2023 CISE Recipient

Faculty Advisor: Carla Hurt, Ph.D., Biology, College of Arts and Sciences

In Tennessee, woodrats (genus Neotoma) have experienced significant population declines due to habitat loss and infection from the raccoon roundworm (Baylisascaris procyonis). Efforts to protect woodrat species have been hindered by a lack of information regarding their taxonomy and distribution. Within Tennessee, the Allegheny woodrat (N. magister), and its sister taxa, the Eastern woodrat (N. floridana),are both recognized as species of greatest conservation need and deemed in need of management. Information regarding the geographic boundaries of these two species is needed to effectively maintain genetic connectivity between conspecific populations. We analyzed sequence data of three mitochondrial genes (12S, 16S, COI) from woodrats collected across the state of Tennessee. Phylogenetic reconstructions were used to assign unknown samples to species and to assess population structure within species. The geographic distribution of species was used to identify species boundaries and potential hybrid zones. Our analysis of mitochondrial sequence data provided information on the geographic distribution of sister species N. magister and N. floridana and added support for recent taxonomic revisions. We also identified geographic structure at the subspecific level for both species. Results from this study will be used for determining critical habitat for Neotoma within Tennessee.

Department of Environmental and Sustainability Studies

Undergraduate Student

Genetic Diversity Analysis of Captive Barrens Topminnow Populations

Primary Author: Lydia Burton

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Faculty Advisor: Carla Hurt, Ph.D., Biology, College of Arts and Sciences

The Barrens topminnow, Fundulus julisia, a freshwater fish native to Tennessee's Barrens Plateau, has faced population declines since the 1980s due to various environmental pressures such as drought, habitat loss, and the presence of the invasive species Gambusia affinis (Western Mosquitofish). In response, efforts to establish captive ark populations were made as early as 1983. Maintaining genetic diversity within these captive populations is crucial, as reduced diversity can increase vulnerability to diseases and a myriad of other threats. Over time, naturally sustained populations of Fundulus julisia have dwindled to the extent that they are now formally protected under the US Endangered Species Act as of 2019. Consequently, ark populations are of heightened importance in conservation endeavors. To better understand the genetic variation and measure drift within and between captive ark populations and the remaining endemic populations, this study employs GBS (genotyping-by-sequencing) to generate SNPs (single nucleotide polymorphisms) data for formal analysis. By comparing genetic data from captive populations to that of native populations, researchers can assess the effectiveness of captive breeding programs in preserving genetic diversity and inform future conservation strategies for the Barrens topminnow.

Environmental Studies - Agriculture

Graduate Student

Response of tomato yield and yield-correlated morphology to hydroponic nutrient solution application regimes

Primary Author: Ronnie Dunn, NSF-NRT Grant

Co-Author/Collaborator: Michael Nattrass, Agriculture, College of Agriculture and Human Ecology

Faculty Advisor: Michael Nattrass, Agriculture, College of Agriculture and Human Ecology

In the U.S., tomato (Solanum lycopersicum) crops have a $1 billion annual value. However, tomato production can cause eutrophication via nutrient pollution. Hydroponic production decreases nutrient leaching, but optimization of nutrient application and cultivar choices could further reduce nutrient discharges. The objectives of this study were to (1) compare the response of tomato yield and yield-correlated morphology to a growth-stage-based nutrient application and a constant concentration application; and (2) analyze the effect of growth habit and cultivar on tomato yield and yield-correlated morphology. The nutrient application strategies were applied to plants of two growth habits and six cultivars, and data was taken on yield and related morphology. Analysis revealed no significant difference in total fruit weight plant-1 between nutrient application regimes ($P = 0.05$), but mean fruit weight (164.26 g) and diameter (71.70 mm) were significantly greater ($P < 0.0001$) for plants receiving the constant-concentration application. Indeterminate plants had significantly greater ($P < 0.0001$) mean fruit weight (192.76 g), and mean fruit diameter (76.42 mm). 'Big Beef' had significantly greater ($P < 0.05$) total fruit weight plant-1 (9.25 kg). Applying a constant nutrient concentration to indeterminate plants, particularly 'Big Beef' and 'Cherokee Purple', seems to be the optimum among the factors analyzed and could decrease nutrient pollution while increasing producer profit.

Environmental Studies - Chemistry

Graduate Student

Microwave-Assisted Synthesis of Pyridazine Complexants for Minor Actinide Separation via Cyclization of N-Tosylhydrazones and Allyl Acetate

Author: Lakshi Thilakarathne

Faculty Advisor: Jesse D. Carrick, Ph.D., Chemistry, College of Arts and Sciences

Currently, 20% of electricity generation in the USA is produced by nuclear energy. Chemoselective separations of the radiotoxic minor actinides (An) from lanthanides (Ln) in spent nuclear fuel is important to improve efficiency of the nuclear fuel cycle. This research focuses on method development to provide synthetic options for convergently constructing unsymmetric heteroaryl donor complexants comprising pyridazines from accessible starting materials for evaluation in An/Ln separations. By using previously studied scaffolds as reference, this work, palladium promoted ligation of N-tosylhydrazones

functionalized with allyl acetate by microwave irradiation to synthesize ÃŸ,?-unsaturated hydrazones. Aldehyde derivatives of N-tosylhydrazones were synthesized using 2-pyridine carboxaldehyde as the starting material with 100% conversion. Currently, the two-pot reaction ÃŸ,?-unsaturated hydrazones facilitated metal-promoted intramolecular cyclization to form pyridazine complexants, which is a more favorable reaction pathway that has already been studied. The method development, current synthetic progress of pyridazine complexants, and future directions will be discussed.

Environmental Studies - Integrated Research

Graduate Student

The Use of GIS to Determine Spatial Variation in Watersheds

Author: Bryant Davis, Research Assistantship

Faculty Advisor: Andrew Callender, Ph.D., Chemistry, College of Arts and Sciences

Streams with underlying differences in geology and land use may contain different concentrations of cationic species. Currently, little is known about these relationships. This research utilizes spatial analysis, via GIS, to determine sampling points to investigate this question. Percentages of primary bedrocks and land-use parameters will be calculated for each watershed included in the analysis. A layer showing roads, that intersect streams, will also be included so that sampling locations can easily be determined. The goal of this analysis is to determine watersheds that are similar and different across middle Tennessee. Any differences in geologic and land-use data will likely dictate any chemical differences that are observed.

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