The 18th Annual

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 2023 Research and Creative Inquiry Day. This is the 18th annual RCI Day where students will once again have an opportunity to prepare and showcase their research and scholarship for a campus-wide audience.

For many, this will be their first public academic presentation – truly a momentous culmination of all of their hard work and training. For many, this opportunity will set the stage for future presentations/interviews and continuing success.

During RCI Day, students will have the opportunity to hone their presentations in front of a supportive audience.

Those of you who are audience participants should take the time to engage students on their projects. I am certain that their underlying preparation and spirited enthusiasm will shine brightly. Each presenter's passion may also ignite interests in others interested in seeking a rewarding mentoring relationship.

This year's RCI Day features posters and papers on topics across every field of study at Tech, as well as transdisciplinary efforts where collaborative teams from different colleges have come together to build novel and exciting projects. Behind each presentation, faculty mentors have exposed students to research and scholarship beyond the classroom – providing a solid foundation for innovation and discovery.

The experiences over the past year do not only introduce students to a faculty mentor's area of expertise; they further inspire active learning, stimulate creativity, build critical-thinking skills, while providing a well-earned sense of accomplishment. The importance of these factors cannot be underestimated in educating and preparing students for their post-Tech goals. Participation in such programs also provides students with an opportunity to test the waters in new areas across a host of disciplines. Through such opportunities, participation and hands-on experiences can readily shape a student's long-term perspectives.

As students have the chance to expand their knowledge-base during RCI Day, I challenge you to identify an area outside of your majors to learn something new today.

As all of the exciting presentations highlight, you have many options in front of you at Tech. Soak up what may be totally new to you, and you might be pleasantly surprised as to what may actually impact your decision-making processes and subsequently influence your career trajectory.

It should also be noted that the Office of Research and Economic Development has grown over the last year, bringing on many new faces. Many staff members are also experiencing their first RCI Day. We've learned even more about hosting, the logistics in moving the event to the Memorial Gymnasium for the first time, and as many of you have recently witnessed — how to best provide printing support for all poster presenters.

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.

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.

Before closing, I want to thank everyone involved in RCI Day from logistical support to generating posters and presentations. We should all recognize and applaud the judges tasked with reviewing and scoring presentations.

And lastly, I want to acknowledge the outstanding volunteers and the team within the Office of Research and Economic Development that worked conscientiously to make this Tennessee Tech tradition – even stronger in 2023.

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

Dr. Carl A. Pinkert
Interim 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.

In conjunction with this year's event, you are invited to view a creative media inquiry project that is available on the event web page at tntech.edu/research/research-day/index.php.

The video was developed in the Social Problems (SOC 1650) class taught by Ada Haynes, professor of sociology, during the Fall 2021 semester.

During this course, students explored a social problem through research with a creative inquiry and sociological lens and as part of the QEP-sponsored redesign of the course, developed creative projects displaying an effective media campaign that promoted awareness and/or offered an innovative solution to the social problem studied. One video was submitted for the event.

The 18th Annual Research and Creative Inquiry Day

Schedule of Events

Wednesday, April 19

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 20

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

2023 Judges

Melinda Anderson ..... Human Ecology
Holly Portia Anthony ..... Curriculum &Instruction
Steven Anton ..... Mechanical Engineering
Megan Atkinson ..... Volpe Library
Ali Arzani ..... Center for Energy Systems Research
Arthur Banton ..... History
Joe Biernacki ..... Chemical Engineering
Ciana Bowhay ..... Agriculture
Christopher Brown ..... Biology
Stacey Browning ..... Nursing
Amber Buckner ..... Human Ecology
Sid Bundy ..... Accounting
Andrew Callender ..... Chemistry
Amanda Carroll ..... Chemistry
William Carroll ..... Chemistry
Derek Cashman ..... Chemistry
Nan Chen ..... Electrical and Computer Engineering
George Chitiyo ..... Curriculum & Instruction
Rufaro Chitiyo ..... Human Ecology
Scott Christen ..... Communication
Bradley Cohen ..... Biology
Janet Coonce ..... Chemistry
Andrew Donadio ..... Nursing
Dennis Duncan ..... Agriculture
William Eberle ..... Computer Science
Robert Engelhardt ..... Physics
Perihan Fidan ..... Curriculum & Instruction
Julia Gruber ..... Foreign Languages
Ranil Gurusinghe ..... Chemistry
Lynette Harvey ..... Nursing
Nicole Henniger ..... Counseling & Psychology
Amy Hill ..... Communication
Adam Holley ..... Physics
Maria C. Humita ..... Foreign Languages
Shelia Hurley ..... Nursing
Samantha Hutson ..... Human Ecology
Bruce Jo ..... Mechanical Engineering
Stephanie Kazanas ..... Counseling & Psychology
Christy Killman ..... Exercise Science
Duckbong Kim ..... Manufacturing & Engineering Technology
Hannah Kinmonth-Schultz ..... Biology
Ajit Korgaokar ..... Exercise Science
Liezl Laurel ..... Computer Science
Thomas Marascia ..... Computer Science
Leora Maxwell ..... Chemical Engineering
Lauren Michel ..... Earth Sciences
Holly Mills ..... Volpe Library
Jon Moldenhauer ..... Chemistry
Michael Paul Nattrass ..... Agriculture
Nikki Panter ..... Biology
Stacy Prowell ..... Cybersecurity Education, Research & Outreach Center
Richard Rand ..... Accounting
Syed Ali Asad Rizvi .. Electrical & Computer Engineering
Robby Sanders ..... Chemical Engineering
Bobbi Severt ..... Exercise Science
Kinsey Simone ..... Curriculum and Instruction
Cara Sisk ..... Human Ecology
Sandra Terneus ..... Counseling & Psychology
Denis Ulybyshev ..... Computer Science
Daniel VandenBerge Civil & Environmental Engineering
Lenly Weathers ..... Civil & Environmental Engineering
Brian Williams ..... English
Kayla Wilson ..... Student Success Center
Matthew Zagumny ..... Counseling & Psychology

Abstracts

College of Agriculture & Human Ecology

School of Agriculture

Graduate Students

Preliminary Study on the Effects of Temperature and Nutrient Concentration on Seedling Emergence and Quality

Primary Author: Ronnie Dunn, EVS Ph.D.

Co-Author/Collaborator: Michael Nattrass, Tennessee Technological University

Advisor: Dr. Michael Nattrass

In 2019, Tennessee produced more than 25 million kg of tomatoes under protection, valued at nearly $3 million. More than a third of this production came from hydroponic systems. In a humid subtropical climate, a drain-to-waste, hydroponic system of 2,500 plants could expel more than 100,000 L of solution into the environment annually. This nutrient-enriched solution is a source of nutrient pollution that can cause excess algae growth and the ensuing eutrophication of bodies of water. One possible solution is to increase the efficiency of nutrient use in tomato production. The objective of this research is to assess the influence of nutrient solution concentrations on tomato seedling emergence and seedling quality. This was a preliminary study that evaluated the response of eight tomato cultivars to three dilution levels (0%, 25%, 50%) of a complete nutrient solution under two temperature regimes (20 or 25 Â°C). Results indicate the greatest viability was observed at 0%-20 Â°C (89%) and the least viability at 50%-25 Â°C (56%). However, 50%-25 Â°C showed the earliest emergence (3 d) and final emergence percentage (11 d) as compared to all other treatments. â€˜Heatmasterâ€™, â€˜Big Beefâ€™, and â€˜Cherokee Purpleâ€™ cultivars exhibited the greatest performance and were among the six cultivars carried forward to assess any potential influence of germination solution on final yield. Further study will also look at response to two hydroponic solution programs and interaction effects.

Assessment of Oviposition Preferences of Adult Periodical Cicada (Brood X 2021) (Hemiptera: Cicadidae: Magicicada spp.) Among Commercial Nursery Tree Species

Primary Author: Martine Patiance Bowombe Toko, EVS-Agr.

Co-Authors/Collaborators: Jason B. Oliver, Michael R. Allen, Douglas L. Airhart

Advisor: Dr. Airhart Douglas

Periodical cicada oviposition damage by Broods XIV (2008) and XIX (2011) in Middle Tennessee caused millions of damages to field nursery trees, and they will return in 2024 and 2025. Brood X (2021) emergence in Tennessee-Kentucky provided an opportunity to study egg-laying damage at two Kentucky nursery sites in that area. Damage, quantified by tree species and cultivar in various tree rows, was severe (55â€“100% of canopy branches) on Amelanchier, Carpinus, Cercis, Ostrya, Prunus, and Quercus. However, four tree types had less damage (0â€“38%), including Cercis â€˜Forest Pansyâ€™, Liquidambar â€˜Hapdellâ€™ and â€˜Slender Silhouetteâ€™, and Prunus â€˜Canada Redâ€™. Host-traits that may reduce oviposition preference could be anatomical (e.g., rough corky bark, frequent buds on trunks) or physical and chemical conditions (e.g., gummy coniferous sap, toxic or repellent secondary metabolites). Other factors might reduce oviposition damage, like nursery habitat (e.g., tree type diversity and planting arrangement), site location (e.g., proximity to adjacent forests), and absence of preventative pest management practices by nurseries. Some trees were considered severely damaged beyond repair; thus, removing them was more cost effective than corrective pruning of injured branches to restore canopy structure and allow new growth. Consequently, cicada damage data from this project may facilitate nursery grower tree selections in the future to reduce costly pruning or tree removal costs.

Rapid-Screening Bioassay Assessing Potential Allelopathic Influence on Spinach by Aqueous Extract from Fresh, Whole-Plant Sorghum-Sudangrass Tissue

Primary Author: Kenny Pierce, Environmental Sciences Ph.D.

Advisor: Dr. Michael Nattrass

Cover crops grown for agroecosystem improvement sometimes have an unanticipated allelopathic effect on subsequent crops. Allelopathy is broadly defined as the biochemical interactions between all types of plants, including microorganisms. Because allelopathic effects include both inhibitory and stimulatory responses, and may be species and cultivar specific, a method for rapidly screening donor and recipient crops for allelopathic interactions is needed. This research objective was to evaluate a growth chamber bioassay for rapidly screening spinach (Spinacia oleracea L.) cultivars for allelopathic interactions with an aqueous extract from fresh, whole plant, tissue of sorghum-sudangrass (Sorghum bicolor (L.) Moench) cultivars. The bioassay exposed the seed of ten spinach cultivars to the aqueous extract from three cultivars of sorghum-sudangrass (SSG) during the imbibition and germination processes and evaluated the consequent root and stem development. The extract from all three SSG cultivars reduced root length of all spinach cultivars. A subsequent field screen where spinach cultivars were planted into decomposing SSG residue resulted in a similar pattern of growth suppression. These results demonstrate that the growth chamber bioassay is suitable for predicting allelopathic interactions between SSG and spinach cultivars. The protocol may also be useful for assessing allelopathic interactions between other crops and weeds.

Field Cage Evaluation of Improved Acylsugar Tomato Breeding Lines for Silverleaf Whitefly Resistance

Primary Author: Erik Koehler, Ph.D. Environmental Science-Agriculture

Co-Author/Collaborator: Martha Mutschler

Advisor: Brian Leckie

Bemesia tabaci, the Middle East Asia Minor 1 (MEAM1) variant (Hemiptera: Aleyrodidae) of the silverleaf whitefly is one of the planets most devastating and economically detrimental invasive species. Due to the silverleaf whitefly's resistance to several common insecticidal chemical classes, alternative means of control may help thwart this pest. Acylsugars are a class of specialized metabolite which modify the ovipositional behavior of SLW. Production of this metabolite has been introgressed into the domestic tomato Solanum lycopersicum, from wild ancestor S. pennellii, creating a domestic tomato with type IV glandular trichomes. Type IV glandular trichomes are hair-like appendages that produce acylsugars at their apical tips. Acylsugar producing tomato lines were field tested in large high tunnel insect cages for silverleaf whitefly resistance. This choice test consisted of five acylsugar producing lines, including an improved line for altered acylsugar chemistry, and a commercial tomato control. Silverleaf whitefly eggs, first and second instar, third and fourth instar, pupae, and type IV glandular trichome densities were observed. Leaflets were sampled for subsequent acylsugar analysis. Acylsugar producing lines had lower nymphal development with the improved line for altered acylsugar chemistry showing the greatest impediment to nymphal development. Further studies are needed to better characterize the impact of this line on nymphal development.

Controversial Case Study (GM) Positively Affected Cognitive Maturity and Engagement Critical Thinking Dispositions

Primary Author: Mary Mahan, Environmental Sciences

Co-Authors/Collaborators: Ciana Bowhay, School of Agriculture, Tennessee Tech; Dennis Duncan, School of Agriculture, Tennessee Tech

Advisor: Dennis Duncan

Critical thinking (CT) dispositions such as maturity, engagement, and innovativeness influence CT skills. Maturity refers to bias awareness and outside influences. Engagement is willingness to participate in logical reasoning. Innovativeness is passion for discovering knowledge and truth. Literature suggests a controversial case study and discourse positively affects CT skills and dispositions. A case study from the National Center for Case Study Teaching in Science influenced a genetically modified organism (GM) activity in introductory plant science laboratory. This project had students read research articles, understand basic GM concerns, and teach their peers. At the end of the semester, students completed a revised, mixed methods retrospective Engagement, Maturity, and Innovativeness survey. Maturity and engagement constructs indicated significant transformation ($P < 0.05$), while innovativeness showed no to little change ($P = 0.29$). Qualitative responses were analyzed using an open coding methodology to identify emerging themes. Students indicated an increase in bias awareness and willingness to practice CT skills. Therefore, incorporating a controversial case study in introductory classes positively affects studentsâ€™ CT dispositions which can impact development of CT skills, equipping students with necessary tools to

succeed in future courses and their careers. Future research should address how to cultivate a passion for knowledge to improve the innovativeness.

Undergraduate Students

Trends of Adjusted Weaning Weight in Simmental and Simmental Crossbred Cattle

Primary Author: Thomas Barnard, Animal Science

Advisor: Dr. Dennis Fennewald

This study examined eleven years of adjusted weaning weights of Simmental and Simmental crossbred cattle. The purpose of this study was to determine trends within the university herd. The study included both bull (n=18 Â± 3) and heifer (n=24 Â± 10) data analyzed separately and as a herd average. Data was excised from the American Simmental Association herd book of TTU Shipley Farm. Each year data was averaged and plotted on a graph demonstrating changes in average weaning weight from 2011 to 2022.

A regression line was placed to find the line of best fit. From year-to-year the data is scattered but still has a trend of weaning weight in bulls increasing 55 lbs. (R2 = 0.29), heifers increasing 25 lbs. (R2 = 0.1719) and as a herd average, 35 lbs. (R2 = 0.281). Phenotypic data such as adjusted weaning weight is a result of environment and genetics. Low R2 values express this statistically because year-to-year, both environment and genetics are highly variable factors that affect weaning weight. Variation in year-to-year data can be explained by factors such as drought, forage quality, creep feed, milk production or new genetics.
This study demonstrates that adjusted weaning weight is increasing but there is tremendous variation. We expect weaning weights to continue to increase until limited by environmental factors or a genetic plateau is reached. In the industry this information will aid in decisions concerning phenotype on an individual operation basis.

Nitrogen Volatilization in a Pot Study: Effect of Different Fertilizers and Soil pH

Primary Author: William Thomas, Environmental Agriscience

Advisor: Michael Nattrass

Nitrogen is one of the major components used in nearly all fertilizers, it is essential for plant growth and maximum yield, but if mismanaged can lead to the volatilization of ammonia into our atmosphere increasing with an accumulation of greenhouse gases. Urea fertilizers account for approximately 50% percent of fertilizer nitrogen (N) usage. Urea fertilizers undergo urea hydrolysis and are susceptible to ammonia volatilization losses up to 30-50% of applied fertilizer. Nitrogen stabilizer products can minimize volatilization losses by inhibiting the urease enzyme. The objective of this research is to investigate the effects of different fertilizer nitrogen stabilizers on ammonia volatilization. Small pots were filled with 200g of Promix media of either pH 5 or 7. Prior to the addition of fertilizers, 500 mL of water was added to wet each pot. The experiment was designed as a completely randomized design. Treatments were unfertilized control, unstabilized urea, and urea stabilized with either Nutrisphere or Altera (n=4), at two pH levels. With five replicates. Fertilizer was applied at 220 kg N ha-1 (224 lb ac-1). We hypothesize greater volatilization loss will occur for untreated urea. Results from this study may be used to develop sustainable nutrient management practices that minimize N loss and maximize plant uptake.

The effects of varying temperatures in a hot water bath on trypsin inhibitor activity

Primary Author: Erika King, Animal Science, Pre-Vet

Co-Authors/Collaborators: D. Hobbs, The Water Center, Tennessee Tech University, V. E. Ayres, School of Agriculture, Tennessee Tech University

Advisor: Dr. Victoria Ayres

Feed and feed manufacture contribute to approximately 60 to 70% of the total cost of poultry rearing. Soybean meal is rich in high quality protein and is the primary protein source in poultry diets throughout the world. However, soybean meal also contains antinutritional factors such as trypsin inhibitor, which has been shown to impede the activation of gastrointestinal proteolytic enzymes and negatively affect protein digestion. Heat-processing of soybean meal has been shown to reduce trypsin inhibitor. Specific feed manufacture techniques may also denature any remaining trypsin inhibitor complexes and improve dietary protein digestibility. The current study aims to identify optimal feed manufacture techniques to reduce trypsin inhibitor activity found in soybean meal. Soybean meal was obtained from the local co-op (Cookeville, TN). Two-gram samples of soybean meal were then submerged in a hot water bath and subjected to either 70 or 90Â° C, mimicking practical conditioning temperatures found in commercial feed mills. Trypsin inhibition was then calculated using methods described by Liu et al., 2019 and 2021.
Each temperature and time combination was repeated in triplicate. Treatments were arranged in a 2 (conditioning temperature) x 8 (conditioning time) factorial. Trypsin units inhibited (TUI)/mg sample decreased when soybean meal was subjected to 90Â°C, compared to 70Â°C (P = 0.0128). This study demonstrates that TUI/mg sample may be reduced with increased temperatures.

Effect of Mycorrhizal Fungi Inoculation of Soil on Phosphorus Uptake in Plants

Primary Author: Gabriella Beck, Animal Science

Co-Authors/Collaborators: Ciana Bowhay, TTU; Michael Nattrass,TTU

Advisor: Dr. Ciana Bowhay and Dr. Michael Nattrass

Phosphorus, a vital nutrient in plants, can be influenced through a symbiotic relationship with mycorrhizal fungi. Researchers are working to find alternative ways to increase uptake of phosphorus in plants while preserving natural reserves in the soil to improve sustainability of large-scale crop production. This study seeks to evaluate the effect of soil inoculation with mycorrhizal fungi on plant phosphorus levels. A randomized block design was utilized in which 9 replications of 3 different treatments were tested. The plant groups include Crimson Clover, Cereal Rye, and plant-less pots intended to study the amount of phosphorus in the soil and not plant growth. These groups were treated with a solution of mycorrhizal fungi, a hybrid solution of dilute mycorrhizal fungi, and the control where no mycorrhizal fungi were present. We expect that the soil treated with mycorrhizal fungi will have a lower level of phosphorus due to increased uptake of the element in the plant. Also, plant growth is expected to increase due to the phosphorus intake facilitated by the mycorrhizal fungi. It is critical to study the effects of mycorrhizal fungi because this can increase the amount of nutrients the plants absorb which will result in healthier plants and soil. These results can potentially help producers find faster return rates in which their crops can grow faster and healthier. This can lead to higher profits while saving time and minimizing resources being used.

Comparison of Regenerative and Traditional Beef Production Business Model

Primary Author: Macy Johnson, Agriculture- Agribusiness and management

Co-Authors/Collaborators: Holden Cornett, Dennis Fennewald

Advisor: Dennis Fennewald

This study examined two production models across three herd sizes. The purpose was to determine the differences in profitability and return on investment. The two production models were Regenerative Agriculture and Traditional. Regenerative Agriculture was defined as methods that increase soil organic matter and generally follow the Soil Health Principles. Traditional was defined as typical practices of Tennessee beef farmers and outlined by the University of Tennessee extension agriculture economist.
Three herd sizes were chosen; 1) 20 cows, which is a typical farm in Tennessee, 2) 100 cows, and 3) 300 cows. The Traditional model used the data from the 2023 Cow/Calf Budget provided by UTK. Traditional farms owned hay equipment, fed hay for 150-days per year, renovated pastures and purchased synthetic fertilizer. Beef producers using the Regenerative Agriculture model have a goal of year-round grazing and do not purchase synthetic fertilizer, renovate pastures, feed hay, or own hay equipment. This model is based on reports from local producers. These results indicate Regenerative Agriculture models with these costs made money while Traditional models with greater costs lost money. Return on investment was much greater for Regenerative Agriculture models compared to Traditional models. Because Regenerative Agriculture farms have little reliance to off-farm inputs, and the return on investment is higher, these farms should have more economic resiliency.

Potential for Use of Wood Chips as a Low-cost Method to Reduce Environmental Impact of Agricultural Runoff

Primary Author: Emily Johnson, Animal Science

Advisor: Ciana Bowhay

One of the largest concerns in crop production today is runoff from agriculture fields into water ways. The National Water Quality Assessment shows that nitrate (NO3-) runoff from agricultural activities is a leading cause of water pollution in rivers and streams. New research has been conducted showing that woodchips can help complete the nitrogen cycle to remove NO3- contamination of waterways decreasing environmental impact. Our goal was to evaluate the influence of particle size of wood chips on aqueous NO3- removal. In this study, water was gathered from a nearby natural spring containing runoff from cattle manure. Three treatment groups were established using spring water, water containing a solution of

calcium NO3- for a known concentration of nitrogen, and deionized water. Two different sizes of pine back, medium and coarse, were used for this experiment. The experiment was conducted as a 3 X 3 factorial in randomized completed block design. Each run consisted of either no wood chips, 5 g of the medium woodchips, or 5 g of the coarse woodchips in 200 mL of solution. Data were analyzed using analysis of variance at a=0.05. Results indicate treatments with pine bark woodchips decreased aqueous nitrate by 93-99% compared to without (P<0.01). However, there was no difference in nitrate removal between particle sizes (P>0.10). This study has potential application for farmers who wish to find a low-cost method to improve water quality on their operations.

Potential For Use of Wood Chips as Bioreactors to Reduce the Amount of Nitrogen From Agriculture Run-off

Primary Author: Madison Jones, Animal Science, Pre-Vet

Advisor: Dr. Nattrass

Proper management of the nitrogen (N) cycle is one of the 14 National Academy of Engineering (NAE) Grand Challenges for Engineers. Management of the N cycle has a key role in the future of the environment, agriculture, and the way we live. The goal of this experiment was to evaluate methods of managing nitrogen in waterways from agricultural runoff by using woodchips as bioreactors to complete the N cycle. Water was collected from a local natural spring containing runoff from cattle manure. Spring water was enhanced with calcium nitrate (CaNO3) to ensure an effect. We used two different-sized softwood pinewood chips, 8/64 round (small) and 12/64 round (large) as bioreactors. Treatments consisted of no wood chips and either 5 g of small or large woodchips added to 200 ml of water at three NO3- levels (0, 1x, 10x) with three replications. After 14 d, samples were analyzed for NO3- by inductively coupled plasma (ICP) (EPA Method 300.1). Data were analyzed using analysis of variance at a=0.05. Treatments with softwood pine chips decreased aqueous NO3- from 6.2 Âµg L-1 to <0.05 Âµg L-1 (P < 0.001). However, there was no difference in NO3- removal between particle sizes (P > 0.10). Similar methods could be useful for cattle producers to minimize nitrogen contamination within their own waterways.

School of Human Ecology

Graduate Students

The relationship between sleep and diet among undergraduates

Primary Author: Amy Collins, Community Health and Nutrition

Advisor: Samantha Hutson

Introduction: Lifestyle changes of attending college from moving out of home, juggling new schedules, and academic pressures lead to effects on sleep quality. There are many connections between sleep and diet. Worsened sleep can result in a variety of health outcomes, including diabetes, cardiovascular disease, heart attack, obesity, depression, anxiety, and stroke. The objective of this review is to examine the relationship between sleep quality and diet among undergraduates.

Materials and methods: An Eaglesearch was performed using key terms â€œsleep,â€ â€œdiet,â€ and â€œundergraduate.â€ The research was performed based on the findings from nine studies.

Results: Studies show that there is a positive correlation between sleep quality and eating healthfully, and that poor sleep quality is associated with a worsened diet and weight gain. Sleep quality is affected by alcohol consumption, caffeine use, cigarette smoking status, mental health status, stress levels, and resilience of an individual. Sleep even plays a role in the intensity of certain tastes. Dietary Inflammatory Index also affects sleep quality. Insufficient sleep has been shown to affect hunger cues and cravings. All in all, it was found that diet and sleep are vital aspects of life that that influence each other.

Conclusion: The relationship between sleep quality and diet among undergraduates is complex. Further studies could shed more light on this relationship while taking influential factors into account.

To Examine the Effects of Food Insecurity On Mental Health Among College Students

Primary Author: Krissie Miranda, Community Nutrition

Co-Author/Collaborator: Samanth Hutson, Tennessee Tech University

Advisor: Dr. Samantha Hutson

Food insecurity among college students is highly prevalent, resulting in a major public health problem that adversely affects mental health outcomes. According to numerous studies, 20 to 50 percent of college students in the United States experienced food insecurity in 2021. Existing literature and studies demonstrate that food insecurity is significantly associated with psychological distress and poor self-perceived mental health status. Food insecurity continues to impact college campuses because of the rising tuition costs, inflated housing costs, student loan burdens, affordable childcare options not being available for parents pursuing degrees, and often not being eligible for public assistance programs. Although previous studies have suggested that students face several challenges in accessing adequate food, there have been limited methods to describe the relationship between food insecurity and mental health in this population. Students discussed seven themes related to the psychosocial effects of food insecurity: 1) the stress of food insecurity interfering with daily life, 2) fear of disappointing their family, 3) jealousy or resentment of students in more stable food and financial situations, 4) inability to develop meaningful social relationships, 5) sadness from reflecting on food insecurity, 6) feeling hopeless or undeserving of help, and 7) frustration and anger directed toward the academic institution for not providing enough resources to support students.

Water is Life: How Water Security means Food Security for Global Communities

Primary Author: Emma Spencer, Community Health and Nutrition

Advisor: Dr. Samantha Hutson

This literature review examines research addressing the impact of water security on food security in communities worldwide. Water security is defined by the Sustainable Water Partnership by, The adaptive capacity to safeguard the sustainable availability of, access to, and safe use of an adequate, reliable and resilient quantity and quality of water for health, livelihoods, ecosystems and productive economies.

Water security has a cascading effect on food security. Water security and scarcity impacts a countries ability to provide agricultural yields to meet their population needs, and river body maintenance is integral in providing food through fishing. Poor and underdeveloped countries face the brunt of the global water shortage through a lack of regulatory oversight as the world is steadily approaching the water threshold. This review explores the problems of regulatory bodies across the globe and how countries have or have not adequately addressed the problems affecting water security with an emphasis on how this has affected food system management.

Effects of a Mindfulness Based Eating Intervention on Weight, Calories and Dietary Choices

Primary Author: Anna Nakamoto, Bachelor of Science in Community & Health Nutrition

Co-Author/Collaborator: Dr. Samantha Hutson, Tennessee Tech University

Advisor: Amber Buckner

The purpose of this literature review was to ascertain if mindfulness-based eating interventions in adults affect body weight, caloric intake, and dietary choices. According to the CDC the obesity rate for adults in the United States from 2017-2020 was 41.9%. Mindful eating could be one way to disrupt the stress response and enable people to make smart eating choices. Mindful eating is a practice where the person pays attention to the food they eat and their feelings without judgment. Mindfulness based eating interventions were shown to be effective at lowering caloric intake when eating at a restaurant in obese women. In a randomized control trial mindfulness based eating intervention that lasted eight weeks it was found that in the intervention group there was a significant effect on BMI loss, external eating, food craving, and intuitive eating. Based on this literature review there is a small relationship between mindful eating and body weight, calorie intake, and dietary choices. More studies need to be done on dietary choices and mindful eating. More studies should also be done on mindful eating interventions in people who struggle with binge eating and are obese.

Non-nutritive Sweeteners and the Gut Microbiome

Primary Author: Kim Dunaway, Community Health and Nutrition

Advisor: Dr. Samantha Hutson

Sugar consumption is high among Americans and nonnutritive sweeteners (NNS) represent an opportunity to lower calorie and sugar intake. The gut microbiome contains trillions of bacteria, and the function of the microbiome encompasses several functions including implications for the immune system, synthesis of vitamins, and glucose tolerance. There is concern that these sweeteners are negatively impacting the gut microbiome and potentially leading to obesity and inflammation. For this review, twelve studies were evaluated to look at the impact of nonnutritive sweeteners on the gut microbiome. The sweeteners that were studied were saccharin, Ace-K, sucralose, aspartame, and stevia. Of the twelve studies, seven showed bacterial

changes. Three studies showed no changes to gut bacteria. Two studies showed mixed results. Saccharin showed the most potential to change the microbiome as five studies showed changes. Future research needs to include more human studies, including individuals with inflammatory disorders, especially Type 2 Diabetes. There is some precedence in the studies to show an impact on the gut microbiome when NNS are combined with a high-fat diet. This potential connection needs to be investigated. Finally, saccharin was widely used in many studies, but due to the high amount of aspartame and sucralose consumed from beverages, there is a great need for more studies researching those sweeteners which are consumed more frequently.

Feeding Patients Admitted to the Hospital with a Diagnosis of COVID-19

Primary Author: Tyler Dill, Community Health and Nutrition

Co-Author/Collaborator: Dr. Samantha Hutson, Tennessee Tech University

Advisor: Dr. Samantha Hutson

The purpose of this literature review was to examine the effects of satisfactory-high protein and energy consumption, timing of nutrition support initiation, and nutrition concerns for patients admitted to the hospital with a diagnosis of COVID-19. COVID-19 has presented many challenges to how healthcare is provided and put many individuals on ventilators which can make it more difficult to provide proper nutrition. There are guidelines in place for enteral and parenteral nutrition support during mechanical ventilation, but there is limited information and guidelines specifically relating to critically ill COVID-19 patients, and how the disease is influenced by nutrition and what physiological changes may alter nutritional status. Research indicates that utilizing guidelines in place as well as continuing to study how nutrition can influence the course of this disease, and keeping nutrition professionals involved safely are important factors to improve treatment outcomes.

What amount of soy consumption can reduce breast cancer development and progression in women?

Primary Author: Kaleb Miller, Nutrition and Dietetics

Advisor: Samantha Hutson

The purpose of this literature review was to determine what amount of soy consumption can reduce breast cancer development and progression in women. Soy has been a controversial topic in the past for whether or not it should be consumed for women concerned about breast cancer. Soy contains isoflavones, particularly genistein and daidzein that bind to estrogen receptors in the body. These compounds have the ability to interact with metabolic pathways that promote tumor growth, and they impact gene expressions of cancer related genes. Epidemiological data shows that women who consume higher amounts of soy have improved breast cancer outcomes and reduction in all-cause mortality. Researchers have found that isoflavone intake of = 15 mg/day reduces womenâ€™s risk of breast cancer, all-cause mortality, and prevent recurrence.

Sugar-Sweetened Beverage Intake in Children and Adolescents

Primary Author: Sara Hoover, Community Health and Nutrition

Advisors: Samantha Hutson, PhD, RDN, LDN

Objective: To investigate the relationship between sugar-sweetened beverage consumption and risk of obesity in children, as well as possible effect on academic performance. Method: Research on this topic was read and analyzed thoroughly. Results from various research studies were compared and results were synthesized. Results: The majority of research shows that children who are frequent consumers of sugar-sweetened beverages are at a higher risk for developing obesity than those who are not. Some studies have concluded with conflicting results. Research shows that early introduction of sugar-sweetened beverages leads to greater consumption later in childhood. Keywords: sugar-sweetened beverages (SSB), obesity, body mass index, academic performance, nutrition education

Undergraduate Students

What is the cost of the clothes we wear?

Primary Author: Jack Cheatham, Design Studies

Co-Authors/Collaborators: Megan Dianne Ivey, Lauren Elizabeth Wallace

Advisor: Hannah Upole

Have you ever considered what the cost of making clothes is? Whether it be Shein or Gucci some of these production processes can be incredibly damaging to our environment, as well as inhumane. These issues need to be quickly addressed by consumers, because of the rate that the industry is traveling. Through our research we have found that Shein isnâ€™t alone when it comes to sustainability concerns and more so the entire fashion industry being the issue. Through our research we have found, consumers may not be aware of these sustainability concerns within the fashion industry. Based on our literature review further research will be done in the 2023 spring semester to test this idea.

How Dietary Patterns, Physical Activity, and Race/ Ethnicity Affect the Incidence of Gestational Diabetes in Pregnancy

Primary Author: Lia Nesbitt, Human Ecology

Advisor: Allision Coutinho

The aim of this literature review was to determine how dietary patterns, physical activity, and race/ ethnicity affect the rate of GDM in pregnant women. Gestational diabetes mellitus (GDM) is a form of glucose intolerance that appears during pregnancy, and complicates 5 to 10% of pregnancies in the United States. The methods used in this review were the Tennessee Technological University Library Database Eagle Search, the Journal of the Academy of Nutrition and Dietetics, Journal of Diabetes Research, and the British Journal of Nutrition for relevant articles. In conclusion, there were higher incidences of GDM in the Western dietary pattern while there were mixed results when pertaining to healthy dietary pattern (Prudent and Mediterranean dietary pattern). With physical activity it found that it does not reduce the risk of GDM during the 2nd half of pregnancy but does for prepregnancy and the 1st half of pregnancy. Lastly, for race/ethnicity, there was significant variations in the association between GDM and racial/ ethnic groups due to type of dietary patterns, health disparities, and GDM education not being culturally competent. Although, there were mixed results from a few articles, all provided evidence that supported a significant relationship between dietary patterns, physical activity, and race/ethnicity and the incidence of GDM. Further studies are needed to clarify associations of dietary patterns and GDM risk and effective nutritional/ behavioral strategies.

The Prevention of Alzheimerâ€™s Disease through Nutrition: The Mediterranean-DASH- Intervention for Neurodegenerative Delay (MIND) diet, The Mediterranean Diet, Dietary Approaches to Stop Hypertension (DASH) Diet, and Specific Nutrients

Primary Author: Addison Lake, Nutrition and Dietetics

Advisor: Allison Coutino

The purpose of this research review was to determine if certain diets and nutrients can play a role in the prevention of Alzheimer's disease. To find research literature the Tennessee Technological University Library Database, the Journal of the Academy of Nutrition and Dietetics, and Google Scholar was used. The criteria was set to include only peer-reviewed articles written between 2012-2022 in an effort to try and find the most current information available. Alzheimer's Disease currently has no known cure. It currently makes up 80% of dementia cases and its death rates have been steadily increasing over the last decade. Because there is no known cure for Alzheimerâ€™s researchers have begun looking at how nutrition can be used to manage and prevent this disease. It has been found that 3 diets have the greatest impact: the Mediterranean diet, the Dietary Approaches to Stop Hypertension (DASH) diet, and the Mediterranean-DASH- Intervention for Neurodegenerative Delay (MIND) diet. There have also been a few specific nutrients that can have an impact on prevention such as copper, antioxidants (vitamin E, vitamin C, cytosolic antioxidant, and selenium), omega 3 fatty acids (fish oil and DHA), B vitamins and folate, medium chain triglycerides (a), huperzine A, resveratrol, turmeric, and curcumin. After this literature review, it can be concluded that nutrition can play a role in management and prevention, but it is still unclear of its possible effects.

The Impact of Volunteers on Children and Families in Healthcare

Primary Author: Morgan Tate, Human Ecology

Advisor: Dr. Rufaro Chitiyo

Volunteer work in hospitals is a familiar concept, but more recently the impacts of volunteers in a clinical setting are being examined. The purpose of this research was to explore the impact of volunteerism on children and families in hospital settings. In searching for existing literature, I used keywords like volunteers, child life, childrenâ€™s hospitals, and volunteerism. Articles that did not focus on volunteers in a clinical setting were excluded. Participants in the research articles included hospitalized children, parents of a child with a serious illness, hospitals with volunteer programs, and Certified Child Life Specialists. This provided an eclectic view of the impact of volunteers on children in clinical settings from various perspectives.

The researchers found benefits of volunteerism to children and families as it relates to family-centered care, patient satisfaction, and the capacity for child life intervention. Child life is a relatively new profession, so there are gaps in child life-specific research in various areas of interest including volunteerism. The literature showed the importance of volunteerism to children and families in clinical settings or experiencing health crises, and the articles showed several benefits of volunteerism. This research is valuable because it justifies the need for volunteerism in childrenâ€™s hospitals and the benefits of expanding the capacity of child life interventions.

The Efficacy of Carbohydrates on Physical Activity

Primary Author: Darian Dela Cruz, Human Ecology

Advisor: Dr. Rufaro Chitiyo

Carbohydrates, also referred to as carbs, for short, play an essential role in our daily lives. This research investigates the efficacy of carbs upon physical activity. This project relies on studies that utilized trials to gather data. Keywords to procure articles included carbohydrates, physical activity, intensity, and volume. If the article did not contain relevance to carbohydrates and physical activity, it was excluded. Participants selected were young, did not smoke, abstained from alcohol, and in good health. Some studies included participants who had muscle maturity, while others had sedentary participants. A key finding is that carb intake before physical activity should be proportional to duration and intensity of the session. This should not be confused with the practice of carb loading. Another finding was that physical activity raises insulin sensitivity, resulting in increased glycogen usage by muscle cells both during and after physical activity. Accelerated glycogen usage results in greater ATP production. Carbs have a positive impact on physical activity, but thereâ€™s more to learn about its various responses in the body. Monitoring both micronutrients and macronutrients in relation to carb intake is likely to yield findings that further support the efficacy of carbs upon physical activity.

Carbohydrate Loading in Endurance Athletes

Primary Author: James Medley, Human Ecology

Advisor: Dr. Rufaro Chitiyo

Carbohydrate loading among endurance athletes has been a practice for a long time and has to some extent to help improve performance. The purpose of this project is to investigate how much an endurance athlete needs to carbohydrate load for training or competition. To find relevant studies to draw upon, the key words used were Carbohydrate loading, Athlete, and endurance. To refine the search medical/medicine, surgery, and articles older 2008 were excluded. The participants in most of these studies were male (and female in one article) young endurance athletes and resistance trained athletes. Carbohydrate loading in endurance athletes has been shown that it can provide some performance improvements when implemented in a correct manner. Carbohydrate loading among endurance athletes improves their performance by small to medium margins and should be implemented accordingly to the athlete and not to be used as a â€œone size fits allâ€ model; for instance, some female endurance athletes have had better results in performance than males while practicing carbohydrate loading. This topic is important because athletes who participate in endurance even sports may not get enough carbohydrates in their daily diet. Increased carbohydrate intake may improve their performance.

The Effects of Communication on Childrens Social Relationships

Primary Author: Sarah Jones, Human Ecology

Advisor: Dr. Rufaro Chitiyo

Communication and social relationships are necessary to create meaningful connections in life, and to learn, grow, adapt, and respond to life's challenges. The purpose of this study is to explore effective communication skills and how they affect children's social relationships. Articles selected for this project focused on the importance of social connection. Some articles focused on positive social effects and the negative effects of social isolation. The key words used to identify existing studies were communication, children, social relationships, and effective communication. Participants included school-aged children and adolescents and their parents. These participants were selected based on age, gender, social economic status, race, and religion. The way in which children are socialized and how children talk to each other affects their communication and social relationships later in adolescence. Their styles of communication all stem from their social upbringing, which must start during infancy. This socialization of the child happens well before school starts and how the parent facilitates social development affects the child for life. If the child fails to make meaningful social connections, they are at a heightened risk for social isolation which can stunt their social development and lead to a negative self-evaluation and even depression. This research focuses on how children talk to each other, why, and what effects of communication are positive and negative.

Emotional Regulation and Coping Mechanisms for Family Science Professionals

Primary Author: Kathryn Dye, Human Ecology

Advisor: Dr. Rufaro Chitiyo

This research topic is about mental health in family science professionals. The profession of family science examines connections, dynamics, and interactions between families to improve quality of life. The problem is that burnout and compassion fatigue are believed to be more prominent and detrimental in these professionals. This project aimed to investigate which coping mechanisms functioned best for family science professionals and if it depended on the profession within family sciences. The criteria used to select studies to inform my research included key terms such as mental health, family science professionals, burnout, and compassion fatigue. Participants in the studies included nursing students, family childcare providers, abuse-specific counselors, healthcare professionals, and social workers. Results included avoidant and nonavoidant coping mechanisms, but it was ultimately determined that nonavoidant coping mechanisms worked best. These results revealed that although there are many different family science professions, implementing a coping mechanism was more important than which mechanism was used. This topic is important because family science professionals are presumed to be more prone to suffering from burnout.

The Relationships Between Hospitalized Children and Medical Professionals

Primary Author: Kartyr Deatrick, Human Ecology

Advisor: Dr. Rufaro Chitiyo

In what ways does frequency of interaction affect the relationship between hospitalized children and medical professionals? The topic is about the different relationships that hospitalized children develop. The problem is that there is information on the hospitalized chi.

The Impact of Child Life Specialist on Children

Primary Author: Geovanna Martinez-Rivera, Human Ecology

Advisor: Dr. Rufaro Chitiyo

Children are sometimes hospitalized for chronic illnesses and are isolated from family and friends, which can cause psychosocial problems. Child Life professionals assist these children by providing psychosocial support. The purpose of this study is to explore the effects of Child Life specialistsâ€™ intervention on children during distress. Keywords such as Child Life specialist, hospitalization, children, and stress were used to find literature. Articles used in this project were selected because they explored concepts of Child Life specialistsâ€™ services and interventions. Participants in previous studies included healthcare professionals, children with special needs, and children undergoing stressors. Key findings were 1. stressors included fear of the unknown and painful procedures, 2. Child Life specialists coped with preparation and family support, and 3. those who had Child Life specialistsâ€™ interventions during IV placement procedures experienced less distress. These studies are unique in that they document child life experiences from healthcare professionalsâ€™ perspectives and also the childrenâ€™s experiences. The findings suggest that Child Life interventions in hospitals yield positive experiences and reduce fear. Research on Child Life specialistsâ€™ interventions with children with special needs is limited and professionals should understand the needs of children with spectrum disorders to meet the needs of all children during stressors in a medical setting.

Regenerated Lighting: Does it effect an athlete's performance?

Primary Author: Anita Boyer, Design Studies

Co-Author/Collaborator: Vivian Gust

Advisor: Hannah Upole

Did you know that different forms of lighting can affect the deep performance of athletes? Lighting is one of the leading industries that are prevalent every day for most people completing daily tasks. Regenerated lighting has been questioned if athletes have the same performance levels in the presence of new lighting products within the stadium or facility compared to older lighting. It has been found that lighting does have an effect on peopleâ€™s emotional and cognitive responses. Different lighting features range from the color of the bulb, the dimness it is used for the space, and the space it is being used for. However, it is relatively unknown how the ways that lighting changes between atmospheres affect athletesâ€™ performance whether itâ€™s indoor to outdoor, their home facility or an

away facility, or brand new lighting products versus older reused lighting products. Because of this, our research question is â€¯Do regenerated light bulbs have the same effect as new light bulbs in an athletes performance setting?â€™ Further research throughout the spring 2023 semester will provide answers to our research.

Using Textiles to Improve Home Efficiency: Are Consumers Willing to Invest in the Future?

Primary Author: Hailey Smith, Design Studies

Co-Author/Collaborator: Molly Huddleston

Advisor: Hannah Upole

Many individuals think of textiles in the home as upholstery on furniture or as curtains in a living room. However, our research has found that textiles have the ability to improve home efficiency and reduce utility bills. As demand for textiles increases and consumers become more conscious, finding areas to reduce the carbon footprint is essential to the environment's health and the future of the home textile industry. Thermal and acoustic insulation for buildings from recycled textiles can play an essential role in energy savings and reducing pollution from the textiles industry (Islam & Bhat, 2019). Through the study of thermal characterization, it was confirmed that adding natural fibers consistently leads to an enhancement of the energy performance of the building during the winter months as opposed to traditional plaster (Majumder et al., 2021). However, it begs the question of whether or not consumers are willing to invest in efficiency practices. Further research throughout the semester will examine consumer behavior and determine if individuals are willing to pay more for more environmentally conscious products to see long-term home efficiency improved.

Dye Pollution in the Textile Industry and Natural Alternatives

Primary Author: Erika Minnear, Design Studies

Co-Author/Collaborator: Dylan Freeman

Advisor: Hannah Upole

The ever-growing textile industry is raising major concerns for the environment and negatively impacting the health of millions of people. â€œIn its current predominant form, the industry â€¦ does not maximize the service which its material and energy flows provide, nor does it limit these flows to what nature toleratesâ€ (Peters et al., 2021, n.p.). More than 8,000 chemicals are used in the fabric manufacturing process, many of which are poisonous. Consequently, 30 out of 72 chemicals detected in wastewater from a textile millâ€™s production cannot be removed (Kant, 2012). The chemical sludge from textile mill production can be carried from a factoryâ€™s drain all the way through multiple villages, deeming peopleâ€™s food and water sources unsafe for use. Because dye pollution has such a negative impact on the environment, people are looking for more sustainable alternatives. For centuries, people have utilized plants, berries, vegetables, and other naturally occurring items to dye their textiles (Purwar, 2016). The market for sustainably-made products and the negative impact on the earth have led consumers and companies to research the practicality of using natural dyes in the textile industry as opposed to synthetic dyes, which our research question will address. Further research throughout the Spring 2023 semester will provide answers to our research question.

Hemp Homes: Is Hemp the Future of Building Materials?

Primary Author: Kate Simpson, Design Studies

Co-Author/Collaborator: Grant King

Advisor: Hannah Upole

More than 15 billion trees are cut down every year due to deforestation, many of those in regards to building materials (Kilgore, 2023). This leads us to wonder, can hemp fix the deforestation crisis specifically in regards to building materials? â€œAn ideal project should be inexpensive to build, last forever with modest maintenance, but return completely to the earth when abandoned,â€ (Akadiri, Chinyio, & Olomolaiye, 2012, p. 127). Buildings should be a continuous cycle, as we will have buildings forever. However, the current state of building materials is creating an unsustainable cycle for home construction. Hemp is a valuable resource in many areas of sustainability that can make a large impact within the building industry. Hemp has the ability to be mixed with lime, which acts as a binder, in order to create hempcrete. This hempcrete, while not being widely utilized yet, is a large step in the direction of making change for the preservation of resources in the future, specifically regarding building materials. Further research will be conducted in the Spring 2023 semester to test the ability of hempcrete as a sustainable building material.

TEXCYCLING: The Future of Textile Recycling is Now!

Primary Author: Grace Schrider, Design Studies

Co-Author/Collaborator: Kevin Mears

Advisor: Hannah Upole

How many times have you thrown out an item of clothing and not really thought about where it goes after that? Many people throw away clothes and textiles without thinking twice about where it will go, and it goes straight to the landfill. Once it goes to a landfill, it just sits thereâ€¦ why is this a problem? The textiles industry has a constant cycle of waste and is one of the leading issues of waste in our society. With parts of society being driven by overconsumption, the part of society that finds it important to conserve goods deserves better education on how to be sustainable through the textile industry. Looking into the process of recycling can help perfect the system and reach the potential needed to create change. â€œRecycling is a way to process, the used materials (waste) into new products to prevent waste of potentially useful materials. It reduces the consumption of fresh raw materials, energy usage, air pollution created mainly from incineration, water pollution and land pollution mainly from land fillingâ€ (Sharma-Goel, 2017). Our research will consider the development of easy-access recycling bins to help lower waste in the textiles industry. This research will be conducted during the spring 2023 semester

Where Does It Go After Goodwill?

Primary Author: Hannah Sullivan, Design Studies

Co-Author/Collaborator: Cameille Schubert

Advisor: Hannah Upole

If you have ever donated unwanted items to Goodwill, you have contributed to the sustainability movement. But have you ever considered what happens to these goods if they are not eventually sold? Many consumers may be unaware of Goodwillâ€™s policy for disposing of unsold items and the process that is followed in correspondence with that policy. Contrary to what some may believe, Goodwill does not just throw away the items that are not purchased by consumers in the thrift stores. According to McLean (2016), unsold stock goes through several phases of selling, sorting, recycling, and then finally as a last resort, burning or burying. After 5 weeks without being sold, items are put into â€œGaylord boxesâ€ (temporary 4-foot cardboard shipping containers) by the thrift store employees. These boxes are then shipped to the outlet center where the Gaylord boxes are dumped into boats (also known as the bins. Items left over from the bins undergo the recycle and salvage process where items are sorted, crushed, and then turned into raw materials that can be sold to vendors (McLean, 2016). Researchers are aware of the positive sustainability impacts that Goodwill has set in place but do consumers know what actions Goodwill takes towards sustainability? Based on our literature review, further research throughout the Spring 2023 semester will test our research question.

Examining the Effectiveness of Malnutrition Screening Tools on Elderly Populations

Primary Author: Megan Keith, Nutrition and Dietetics

Advisor: Allison Coutinho

The purpose of this review of literature was to examine the effectiveness of malnutrition screening tools on older adult populations. The older adult population poses a unique challenge in nutrition care as this population may progressively lose their independence and thus often relies more on loved ones, care-takers, and health professionals for their needs. Because of this dilemma, older adults are often admitted to senior care facilities and hospitals where it is expected that they will be given adequate care and treatment, even though malnutrition prevails in hospitals and long term care facilities. Screening tools are a resource designed to detect and prevent malnutrition, yet many patients go undiagnosed. The Malnutrition Quality Improvement Initiative (MQii) tool, Malnutrition Screening Tool (MST), Mini Nutritional Assessment-Short Form (MNA-SF), Older Adult Screening Tool (COAST), full Mini Nutritional Assessment (MNA), Malnutrition Screening Tool (MUST), and the Simplified Nutritional Assessment Questionnaire were the screening tools represented in this review of literature. Screening tools that were found most reliable from this list were the COAST, MST, MNA-SF, and MUST, in combination with training. Some of the research in this review tested the accuracy of certain screening tools when conducted by health professionals with varying levels of malnutrition screening training and found those without training did not amply identify patients with malnutrition.

Dirt Homes: The Housing Choice of the Future

Primary Author: Kolby Knight, Design Studies

Co-Author/Collaborator: Leanna Marcy

Advisor: Hannah Upole

Would you ever consider living in a house constructed mainly of dirt? Contrary to popular belief, dirt and other elements can combine to make one of the strongest, most sustainable, and unique housing styles. Rammed Earth homes posses low energy demand that comes from being made of natural materials. Today, most new construction is not sustainable, is increasing environmental issues, and depleting natural resources. The construction of Rammed Earth homes is made from compacted sand, clay and silt combined to create layers called lifts (Sooklal, V.K., 2015). The panels of the home consist of the lifts that can range between twelve and twenty-four inches in thickness (Hardin & Comella, 2006). Because of this rammed Earth homes provide overall better air quality compared to traditional residential spaces because of the thermal mass properties. Rammed Earth homes have been found to be one of the most self-sufficing housing styles. This housing choice allows for better heating and cooling of the home, less energy used, and most importantly it is made from natural resources that do not require high energy cost to build. However, would consumers actually consider living in a home constructed mainly of dirt? Based on this literature review, further research is being conducted in Spring 2023 to help address our research question.

The Effectiveness of Calorie Tracking Mobile Applications for Developing Healthful Nutrition Habits in Young Adults

Primary Author: Alexandra Garcia, B.S. in Human Ecology

Advisor: Allison Coutinho

Diet-tracking mobile applications have become increasingly popular, yet research on these mHealth tools is limited. This research review aims to assess the effectiveness of popular mobile applications in inducing weight reduction, increasing physical activity, and developing healthful behavior changes in young adults. There are quantitative studies examining weight loss in correlation to the use of popular mHealth applications and qualitative studies assessing participantsâ€™ perspectives on these applications. By determining the effectiveness of mHealth tools, dietitians can implement them as diet tracking methods with clients that may not like other food record-keeping methods. To find relevant studies for this research, I used databases such as google scholar, the Journal of the Academy of Nutrition and Dietetics, and Eagle Search using key terms such as calorie-tracking apps, mobile applications, behavior-change apps, and more limiting research to peer-reviewed articles published within the last 10 years. Physical activity level increased with the use of the application Vidahora, studies showed that mobile applications were effective in establishing behavior changes, and most studies investigating weight loss saw significant data that the use of mHealth applications led to weight loss in participants. Diet-tracking mobile applications could be helpful tools for dietitians to promote weight loss and behavior change to their clients paired with dietitian intervention.

The Effects of Divorce on Parent-Child Relationships

Primary Author: Kylee Gaumont, Human Ecology

Advisor: Dr. Ricardo Chitiyo

Throughout the world, divorce is more prevalent than we could realize. It is an occurrence that either builds relationships or destroys them. Parent-child relationships are the main things affected by divorce, and it is not talked about enough. In this project, divorce will be explored and recognized as a subject that has many impacts for all types of relationships, but specifically, parent-child relationships. How was research found for this project? They were found using various scholarly websites using key words, such as â€œdivorce,â€ â€œparent-child relationships,â€ â€œdevelopment,â€ etc. The research findings will support these effects while also discovering more information about gaps in specific areas, such as the relationship between single mothers and their children after divorce. While it is more common to talk about children and their relationship with their parents individually, it is easy to overlook the other circumstances surrounding this as well. Many of the findings included research on divorce, parent-child relationships, development after divorce, intimate relationships as a result of divorce, and post-divorce functioning. There is also an argument whether divorce is good or bad for children and their parents. This exposes another gap here in research that does not support the positive outcomes from a divorce. This topic is important because divorce is something that affects more than just the couple involved, and everyone should realize that it is more than that.

The Correlation Between Abnormal Levels of Vitamin D, Magnesium, and Calcium and the Frequency, Intensity, and Duration of Migraine Headaches

Primary Author: Hannah Bailey, Human Ecology

Advisor: Allison Coutinho

Migraine is defined as a debilitating headache disorder characterized by unilateral, pulsating headache, photophobia, phonophobia, nausea, and other neurological symptoms. Based on mechanisms of vitamin D, calcium, and magnesium, it is hypothesized these vitamins may have an impact on migraine. The purpose of this literature synthesis was to examine the effects of abnormal values of vitamin D, magnesium, and calcium on the frequency, intensity, and duration of migraine. Peer reviewed articles 10 years or younger were found by keywords: migraine, migraine with and without aura, vitamin D, magnesium, calcium, vitamin D deficiency, hypomagnesemia, hyper and hypocalcemia. Exclusion criteria was: menstrual migraine, cluster headache, non-migraine headache, and migraine treated without vitamin D, magnesium, and calcium. Results for vitamin D showed 77% of migraine patients are deficient, those with deficiency had a 120% higher migraine prevalence, and migraine levels were statistically significantly lower in patients treated with vitamin D. Results also showed an increase in serum calcium by 1mg/dl caused a 1.8-fold increase in migraine frequency. Results were found to be inconclusive on the impact of magnesium and calcium deficiencies. Dietary regulation of vitamin D, magnesium, and calcium may be an effective approach in lowering the frequency, intensity, and duration of migraine headache, and it is recommended RDs consider adjusting RDVs of these vitamins in migraine patients.

Children Advocating for Themselves with 504 Plans

Primary Author: Lauren Tucker, Human Ecology

Advisor: Dr. Rufaro Chitiyo

In the research it was focused on self-advocacy in children in a school setting when having a 504 plan. The problem is a deficit of research on the topic itself however, there has been research on the different aspects of this topic. The keywords used to find research were self-advocacy in school settings and self-advocacy in a clinical setting. I used these keywords to find articles that worked best with my research topic. These articles focused on the childâ€™s point of view. Exclusion criteria? The purpose of this study was to bring awareness into the amount of research need and work that is needed to be done on this topic. The participants in previous studies included parents, children, and teachers. These were all the main groups that need to work together to create the best accommodations for the child. The results showed how much parents had to get involved in their childâ€™s academic life to get the accommodations to thrive in the environment. In addition, parents believed it was important for the child to learn about their illness to be able to educate their teachers themselves. The main gap in the literature is the lack of research investigating the topic. This does not allow us to know the full extent of the problem. Finally, the goal is to bring awareness to the problem to gain more understanding of what can be done.

Factors That Affect Weight Gain Among College Freshman

Primary Author: Christian Murphy, Nutrition and Dietetics

Advisor: Allison Coutinho

The purpose of this review of literature is to explore the differences in male and female weight gain during their freshman year of college and what factors affect weight gain in these young adults. This review compiled three main studies that discussed the differences of eating habits and knowledge of males and females, eating habits of college freshman, and the consequences of impulsive decision making. This literature review found that women are more conscious of their diets when compared to men. The primary factor that caused weight gain in college freshman was impulsive decision making and easy access to unhealthy foods. The evidence gathered shows overwhelmingly that better education for college freshmen and more intensive research on how to aid this population is a need.

The Impact of Child Life Specialist On Children in the Hospital

Primary Author: Mary Estep, Human Ecology

Advisor: Dr. Rufaro Chitiyo

Child Life Specialists impact children in many ways. Knowing the specific ways, positively or negatively, can help them as professionals to use different methods and find the one that works best in any given situation. The purpose of this study is to explore the ways in which Child Life Specialists impact children in the hospital. When choosing studies to inform my project, I used keywords such as child life, impact and children. I read each abstract and chose ones that specifically talked about the impact of Child Life

Specialist. The topic under investigation is about the ways that Child Life Specialists impacted children. The participants in these studies were children and Child Life Specialists. Within the studies I found, the main finding was a positive correlation between having a Child Life Specialist as part of the medical team than not having one. These results provide insight that having a Child Life Specialist available to intervene is a positive aspect to a childâ€™s overall experience. These studies were heavily quantitative with very little qualitative research, so with more qualitative research we could get more feedback that would be more useful. This topic is important because knowing which ways of intervention were most effective would give future child life specialist insight as to what method to use and what method works best.

The Effects of Childcare on Children's Attachment Styles

Primary Author: Victoria Bell, Human Ecology

Advisor: Dr. Rufaro Chitiyo

Childcare is highly integrated into American society and is part of a normal life for many people. Children as young as six weeks old often attend daycare for up to 25 hours. The purpose of this research is to examine what the effects of full-time childcare might be on a child's attachment to their primary caregiver, and how these attachment styles might affect them in all relationships later in life. Articles for this research were chosen based on the importance they placed on childcare for young children and their thoroughness in detailing different attachment styles and the variables that affect them. Participants in these studies included children ranging from zero to five years and their parents. A portion of the studies also detailed the childcare workers. The main findings of all the articles combined were that though childcare does play a part in what a child's attachment style will be, other factors such as parenting style play a more significant role, or that there are no adverse effects. To include adequate research on both attachment styles and full-time childcare in this project, studies from outside the U.S. were also used as they provided more detail on the subjects combined. The lack of previous research done on the effects of childcare on attachment styles made it clear that more research on the topic is necessary for ensuring the systems we have in place for our children are benefiting them.

The Role of Parental Stress During a Child's Hospitalization

Primary Author: Nyani Jones, Human Ecology

Advisor: Dr. Rufaro Chitiyo

The hospital can be an overwhelming and scary place for children and families. Aside from the childâ€™s diagnosis, parents and caregivers endure stressful events related to hospitalization. It is known that parents experience high levels of stress during the hospitalization of their child. The purpose of this research was to explore the extent of parental stress during a childâ€™s hospitalization plays a role in parents' coping skills. This is important to discover to better support parents, which in turn will strengthen the child's support system. In regard to the criteria used for this study, studies were selected based on relevance to parental stress. Determining parental stress and the factors of parental stress were two main ideas found throughout the sources used. Keywords included parents, child, family, stress, psychological distress, and hospitalization. Participants in the studies included parents or caregivers of hospitalized children. The main results included factors that affect parental stress and identifying the sources of stress. Factors include psychological and emotional distress, health condition of child, duration of hospitalization,function of family, parents ability of self-expression and ability to cope. These results indicated that once the sources of stress are identified, interventions to prevent and lower levels of parental stress can be developed. This is important because parents and caregivers need tools to cope to support their child.

Consumers' Attitudes Towards Sustainable Dyeing Methods

Primary Author: Alyson Parks, Design Studies

Co-Author/Collaborator: Allie Boles

Advisor: Hannah Upole

Removing dyes from water is an extremely difficult process and often still leaves traces of the chemicals used in waterways and soil. However there are many advances being made within the sustainability of textile water waste. While these advances are extremely important to further improve the textile industry, the only way to reduce the incredible waste and spread of dye chemicals is to reduce water used in the first place. AirDye is a new technology that utilizes waterfree dyeing and printing on textiles to solve the current issues of uncontrolled water waste (Debs, n.d). This process uses up to 95% less water as well as 86% less energy compared to traditional dyeing practices. (Debs, n.d). Being informed about environmentally sustainable dying procedures, like AirDye, as a consumer can be a powerful influence on purchasing behavior. Researchers have suggested that individuals with higher environmental knowledge are more likely to be concerned about environmental issues, and more likely to make environmentally friendly consumption choices in their life (Kim & Damhorst, 1998). When consumers are more educated on the negative effects of unsustainable dying practices, what are their attitudes towards traditional dyeing methods versus more sustainable options? Further research will be conducted over the spring 2023 semester to determine consumers attitudes towards traditional dyeing practices versus more sustainable options.

The Contributing Factors and Prevalence of Metabolic Syndrome and Insulin Resistance in Women Diagnosis with Polycystic Ovarian Syndrome and/or Breast Cancer

Primary Author: Lorena Wance, Nutrition and Dietetics

Advisor: Allison Coutinho

The purpose of this literature review was to comprehend contributing factors/prevalence of metabolic syndrome and insulin resistance (IR) in women with PCOS and/or breast cancer. Womenâ€™s health issues should be identified, monitored, and addressed for the health and wellness of the female population. The gynecological side of womenâ€™s health presents with an array of cancers, diseases, and syndromes. Minimal knowledge on why this occurs and limited preventative testing prompts further exploration of these issues. Considerations to the development of serious health problems can be correlated with PCOS and breast cancer. Overweight/obese women increase their risk for developing type 2 diabetes. IR and metabolic syndrome can be more prevalent in the course of disease for these individuals. Methods used included search engines through the Tennessee Technological University Library Database Eagle Search, the Evidence Analysis Library (EAL), and the Journal of Nutrition and Dietetics. Literature on this topic is minimal and inconclusive. The reviewed literature indicates that IR accompanies more than half of the women diagnosed with PCOS and postmenopausal women were more likely to experience risks that resulted in breast cancer and death following remission. Further identification of how IR affects postmenopausal women and premenopausal women with breast cancer and its prevalence on mortality should be addressed to aid in preventive care.

Eating Disorder Risk Factors, Quality of Life, and Treatment Options Among Adolescents and Young Adults

Primary Author: Olivia Sexton, Nutrition and Dietetics

Advisor: Allison Coutinho

The purpose of this literature review was to explore the risk factors associated with eating disorder development, examine individualsâ€™ quality of life, and discover treatment options to improve that quality in adolescents and young adults. The research evaluated determined there is a significance between eating habits, weight loss behaviors, number of meals consumed per day, dieting, weight loss drugs, technologies, and an individualsâ€™ level of self-esteem as aids in the creation of behaviors linked to ED development. Restrictive dieting has proven to be problematic for not only personal well-being, but also disruptive in oneâ€™s daily functioning. Body dissatisfaction in people who already present risk factors such as obesity, depression, perfectionism, and low self-esteem indicate the development of extreme weight control behaviors in the future. There are few definitive methods on how to prevent, treat, and rehabilitate the mental and physical well-being of individuals that struggle with EDs. However, guidelines can be created to educate patients on the components of a healthy and balanced diet to prevent these habits from developing further, as well as guide those who are going through recovery. Studies have provided data that support how understanding the risk factors of EDs can act as a preventative factor in their development, how EDs have a negative impact on quality of life, and how tailored weight restoration guides have a positive impact on the recovery process.

College of Arts & Sciences

Department of Biology

Graduate Student

Applied Functional Genomics for the Conservation of the Imperiled Hardin Crayfish (Faxonius wrighti)

Primary Author: Holly Gothard, Master of Science in Biology

Advisor: Dr. Carla Hurt

The crayfish genus Faxonius is a focus for many conservation efforts. Many Faxonius species are

narrowly endemic and vulnerable to habitat loss. Faxonius wrighti (Hardin crayfish) is a stream-dwelling crayfish native to tributaries in the middle Tennessee River basin; this species is being petitioned for federal listing under the Endangered Species Act. The objective of this project is to provide genomic resources that inform management and conservation efforts for F. wrighti. We are using whole genome sequencing (WGS) and comparative transcriptome analysis to investigate functional genetic variation. Whole genome assembly of crayfish is challenging due to the high repetitive content of crustacean genomes. We are optimizing a workflow for de novo assembly of crayfish genomes with short-read sequence data. Transcriptomes will be used to explore differential expression between three tissue types: hepatopancreas, gills, and abdominal muscle. A high-quality transcriptome has been assembled for each tissue type through a combined assembly approach. Differential gene expression across tissues provides baseline information regarding key mechanisms in each tissue type. This project will generate the first WGS assembly for the this ecologically important genus and observe the impact of repetitive elements on whole genome assembly. Comparative transcriptome analysis will improve the annotation of the genome and inform conservation efforts by understanding tissue-specific pathways.

Undergraduate Students

Identification and Characterization of the Serum Protein that Affects Reversion Rates of Small Colony Variant Staphylococcus aureus

Primary Author: Preston Hart, Cellular and Molecular Biology

Co-Authors/Collaborators: Dawson Blackley, Tammy Nguyen, Michael Davis

Advisor: Dr. David Beck

To identify the Bovine Calf Serum (BCS) protein that affects the reversion rate of small colony variant (SCV) S. aureus to normal normal colony variant (NCV) and its effects on gene expression in S. aureus.

Background: SCV S. aureus is characterized by slow growth and small colony size and is commonly found in patients with Cystic Fibrosis and osteomyelitis. The mechanism underlying the conversion to, and reversion from the small colony variant form is currently unknown. However, the presence of bovine calf serum (BCS) induces reversion likely via an epigenetic factor.

Methods: BCS was fractionated using a phenyl column, then a Q-Sepharose anion exchange column which was eluted by gradually increasing salt concentrations. Fractions were then screened for activity by a reversion assay. The fractions were visualized using an SDS-PAGE and silver stained.
Results: We determined that the protein was between 117-308 kDa. It eluted at approximately 80-100 mM NaCl off the Q-sepharose column. Silver stain revealed that approximately 30 proteins remained in this fraction.

Future Directions: We are now fractionating these 30 proteins to determine which one has the effect on reversion. The most promising protein will then be identified by LC/MS Spectroscopy. With the protein now identified and purified, we will test its effects on gene expression in S. aureus. Precise genetic mechanisms for the switch from small to large colony variants will then be determined.

Erosion Risk Assessment for a Proposed Public Trail

Primary Author: Katherine Wieczorek, Wildlife and Fisheries Science

Advisor: Dr. Nikki Panter

CISE Recipient

Trails are an important recreation feature that allow people to immerse themselves in the wilderness away from the office and urban life, reconnect with nature and each other, and learn about flora and fauna, wildlife, and the wonders of nature. However, trails also bring the potential threat of land degradation by erosion to the areas along the trail. Trails must be well-constructed and carefully maintained to prevent erosion from occurring. It is therefore important that areas along trails that are at high risk for erosion be identified so that preventative actions can be taken. This study identified areas prone to erosion along a public access trail at The Nature Conservancyâ€™s Bridgestone Nature Reserve at Chestnut Mountain in Sparta, TN. Measurements of trail width, outslope, trail grade, slope aspect, canopy density, waterflow, and tread were taken at 0.16-mile intervals along the trail, totaling to twenty-four measurement points. These measurements were then analyzed and twelve of the measurement points were considered areas at risk for erosion. This study also included a general overview of the trailâ€™s condition and a vegetation survey along the trail in order that further changes can be monitored.

Effects of moisture and heat stress on eastern fence lizard eggs

Primary Author: Lydia Dudley, Environmental and Sustainability Studies

Co-Authors/Collaborators: Haley Ortner; Dr. Joshua Hall, Tennessee Tech; Devo Eco Lab
Advisor: Dr. Joshua Hall

CISE Recipient

The effects of moisture and heat stress on embryo development have been extensively studied separately in vertebrate ectotherms but combined effects represent a critical knowledge gap given that climate change will alter both temperature and rainfall simultaneously. To understand the interactive effects of moisture and temperature on development, we incubated eggs of the Eastern Fence Lizard (Sceloporus undulatus) at two moisture concentrations and measured fitness-relevant phenotypes of embryos and hatchlings. We then incubated eggs in a 2 by 2 factorial design of moisture and temperature.
One temperature treatment was suitable for development and the other induced thermal stress. Eggs in the moist treatment absorbed more water but developed more slowly than those in the dry treatment; however, there were no treatment differences in hatchling body size due to moisture. Thus, our moisture treatments influenced physiology but not morphology. The factorial experiment is still underway; however, current data indicate that interactions between moisture and temperature will result from moisture-induced changes in physiology related to water uptake.
These foundational studies will establish S. undulatus as a model for understanding the combined effects of altered temperature and rainfall patterns due to climate change. Such knowledge will benefit reptiles of Tennessee and beyond by enhancing our understanding of ectotherm responses to global change.

The Protobiome: Identifying Amoebae and Other Resident Protozoans in the Cutaneous Microbiome

Primary Author: Chelsy Bartley, Wildlife and Fisheries

Co-Authors/Collaborators: Laurel Wall, Emily Lannom, Nathan Owens, Dr. Robert Paine, Tennessee Co-op Fisheries Research Unit, Dr. John Gunderson, Department of Biology

Advisor: Dr. Aubree Hill

Previous work used high-throughput DNA sequencing (HTS) to characterize the bacterial and fungal components of the salamander skin microbiome, and culture-based techniques were used to identify microbes capable of inhibiting the growth of the pathogens Batrachochytrium dendrobatidis and B. salamandrivorans. However, little is known about the protistan component of the salamander microbiome. Protists are known to play important roles in the soil rhizosphere and mammalian gut. We hypothesized that skin-dwelling protists may impact microbiome structure and, therefore, host health. We conducted a pilot study to identify protistan members of the salamander skin microbiome, the so-called protobiome, using traditional microbiological isolation techniques, PCR amplification and HTS of the 18s rRNA gene. Skin swabs from six Plethodon glutinosus salamanders were collected in duplicate; the first swab was used for molecular biology work, and the second swab was used for microbial isolations. Oomycetes, or water molds, and Acanthamoeba species were both identified as core protobiome members. Furthermore, we were able to isolate these protists from the second set of skin swabs, indicating they might be useful in the fight against fungal pathogens. Results shed light on a lesser known but ecologically and, perhaps, clinically important cohort of symbionts in the cutaneous microbiome. Future work will determine whether these isolates can inhibit growth of chytrid pathogens in co-culture.

Effects of Predator Guard Type on Eastern Bluebird Nesting Success

Primary Author: Chance Hale, Finance

Advisor: Dr. Nikki Panter
CISE Recipient

Eastern bluebirds (Sialia sialis) are vital to the Appalachian region ecosystem because they reduce the insect population around farms. Often, farmers will put bluebird nest boxes around their crops so they will eat the insects that threaten their crops. Recently, bird populations have declined worldwide due to habitat loss, pesticide use, and predation. Predator guards aid birds by repelling predators from bird nests. Significant scientific evidence suggests that predator guards increase the nesting success of all bird species. However, most studies on predator guards focus on house wrens. There is little evidence of the impact of predator guards on eastern bluebirds nesting success. This project aimed to determine which predator guard was the most efficient at protecting bluebird populations so farmers across Middle Tennessee and the Southeast could be

better informed about managing their birdhouses. In collaboration with The Nature Conservancy, three extension, tube and funnel predator guards were placed on nest boxes and then distributed equally around the Chestnut Mountain Reserve, as well as three nest boxes with no predator guards (control group). Determining which predator guard was the most effective in preventing predation would allow farmers to protect their bluebird populations on their farms and keep the insect population manageable, ultimately benefiting the ecosystem and supporting the agricultural communities surrounding Cookeville.

Utilizing Leukocyte Profiles to Compare Stress Levels in Brooding Canada Geese (Branta canadensis)

Primary Author: Natalie Perkins, Pre-Medicine

Co-Author/Collaborator: Richard Pirkle, Tennessee Tech University, Biology Department

Advisor: Richard Pirkle

CISE Recipient

Canada geese (Branta canadensis) frequently form brood aggregations subsequent to hatching. Generally thought to be an adaptive response to increase survivorship of individual goslings, little is known about the physiological mechanisms that drive aggregating behavior. Canada goose brooding physiology is initially very stressful on the female who takes sole responsibility for egg incubation. Subsequent to the goslings hatching, the gander (male goose) becomes exceptionally wary allowing both the female and the goslings to graze freely. We believe brood aggregations may reduce the required vigilance of parent geese and lower the stress compared to geese who choose to brood alone. Leukocyte profiles, in particular the heterophil to lymphocyte ratio (H:L), serve as a useful tool to determine stress levels in a variety of vertebrates including geese. Our results indicate increased leukocyte counts for breeding geese compared to non-reproductive geese and a generally higher than previously reported H:L ratio for all geese in the Upper Cumberland flock.

Department of Chemistry

Graduate Student

Molecular interactions between a novel peptide scaffolds in ASK-1-JNK3 Cascades

Primary Author: Brian Chong, Biochemistry

Advisor: Xuanzhi Zhan

Mitogen-activated protein kinase (MAPK) cascades play a critical role in signaling pathways by amplifying and relaying signals from a myriad of stimuli and elicit vital physiological processes such as cell growth, cell differentiation, and apoptosisJNK3, a member of Mitogen-Activated Protein kinases (MAPK), controls many signal transduction cascades related to apoptosis, and various diseases such as Parkinsonâ€™s and Alzheimerâ€™s. Of particular interest is the novel self-scaffolding interaction between ASK1-JNK3, the MAPK kinase kinase (MAPKKK) and MAP kinase respectively.

This project seeks to eludcidate the structural basis of the novel ASK1-JNK3 interaction using a combination of in vitro biochemical assays. The role of NJBC, a fragment from the N-terminus of JNK3, in the JNK3-ASK1 interaction will be clarified. Characterization of the mini-scaffolding interface between NJBC-ASK1 will be done using pulldown assays. In addition, this project seeks to corroborate these results with analysis via SPR. Allosteric regulation of this system using ATP, IP6, and other binding partners will also be investigated to study the change in binding affinity of these interactions. This research ultimately seeks to verify results with an in vivo assay to test the mini-scaffolding ability and biphasic inhibition of NJ40 fragments.

Synthesis of supramolecular-dye conjugate macrocycles via coupling reactions of chromophores

Primary Author: Andrew Nguyen, Chemistry

Co-Author/Collaborator: Dr. Kyle Murphy

Advisor: Dr. William Carroll

The formulation of new colorants that are both inherently colorfast and stable is an active area of research. By using N, N'-Dicyclohexylcarbodiimide (DCC) coupling between carbazole derivatives and carboxylic acid functionalized dyes, a substituted pre-monomer can be formed. This pre-monomer can then undergo a Suzuki 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 pre-monomer and linker. By covalently bonding the dye to the macrocycle, an extension of conjugation and resonance can be achieved increasing the overall stability of the dye. With the increase in stability, the possibility of photodegradation is reduced allowing for the addition to plastics for long-lasting coloration. With the substitution of the dye for a bifunctional reactive dye, the reactive dye can maintain its reactive nature towards fabrics, allowing for a two-fold application within textiles and polymer production. With the manipulation of the pre-monomer and linker, this work explores the creation of more stable, vibrant reactive colorants for application to plastics and textiles.

Virtual Screening and Validation of Hamigeromycin B Natural Product Derivatives in JNK3, EGFR, and Hsp90

Primary Author: Meagan Edmonds, MS

Co-Authors/Collaborators: Derek Cashman TTU; Jesse Carrick, Tennessee Tech University

Advisor: Derek Cashman

Hamigeromycin B analogs are natural product derivatives with potential for mediating signal transduction in human kinases. The goal of this project is to develop a high-affinity cancer drug from the lead compounds that is also easy to synthesize, cost-effective, and specific to one kinase. This can be accomplished using virtual screening, a computational method to design drugs for protein targets. Eleven Hamigeromycin analogs were evaluated using MOE 2020 and optimized using AMBER14:EHT. The analogs were docked into 26 human kinase structures obtained from the Protein Data Bank using the Docking module of MOE 2020. The docking sites in each kinase were targeted using the Protein Frustratometer and Evolutionary Trace to characterize the energetics and evolutionary importance of amino acids for contributions to binding. The lowest binding free energy scores were used to determine the best binding and orientation of each analog. The data suggest that three kinases as potential targets: EGFR, HSP90, and JNK3. The compounds were subjected to pharmacophore modeling for further refinement. The pharmacophore docking studies suggest that A6, monocillin II, and A15 are the strongest binding compounds. Molecular dynamics studies were performed to study binding contributions to the holo-protein complexes in comparison to the apo-proteins. The objective of this project is to develop a high-affinity cancer drug that can be easily synthesized and bound to specific targets.

Identification of the Interface Between N-terminal of JNK3 With Scaffold Protein Arrestin-3

Primary Author: Nadia Mireku, Master's in Chemistry

Co-Author/Collaborator: Xuanzhi ZhanBrian Chong

Advisor: Dr. Xuanzhi Zhan

Scaffold proteins orchestrate cellular signaling by assembling multi-component complex. The three-tiered mitogen activated protein kinase (MAPK) cascades are highly regulated by various scaffold proteins. Arrestin-3 is a scaffold protein that assembles signaling complexes in the MAP kinase pathway for effective signal transmission without any interferences. JNK3 is a member of the MAP kinase pathway which is highly expressed in the brain and is involved in several neurological disorders like Parkinsonâ€™s disease and Alzheimerâ€™s disease. JNK3 has an extended N-terminus (NJ40) compared to the other JNKs that consists of 38 amino acids. This N-terminal of JNK3 was previously identified as the binding site for scaffold protein arrestin-3. To determine the precise interface of arrestin-3 within this motif, we have constructed three smaller truncated peptides (NJ20, NJBC and NJCD), and tested their interaction with arrestin-3. The results from this study will reveal the structural basis of the roles of this unique N-terminal of JNK3.

Synthesis of Heteroaryl Azoles via Cyclization Method

Primary Author: Bolade Ajibola, Master`s

Advisor: Dr. Jesse Carrick D.

ABSTRACT

The transition to nuclear fuel as a primary, sustainable energy source has been hindered by environmental concerns surrounding the remediation and recyclization of spent nuclear fuel (SNF). A major caveat in recycling SNF is the presence of highly radioactive minor actinides and neutron-absorbing lanthanides. Lewis-basic heterocyclic complexants have been shown to facilitate the extraction of minor actinides from SNF utilizing liquid-liquid separation techniques. Complexants including mono-triazinylpyridine (MTP) and bis-triazinylpyridine (BTP) scaffolds have been synthesized in this lab. This research is focused on using heteroaryl MTP carbonitriles as the central scaffold to derive conditions for the successful synthesis of two major classes of azoles, namely, MTP imidazole and 1,2,4- triazole scaffolds. Conventionally, the nitrogen atom in ligand scaffolds enables polydentate coordination opportunities due to strong electron-donating properties. The two classes of scaffolds focused on in this research are also asymmetrically substituted Lewis bases which can act as coordinating heterocycles as well as having the different substituents propel their polydentate conformational mobility on chemoselective minor actinide extraction

in polar solvents. Thus far, the diverse conditions for synthesizing these precursors through a multi-step approach and the envisaged substrate scope will be presented.

An Investigation of Pollution in Subterranean Karst Streams

Primary Author: Bryant Davis, Integrated Research

Advisor: Dr. Andrew Callender

Research and exploration have shown that subterranean karst streams are subject to extensive contamination from pollution. This pollution accumulates in underground portions of streams, and is not easily remediated. This research couples our previous geochemical fingerprinting work with an examination of subterranean streams in Cookeville, TN, to assess the damage caused by this pollution. Particularly, this work will consider guidelines established by the EPA to determine the risk of heavy metal contaminants in our waterways. Grab samples will be obtained, at the surface, before the waters are subducted, then again once they resurface. Any differences obtained are most likely attributed to the extensive pollution in the caverns beneath the surface.

Synthesis of Carboxylated Symmetric Bis-(1,2,4)-triazinyl pyridine (BTP) Complexants for Minor Actinide Separations.

Primary Author: Samiat Olayiwola, Chemistry

Advisor: Dr. Jesse Carrick

Nuclear energy is an established, reliable source of electrical power, accounting for 20% of electricity production in the U.S. alone. The management and disposal of radioactive by-products from fission, contained in spent nuclear fuel (SNF), remains a key barrier to the expansion of nuclear energy as a primary power source. SNF contains a mixture of minor actinides, such as 241Am3+ and 247Cm3+, and lanthanides, which are difficult to separate due to their physical and chemical similarities. Prior synthesis in our group has afforded unsymmetric and symmetric mono-triazinylpyridine (MTP) and bis-(1,2,4)- triazinylpyridine (BTP) scaffolds that have shown potential advantages toward liquid-liquid extraction of minor actinides. Current work in our lab is centered on the functionalization of these scaffolds to enhance ligand solubility and build resistance to acidic environments pertinent to SNF. One avenue of exploration involves introduction of a carboxylic group to the symmetric BTP scaffolds to modulate the performance of this tridentate ligand through increased solubility. This work involves a telescoped reaction approach which includes alkylation of dihydroxybenzil with acyl chlorides and its derivatives, and further condensation with bis-hyrdazonamide to afford the carboxylated symmetric bis-(1,2,4)-triazinylpyridine (BTP). The preliminary results obtained and the desired compounds to be synthesized will be presented.

Progress towards the enantioselective synthesis of Hamigeromycin B

Primary Author: Victor Jonathan, Chemistry

Co-Author/Collaborator: Dr. Jesse D Carrick

Advisor: Dr. Jesse D Carrick

Hamigeromycin B is a naturally occurring molecule belonging to the resorcylic acid lactone (RAL) class of structurally diverse fungal polyketide metabolites with a macrolide core structure linked to an aromatic ring called resorcinol. it is known to have some interesting biological actions, due to structural similarities with other RAL natural products, including cytotoxicity, antibiotic properties, and inhibition of different kinases. In this study, we attempt the enantioselective synthesis of Hamigeromycin B building upon previous efforts in the total synthesis and computational findings substantiating the drugability of this molecule. The retrosynthetic pathway involves two key synthons â€“a pyranone and a styrene synthon. A reaction pathway has been charted for synthesis of the pyranone synthon via hetero diels-alder reaction and conjugate addition employing allyl tributyl tin before condensation with the styrene synthon. Optimization and scale up reactions are still to be conducted on the non-styrene synthon reaction pathway utilizing several protecting group strategies with the readily available starting material alcohol. Upon successful synthesis of Hamigeromycin B, Inhibition studies will be carried out to investigate its potential as a drug candidate. The importance of this molecule, other RALs and the peculiar challenges involved with this study will be discussed.

Synthetic Access to Unsymmetric, Pyridyl-1,2,4-Triazine Complexant Scaffolds via Oxidative Condensation of Heteroaryl Carbaldehydes

Primary Author: Eric Agyei, Chemistry

Advisor: Dr. Jesse D. Carrick

The creation of soft-Lewis basic complexant scaffolds for potential use in chemoselective liquid-liquid separations of trivalent actinides from lanthanides in spent nuclear fuel remains the focus of current research in this group. Conventional ligand design has concentrated on symmetric moieties of these soft-Lewis base structures including the bis-triazinylpyridine (BTP) class of compounds. It is hypothesized that the introduction of unsymmetric BTP complexants would have improved solubility as well as good complexation performance over the symmetric BTP scaffolds in process-relevant diluents. In this study, the direct synthesis of heteroaryl carbonitriles from the corresponding carbaldehydes was achieved by an oxidative condensation method using the hypervalent iodine reagent, bis(acetoxy) iodobenzene (BAIB), as the oxidant and NH4OAc as the nitrogen source. These advanced carbonitriles have subsequently been used to produce unsymmetric bis-1,2,4-triazinyl pyridine (BTP) scaffolds via telescoped condensation techniques previously reported by our lab. Further separation studies from simulated used nuclear fuels will be possible with access to these unsymmetric BTPs. Development and optimization of synthetic methods, relevant substrate scope, and a scale-up reaction of these essential materials will be presented.

Synthesis of Heteroaryl 1,2,3-triazoles via an Intermolecular Cyclization Method Mediated by DBU

Primary Author: Orume Edirin, Master's

Advisor: Dr. Jesse Carrick

An essential stage in closing the nuclear fuel cycle is the chemoselective extraction of the minor actinides from the lanthanides. Complexants that influence covalent orbital interactions with significant additives of interest can aid liquid-liquid separations to achieve the desired results. This allows for the potential of using additional transmutative processes to solve issues with the storage of spent nuclear fuel (SNF), which is generated during the production of energy and weapons. In this work, N-tosylhydrazones were successfully produced in high yields by a thermally induced intermolecular reaction between formyl mono-1,2,4-triazin-3-yl pyridine and 4-methylbenzenesulfono-hydrazides. 1,8-diazabicyclo[5.4.0]undec-7-ene-catalyzed cycloloaddition of N-tosylhydrazones led to the synthesis of pyridyl [1,2,3]-triazoles in good yields. Isolation of end-product through reverse-phase chromatography technique was established. Development of a reverse-phase automated flash purification process for the mono-1,2,4-triazin-3-yl pyridyl [1,2,3]-triazoles, substrate scope, and functional group interconversion of necessary starting materials will be presented.

Detection of Synthetic Musk Compounds in Indoor Dust by In-Tube Extraction (ITEX) HS-GC-MS

Primary Author: Oluwasola Ifedayo, Masters

Co-Author/Collaborator: Dr. Andrew Callender
Advisor: Dr. Andrew Callender

Synthetic musk compounds (SMCs) are fragrances widely used in personal care products (PCPs), but their toxicity and occurrence in diverse environmental compartments suggest possible harm to people and the environment. Other researchers have shown that dust can provide a significant reservoir for semi-volatile compounds (SVOC) in the built environment. Comparative studies of SMCs in dust have been limited by the lack of a fast, straightforward method for the analysis of these compounds in dust from a variety of sources. A method based on GC-MS examination of the dust headspace would allow rapid solventless analysis. However, dust from different built environments may present different inorganic (mineral) and organic compositions. This poster presents work toward an optimized method for static headspace GC-MS analysis, including a study of how the polarity of dust surrogates may affect the desorption and detection of different SVOCs.

Undergraduate Students

Thermal Characterization of Liquid State Quinidine Compounds

Primary Author: William Collier, Chemistry

Co-Authors/Collaborators: Thomas D. Robertson II; Dr. O. Andreea Cojocaru, Tennessee Tech University

Advisors: Dr. O. Andreea Cojocaru

In their solid forms, many drugs exhibit polymorphism, existing in multiple crystalline arrangements. These arrangements can alter the effectiveness of a drug or cause unwanted side effects. Quinidine (QD), a drug used to treat certain kinds of irregular heartbeats, is an example of a drug that displays this phenomenon. One side effect of the long-term use of this drug is damage to the liver. To combat these issues, QD cation can be combined with other anions to form multifunctional liquid drugs that will display the original pharmaceutical

properties of the solid-state drugs. We have previously shown that QD cation can be combined with N-acetyl-L-cysteine (NALC), a drug used to treat acetaminophen poisoning, and docusate (Doc), a well-known penetration enhancer, both individually with each anion and collectively in various molar ratios. This presentation focuses on the thermal characterization of these different ILs. Their decomposition temperatures will be measured using the thermogravimetric analysis and used to compare the effects of different anion ratios.

Effects of COVID-19 on general chemistry exam scores

Primary Author: Alice Letran, Biology Health Science

Co-Author/Collaborator: Dr. Chad Rezsnyak, Tennessee Technological University

Advisor: Dr. Chad Rezsnyak

In 2019, the world experienced the COVID-19 pandemic, leading to quarantining, social distancing, and self-isolation. Due to these measures in the United States, education became virtual, widening the education gap due to socioeconomic class, language, or special needs. COVID-19 also decreased communication by decreasing face-to-face interactions between students and teachers. This study will investigate the effect of the COVID-19 pandemic on General Chemistry I and II students from a rural university through a statistical analysis of final exam performance between 2016 and 2022.

Isomer-specific Negative Ion Photoelectron Spectra of Deprotonated Dicyanobenzene Radical Anions

Primary Author: Rebecca Firth, B.S. in Chemistry

Advisor: Dr. Wilson Gichuhi

URECA Recipient, CISE Recipient

Isomer-specific, negative ion photoelectron spectra of deprotonated dicyanobenzene (DCNB) anions, obtained via the calculation of Franck-Condon (FC) factors are presented. The adiabatic electron affinities (EAs) of the deprotonated DCNB radicals are in the range of 2.5 eV, which is higher by ~600 meV than those of deprotonated benzonitrile (BZN) radical isomer. This observation illustrates the extent to which an additional CN group on the phenyl ring stabilizes the unpaired electron in the respective radicals via increased p resonance interaction. Additionally, the substitution of a H atom in BZN with a CN group to form DCNB result in ~60 kJ mol-1 decrease in the gas-phase acidity (?_acid H_(298 K)^o)values in DCNB isomers, which means that the protons in DCNB are more acidic than the ones in BZN. The observed trend in the EAs and ?_acid H_(298 K)^o of BZN and DCNB mirrors that of linear cyanomethane (CH3CN) and dicyanomethane (CH2CN2) studied ealier by the Andrei Sanov group. Franck-Condon analysis based on the harmonic oscillator model show that in addition to ring-distortion vibrational modes, the negative ion spectra of deprotonated DCNBs are characterized by low frequency vibrational progressions that appear at calculated harmonic frequencies of <300 cm-1. Results from this study are used to address the relative energies of the BZN and DCNB anion and neutral isomers, as well as the site-specific bond dissociation energies of DCNB isomers.

Computational Validation of Novel Inhibitors of Dihydrofolate Reductase in Three Bacterial Species
Primary Author: Allison Adams, Chemistry

Advisor: Derek Cashman

CISE Recipient

The aims of this project are the design of high affinity small molecule inhibitors of bacterial dihydrofolate reductase (DHFR) to obtain broad-spectrum antibiotics against multiple bacterial diseases, including Bacillus anthracis, Staphylococcus aureus, and Mycobacterium tuberculosis. Inhibitors were designed to target the active site of DHFR based on computational analysis of the energetic frustration for determining areas of the molecule in high energetic states and evolutionary importance of amino acid residues for determining binding specificity present in order to help determine the active site. 388 small molecules were designed to interact with these amino acids based on complementary, non-covalent functional group interactions. The compounds were assessed according to Lipinskiâ€™s Rule of Five and Gram-Negative eNTRy Rules. Ligand-based and receptor-based pharmacophores were designed, and the molecules were analyzed based off of these models. Nine of the most favorable compounds identified through these methods were then analyzed through 200 ns molecular dynamics simulations conducted in order to verify and refine these results. The simulations were analyzed to determine the most stable, strongest binding drug candidate across all three bacteria. The energetic frustration and evolutionary importance models were effective in identifying residues important for drug binding. The pharmacophore models were also effective in determining potentially effective inhibitor.

Designing a Motion Platform for a FTMW Cavity Spectrometer

Primary Author: Mitchell Swann, Chemistry
Co-Author/Collaborator: Vas ZhukovaJared Starnes

Advisor: Dr. Ranil Gurusinghe
Fourier transform microwave (FTMW) spectroscopy provides accurate spectroscopic data that facilitates the observation of radical species in the interstellar medium and planetary atmospheres. Laboratory analysis of the rotational spectra of molecules can be done with a Balle-Flygare type cavity FTMW spectroscope, which provides very high resolution and sensitivity compared to other techniques. This method requires the use of a Fabry-Perot optical cavity, which is formed between two polished aluminum mirrors. Tuning of this cavity is essential for a high signal-to-noise ratio and is done by moving one of the two mirrors. The purpose of this research is to develop a motion platform for use in real-time tuning of a Balle-Flygare type FTMW spectrometer.

Synthesis of pharmaceutically relevant terpene derivatives for use as topoisomerase inhibitors

Primary Author: Taylor Fletcher, Bachelor's

Advisor: Dr. William R. Carroll

Topoisomerase inhibitors play an important role in the fight against cancer. The focus of this research is to create a suite of pharmaceutically relevant terpene derivatives based on the trachylobane family of diterpenes. These candidate molecules can then be evaluated for topoisomerase inhibition. Past work has expanded the diterpene core to include thiosemicarbazone functionalities. This work aims to expand the ring system in the commercially available diterpene carvone towards that of the trachylobane of interest. The scope of this synthesis and the novel molecules produced were evaluated for reproducibility and usefulness in the inhibition of topoisomerase.

Development of a presumptive field test kit for the identification of heroin, morphine, and novel synthetic opioids using thin-layer chromatography

Primary Author: Claudia Mcdavid, Bachelor's

Advisor: Dr. Jeffrey O. Boles

CISE Recipient

In the United States, illicit opioid use is on the rise due to the opioid epidemic. There has been an increase in the usage of heroin, illicitly manufactured fentanyl, and other novel synthetic opioids (NSOs), such as U-47700, AH-7921, and MT-45. NSOs can be used alone, as adulterants in heroin, or as a component of counterfeit prescription medications. The use of these opioids has led to an increase in overdose deaths, which creates challenges for law enforcement and medical professionals. Current presumptive drug tests used to identify these compounds are often inaccurate. Diluents and over-the-counter medications have been shown to give false positives. Additionally, no presumptive test kit currently exists for novel synthetic opioids other than fentanyl. This project plans to use a technique more common to definitive analysis: thin-layer chromatography. A TLC kit would be run on a small scale by law enforcement. This project aims to presumptively identify heroin, morphine, U-47700, MT-45, and AH-7921 using this technique.

Impacts of NQSA- TSC ligand loading on metal ion removal from aqueous solutions by chelating resins

Primary Author: Shawna Radford Coulter, Applied Chemistry

Advisor: Dr. Amanda Carroll

URECA Recipient

Human impacts and pollutants can be a source of heavy metal ions accumulating in the environment, which can cause environmental and human health risks to occur. This research considers Napthoquinone Sulfonic Acid (NQSA) Phenyl Thiosemicarbozone (PTSC) ligands attached to anion exchange resin beads at various loading percentages by mass to create chelating resins that can be used to remediate metal ions from aqueous samples. By studying different loading percentages, the maximum effectiveness of the resins can be determined. The extraction of metal ions from an aqueous solution by these chelating resins is studied at an environmentally relevant pH. The chelating resins are contacted with a reaction solution containing heavy metal ions for specified periods of time. The solutions prior to and after contact with the resins are analyzed by ICP-OES to determine the concentration of metal in the solutions. The changes in the concentration are used to calculate a dry-weight distribution, Dw, value, which provides a measure of how effective the resin is at removing the metal from the solution. It is anticipated that

differences in the effectiveness of the chelating resins at removing the ions from solution will arise due to differences in the ligand loadings.

Topoisomerase and thiosemicarbazone binding affinity analysis

Primary Author: Hunter Davis, Bachelor of Science

Advisor: Xiaohua Jiang

URECA Recipient

Topoisomerases are enzymes found in all living organisms that have a role in the untangling of DNA during replication, resulting in it becoming a candidate target in the treatment of cancers. Topoisomerase IIa specifically is a target due to its involvement in double stranded DNA breaks in proliferating cells. Thiosemicarbazones have been used to treat cancers, and recent research has shown one of their targets is topoisomerase. Despite this significant interaction, the mechanism is not fully understood. There are different types of thiosemicarbazones. Our recent research found that alpha-N-heterocyclic thiosemicarbazone with Cu complexes exhibited strong inhibition on Topoisomerase IIa. We synthesized a small possible structure with alpha-N-heterocyclic thiosemicarbazone Cu(BDMO) and it showed similar inhibition compared with other compounds. We also found that Cu(HD) which includes two thiosemicarbazones in the structure does not inhibit Topoisomerase IIa. We plan to further study the binding affinity between various thiosemicarbazones and topoisomerase IIa and study the mechanism of inhibition.

Remediation of heavy metal ions from water utilizing ISA- PTSC chelating resins

Primary Author: Chance Morris, Chemistry

Advisor: Dr. Amanda Carroll

URECA Recipient

The EPA currently regulates over 90 water pollutants under the National Primary Drinking Water Regulations (NPDWR). Among these pollutants, found to contribute to increased risk of cancer, liver and kidney damage, allergic dermatitis, and other health issues. This project focuses on the removal of several heavy metal ions from aqueous sources using Isatin Sulfonic Acid (ISA) Phenyl Thiosemicarbazone (PTSC) chelating resins that are immobilized onto resin beads via anion exchange. The chelating resins are loaded at various percentages by mass to determine the maximum efficiency of each resin. These chelating resins are then stirred in solutions at an environmentally relevant pH containing the metal ions for specified periods of time. The metal concentrations prior to contact with the resin and after contact are analyzed via ICP-OES and are used to calculate dry weight distribution values (Dw) to determine the effectiveness of removal by the two chelating resins. It is anticipated that these resins will be successful at removing heavy metal ions from the solutions, and differences in the ion removal will arise due to differences in the ligand loadings. This project holds the potential to become a contributing step to remediating metal concentrations in contaminated water sources.

Rotational spectrum prediction for guaiacol-water Van der Waals complexes using computational methods.

Primary Author: Andrew Nguyen, Chemistry

Co-Author/Collaborator: Noha

Advisor: Dr. Ranil Gurusinghe

The prediction of rotational spectra using computational methods is an active area of research. However, the prediction and analysis of the rotational spectra of guaiacol-water van der Waals complexes have not been explored thoroughly. By utilizing Molecular Operating Environment (MOE) and Gaussian to model and predict the energies of such complexes, the rotational spectrum can be elucidated. The specific van der Waals complexes that were explored were hydrogen bonding and polar hydrogen-pi interactions (Hp-p). Here, the water is positioned at multiple significant places such as, the hydroxyl group and methoxy oxygen to facilitate hydrogen bonding and above or below the orbital phase to facilitate Hp-p coordination. The complexes were then modeled using the ?B97XD/6-311++G(d,p) model structure with an anti-anti and anti-syn conformer of the monomer. The lowest energy interaction of each conformer is then used as a baseline to obtain the relative energies values of each interaction. Using the values, the rotational spectra can be predicted. Then, the predicted rotational spectra can be used to confirm rotational spectra obtained from an in-house built rotational spectrometer.

Synthesis of Thiosemicarbazone Ligands using an Isonitrosopropiophenone (INPP) Substrate

Primary Author: Nathan Cason, Pure Chemistry

Advisor: Edward C. Lisic

Thiosemicarbazones and oximes and their complexes each have been studied as compounds and ligands to bind transition metals. However, there are very few reports concerning ligands and complexes that contain both of the thiosemicarbazone and oxime groups. Therefore, our research has focused on creating such mixed ligands, containing both the thiosemicarbazone and oxime groups, by using isonitrosopropiophenone (INPP) as the substrate, which contains a monoxime group, and a place to attach the thiosemicarbazone functionality.
The oxime thiosemicarbazones synthesised were: INPP-MTSC, INPP-ETSC, INPP-tBTSC, and INPP-BzTSC. Each of these ligands were characterised by proton NMR spectroscopy. These ligands were also used to synthesise selected metal complexes.

Gender effects on item responses for general chemistry exams

Primary Author: Olivia Furr, Chemistry

Advisor: Chad Rezsnyak, Ph.D.

Gender has an impact on many aspects of our society, some more visible than others. In fields related to science, technology, engineering, and math (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 investigation plans to analyze the effects a studentâ€™s gender may have on not only overall test scores, but also on item selection and the manner in which these students interact with questions and answer choices. The intentions for the data acquired are to recognize disparities in the exams that affect students based on gender and use that knowledge to create exams, questions, and answer choices that are more fair to all students in order to set up all students for success regardless of gender.

Affordable Science: 3D Printing Electrodes

Primary Author: Evie Lawlor, Chemistry

Advisor: Dr. Moldenhauer

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 designed using CAD software. It is printed from conductive and non-conductive filament using a 3D printer. The electrode is then used in a series of electrochemical tests to test its conductivity and efficiency. The data can be compared to a typical electrodeâ€™s performance. It is anticipated the data will be comparable to a typical electrode. If successful, this method can be used to easily produce electrodes of different designs and in smaller sizes.

N-acyl hydrazone furfural derivatives as quorum sensing inhibitors to combat bacterial biofilms

Primary Author: Iroda Abdullaeva, Chemistry, Biology

Co-Author/Collaborator: Danielle Ferguson

Advisor: Kyle Murphy

It is estimated that antimicrobial resistant infections will culminate in 10 million deaths annually by 2050. The expanding antimicrobial resistance is notably consequential from strategies pertaining to microbial biofilm formation – an assemblage of surface-associated microbes governed by cell-to-cell signaling. Quorum sensing, the signaling network, imparts activation/inactivation of genes that direct biofilm differentiation at sufficient population densities. This project aims to create a library of possible quorum sensing inhibitors to target biofilm formation and combat the rising public health crisis. The incorporated methodology pertains to organic syntheses of hydrazone furfural derivatives performed under sustainable and green chemistry conditions through usage of short reaction times, no thermal conditions, 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 yield and purity is anticipated by the end of the project. If successful, samples will be evaluated for quorum sensing inhibitory capabilities. Future work includes expansion of the collection of derivatives and subsequent antimicrobial testing

Release Profiles of Liquid State Aliphatic Phenothiazine Drugs from Silica Materials of Various Pore Sizes

Primary Author: Brayden Copeland, Chemistry

Co-Author/Collaborator: Lillian G. Pipkin, Tennessee Technological University

Advisor: Dr. O Andreea Cojocaru

Solid-state drugs exist in crystalline structures and possess numerous disadvantages, including polymorphism, reduced bioavailability, and aqueous solubility. Application of the ionic liquid strategy by pairing a phenothiazine cation with multiple anions can resolve these issues and create a new dual-functional drug. Ionic liquid-state medications have increased chemical and thermal stability; despite the advantages of new liquid-state drugs, their high viscosity results in handling issues. Adsorption onto a solid support (supported ionic liquid phases strategy, SILP) will alleviate these issues allowing for a more targeted delivery. Past work has resulted in the successful conversion of four solid-state aliphatic phenothiazine drugs into the ionic-liquid state by pairing a phenothiazine cation with an NSAID or docusate anion. The work presented here discusses our progress using various silica mesh as a solid support system for targeted delivery into aqueous environments such as simulated gastric fluid.

Element Composition of Dust Samples Using X-Ray Fluorescence Spectroscopy

Primary Author: Sydney Decatur, Chemistry

Advisor: Dr. Andrew Callender

There is a lack of understanding of the relationship between dust samples from similar environments and between different locations. In this research, X-Ray Fluorescence Spectroscopy was used to compare the elemental composition of house dust, office dust, and dirt. The data was analyzed using the software Spectragryph, in which the data points were compared to the standard characteristic energies of elements to determine the sample's composition. Elements from calcium to zinc were found in the majority of samples; no heavy metals were detected. Replicate spectra of the same dust samples showed good agreement, while spectra of dust from different houses showed different element profiles. The mass percent for each element was estimated by creating standards of each element (approx. 0.5% and 2.5% w/w) to compare with the samples to understand how much of each element was present. By understanding the relationship between different types of dust, data like this can be applied to fields like forensics and environmental chemistry.

Synthesis of supramolecular-dye conjugate macrocycles via coupling reactions of chromophores

Primary Author: Andrew Nguyen, Chemistry

Co-Author/Collaborator: Dr. Kyle Murphy

Advisor: Dr. William Carroll

The formulation of new colorants that are both inherently colorfast and stable is an active area of research. By using N, N'-Dicyclohexylcarbodiimide (DCC) coupling between carbazole derivatives and carboxylic acid functionalized dyes, a substituted pre-monomer can be formed. This pre-monomer can then undergo a Suzuki 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 pre-monomer and linker. By covalently bonding the dye to the macrocycle, an extension of conjugation and resonance can be achieved increasing the overall stability of the dye. With the increase in stability, the possibility of photodegradation is reduced allowing for the addition to plastics for long-lasting coloration. With the substitution of the dye for a bifunctional reactive dye, the reactive dye can maintain its reactive nature towards fabrics, allowing for a two-fold application within textiles and polymer production. With the manipulation of the pre-monomer and linker, this work explores the creation of more stable, vibrant reactive colorants for application to plastics and textiles.

Synthesis of Butanedione-Monoxime Thiosemicarbazones and their Reactions with Metal Ions

Primary Author: Kyle Schulmeister, Chemistry

Co-Authors/Collaborators: Andrew Nguyen, Justin Pemerton, Nathan Cason

Advisor: Edward Lisic

Previously, a series of compounds called Butanedione-Monoxime Thiosemicarbazones (BDMO-TSCâ€™s) was synthesized in our lab. We have discovered a new procedure to produce them in higher yield and purity. We are reporting the synthesis of 4 of these BDMO-TSCâ€™s. These four are BDMO-MTSC, BDMO-ETSC, BDMO-tBTSC, and BDMO-BzTSC. We present characterization by NMR spectroscopy. Furthermore, we have investigated the reaction with Nickel to form monomers and dimers of these ligands.

Progress Towards Palladium-Free Cross-Coupling Reactions using 1,2,4-Triazinyl Pyridine Scaffolds

Primary Author: Christopher Hudak, Chemical Engineering

Co-Author/Collaborator: Jesse D. Carrick, Tennessee Tech University

Advisor: Dr. Jesse Carrick

Cross-coupling reactions are an important mechanism in the development of a variety of industrial and medicinal compounds. A palladium catalyst is typically used to achieve such reactions, which pose both environmental issues and health hazards. In this work, various palladium-free cross-coupling reaction conditions were studied. The conditions included the use of 2,6-bis(5,6-diphenyl-1,2,4-triazinyl-3y-yl) pyridine ligand previously developed by the Carrick Group (2015) and various metal catalysts such as copper, nickel, gold, and silver. Method development and preliminary optimization work will be presented.

Synthesis of Macromolecules to Reduce the Potential of Cell Death by Nanoplastics

Primary Author: Wesley Gibson, Chemistry

Co-Author/Collaborator: Drew Byrum

Advisor: Dr. Kyle Murphy

Plastic pollution has been a known problem facing Earthâ€™s ecosystems for quite some time. However, only recently has there been mention of issues posed by nanoplastics. Nanoplastics are beyond microscopically small bundles of hydrophobic polymers (e.g., polystyrene), that are so small that they may penetrate cell membranes. Once inside a cell, the nanoplastics are no longer in an aqueous environment and thus unravel themselves to individual polymer strands, which ultimately results in the death of the contaminated cells. New methods are needed to effectively remove nanoplastics from the various ecosystems they have affected. This research project intends to pursue the synthesis of shape-persistent macromolecules and to investigate their interactions with polystyrene-based nanoplastics. The ability to untangle these bundles of hydrophobic polymers into individual strands is investigated. Through Suzuki coupling/imine condensation, it is expected that fluorene and carbazole compounds which act as building blocks, along with dihalogenated-dianiline linkers to bring these units together, can form well-defined macromolecular rings or polymeric helicenes. Analytical methods used to characterize the products include proton NMR, Carbon-13 NMR, and Thin Layer Chromatography. If successful, unraveled nanoplastics could be removed from water systems and therefore pose less of a threat to affected ecosystems.

2D-NMR Characterization of liquid state thioridazine drugs

Primary Author: Claire Rust, Applied Chemistry

Advisor: Andreaa O. Cojocaru

CISE Recipient

Thioridazine hydrochloride is an orally administered phenothiazine drug used to treat symptoms of psychosis and schizophrenia. However, thioridazine is known to cause cardiac arrhythmia, and as a result, its manufacturer, Novartis, removed it from the market in 2005. This issue can be addressed by converting the solid-state thioridazine drug into a liquid state: the thioridazine cation can be successfully paired with lidocaine cation (a well-known anti-arrhythmic drug) and docusate anion (a penetration enhancer) to create new liquid state drugs that will keep the pharmaceutical activity of the constituent ions. Along with providing a resistance to cardiac arrhythmia, these new liquid state medications will also allow for the development of new delivery options (e.g., transdermal delivery) and will have improved bioavailability. Here we present the characterization of several thioridazine liquid state drugs by using two dimensional NMR spectroscopy.

Synthesis and Characterization by NMR Spectroscopy of the Fluoro-Isatin Thiosemicarbazone Ligands and their Palladium (II) Complexes

Primary Author: Bailey Talent, BioChemistry

Co-Author/Collaborator: Emma Zachary
Advisor: Dr. Edward Lisic

Isatin thiosemicarbazones have been known for a long time to have biological and medicinal properties, such as being used for anti-tuberculosis drugs. Recently, they have been used in the synthesis of metal complexes that have additional medicinal uses. We have expanded research into synthesizing new Fluoro-Isatin Thiosemicarbazone ligands and their Palladium (II) complexes. This work will show the synthesis and characterization by NMR spectroscopy.

Department of Earth Sciences

Undergraduate Students

Strike-slip faulting associated with the Cumberland Plateau overthrust, Spencer, Tennessee

Primary Author: Clarice Kiser, Geosciences
Co-Authors/Collaborators: Alex Hall, Kaiah Whited

Advisor: Dr. Michael Harrison

The Cumberland Plateau overthrust is a network of faults that extend southwest from the Emory River fault zone to the vicinity of Spencer, Tennessee. The faults are associated with a regional thrust sheet that formed during the Alleghanian orogeny and the building of the Appalachian Mountains. Around Spencer, the faults are exposed in the Pennsylvanian Sewanee Conglomerate that locally forms the caprock for the Cumberland Plateau. The Sewanee Conglomerate is a yellowish-gray to yellowish-brown 40-meter thick cross-bedded conglomeratic quartz arenite. Interestingly, we have documented hundreds of centimeter- to meter-scale strike-slip faults within a span of 5 km in this unit. These strike-slip faults show two general trends, northeast and southeast, and show both right- and left-lateral shear sense. This study aims to understand how these strike-slip faults relate to the regional tectonics of the Cumberland Plateau overthrust.

Petrographic Study of Carbonate Nodules from the Late Mississippian Pennington Formation

Primary Author: Darrison Wharton, Geosciences

Advisor: Dr. Lauren Michel

The Mississippian occurred from about 358.9 to 298.9 Ma ago and is the last period of Earthâ€™s history where there is strong evidence of icehouse conditions. As a result, this time period serves as an analogue to climate change today, with scientists reconstructing paleoclimate conditions using different proxies. One proxy used to reconstruct pCO2 is micritic carbonate nodules found in fossil soils (paleosols) because they are a mixture of atmospheric and soil-derived CO2. However, in order for paleosols to be used in reconstructing CO2, the carbonate must be from initial (pedogenic) and not later (diagenetic) processes. Paleosol samples from the Carboniferous Pennington Formation were petrographically studied using plane polarized light (PPL) and cathodoluminescence (CL) microscopes. Under PPL, different types of calcite and dolomite were observed including micritic and sparry calcite and microspar dolomite. While most thin sections were dominated by micritic calcite, it was sometimes crosscut by sparry calcite and/or dolomite. Under the CL scope, different luminescence patterns where observed that correspond to different carbonates. My observations suggest that while there is still some pedogenic material left, there has been diagenetic alterations of the micritic calcite by later fluids, and future sampling needs to be undertaken with care.

Identifying Sources of Water Contributing to Discharge of Boils Spring, Gainesboro TN

Primary Author: Gabi Burke, Geology

Advisor: Dr. Joseph Asante

In middle Tennessee, the main water supply comes from rivers and lakes. In karst environments, the quality of these surface and subsurface waters is intricately linked. The karst spring in Jackson County, Tennessee, known as the Boils, is an important hydrogeological feature of recreational use. Using dye tracing, previous researchers have identified the contribution of overland flow to the discharge of the Boils via sinkholes in the watershed. However, the roles of the soil, seasonality, and groundwater in spring discharge remain inconclusive, in addition to the potential occurrence of mixing of water from different sources. This is relevant to understanding sources of potential contamination and protecting water resources. For this study, water samples were collected in 2015 and 2020 from the Boils Spring, Waterloo Falls, and the Roaring River sink. The field parameters pH, temperature, electrical conductivity, alkalinity, and dissolved oxygen were measured at each site. Water samples were collected into plastic bottles and sent to the TTU Water Center Lab, where they were analyzed for the concentrations of major cations and anions. Also, strontium isotope concentrations, d18 O, and dD in precipitation, snow, spring, and surface flows were measured. In this study, water chemistry data are used to test the hypothesis that multiple geochemical groups will be detected within the samples, suggesting multiple sources of water flowing to the Boils.

Svalbard Terraced Fan-Delta as a Terrestrial Analog for Tyras Vallis Fan-Delta, Xanthe Terra Mars

Primary Author: Sydney Beltran, Geosciences

Co-Author/Collaborator: Jeannette Luna, Tennessee Tech

Advisor: Dr. Jeannette Luna

URECA Recipient, CISE Recipient

Geologic structures studied on Earth are useful when making observations or interpretations on features we see on other planets. These structures are referred to as Earth, or terrestrial, analogs. For this comparison, a geologic map of a terraced fan-delta was created on Earth and Mars. The first fan is in Svalbard, Norway (15.64E 77.74N); the second is found at the end of Tyras Vallis in Xanthe Terra, Mars (49.71W 8.43N). Fan-shaped features usually form during the transportation of unconsolidated sediment from the confined flow of a channel or valley to the unconfined flow of a shore or crater basin. Both maps were created at a mapping scale of 1:4K with a publishing scale of 1:18K on ArcGIS Pro. For the Tyras Vallis map, we used Mars Reconnaissance Orbiterâ€™s High Resolution Imaging Science Experiment (HiRISE) imagery. For the Svalbard map, we used Landsat and Satellite Pour/Observation de la Terre (SPOT) satellite imagery. Twelve units were identified on the Martian structure and 14 preliminary units on the Svalbard fan. Each unit was mapped using contrasts in value, texture, elevation, and superposition of the surface. Preliminary results on the comparison between these sedimentary features like similarities in their structures like 200+ meter, bifurcating channel units and distinct, scarped lobes of the fans. Due to these similar conditions, these fan-deltas could be used as future evidence for theories on Mars' climate transition from warm and wet to cold and dry.

Photogeologic Mapping of the Lunar South Pole: Shackleton and De Gerlache Crater Ridge

Primary Author: Olivia Bell, Geoscience: Geology

Co-Author/Collaborators: Jeanette Luna, Sydney Beltran

Advisor: Dr. Jeanette Luna

With Artemis-era lunar exploration underway, accurate and orthorectified maps of the Moonâ€™s South Pole are a necessity. NASA has identified 13 potential landing sites for the Artemis III mission, the first crewed mission since Apollo 17. Here, we have elected to map the Connecting Ridge(-89.46761, 226.41239) and the Connecting Ridge Extension(-89.00411, 258.11174), two sites located on the crater rim between the Shackleton and De Gerlache craters, on the Lunar South Pole. The maps will be publishable at a 1:10K scale and were digitally mapped at a 1:5K scale, in response to the call for this map size in the Artemis Report from 2020. Five preliminary units were identified, determined by impact concentrations, and textural and tonal differences. These units are consistent between the two sites, and to units within the broader regions.

As a base map, we used the 1m/px image and image mosaics from the Lunar Reconnaissance Orbiter (LRO) Narrow Angle Camera (NAC) and the 5m/px data from the Lunar Orbiter Laser Altimeter (LOLA) digital elevation model. All raster and vector data was managed in ArcGIS Pro, and map products will be archived for scientific community use. In the coming months, we will continue to create nested maps of the regional area, incorporating these larger scale maps into a broader context of the rim and ejecta surrounding the De Gerlache Crater to facilitate safe travel to and sustained exploration of, the Lunar South Pole.

PHOTOGEOLOGIC MAPPING OF ARTEMIS III LANDING SITES ON THE LUNAR SOUTH POLE: DE GERLACHE CRATER RIM.

Primary Author: Isaac Hollingsworth, Geosiences

Co-Authors/Collaborators: Anthony Lamantia; Jeanette Luna, Tennessee Technological University

Advisor: Dr. Jeannette Luna

In lieu of NASAâ€™s efforts towards the Artemis III lunar landing mission, we recognize a unique need for surface exploration maps. Nested photogeologic mapping of Artemis III candidate landing sites is important for lunar research and plays a crucial role in furthering the understanding of the Moon. We present a photogeologic map for two de Gerlache Rim landing sites proposed for Artemis III lunar south pole exploration. The lunar south pole features a variety of geologic specimens across the Selenological timescale. Craters that receive little to no sunlight in their interior. These permanently shadowed regions (PSRâ€™s) could contain records of water ice and other volatiles of interest. We map at a scale of 1:10K, and digitize at 1:5K. As a base map, we use 1 m/px Lunar Reconnaissance Orbiter (LRO) Narrow Angle Camera (NAC) images and mosaics. We also integrate data from the 5 m/px Lunar Orbiter Laser Altimeter (LOLA) digital elevation model. We use Esri's ArcGIS Pro to manage raster and vector data and create map products. Photogeologic mapping efforts are

meant to be unbiased in the description of geologic units. Through extended analysis and characterization, we identified six unique map units and characterized them using tone, texture, and slope. Future efforts will focus on further refining digitized data and correlating units across the de Gerlache crater rim area. Additional mapping of remaining candidate Artemis III landing sites will be conducted in summer 2023.

Department of English

Graduate Student

"We're Just Doing Drag": How Social Media Affects User Perceptions of Drag Queens

Primary Author: Nicki Parish, English Professional Technical Communication

Advisor: Dr. Kris Pickering

Drag culture and the art of Drag have recently gained more visibility in popular culture. RuPaulâ€™s Drag Race is one of the most popular shows in queer entertainment with contestants who have a huge social media presence. The research in this paper will tie directly to the investigation of how social media and its communities influence usersâ€™ perceptions of drag and drag queens as well as how the heteronormative notions idealized in our society force queer communities to be silent. In the field of technical communication, there appears to be a gap in research related to studying drag queens, social media, and the ways they interact that I hope to fill. My study was written for PC 6030 and examines the relationship between perception and social media and how LGBTQIA+ voices get suppressed using Instagram, TikTok, and YouTube as the core platforms. The conclusion I reached is that social media seems to affect usersâ€™ perceptions of drag queens based on the opinions and media they see and consume the most. Meaning, generally, if someone is following creators who have negative stances about drag, they'll agree with their opinions. The opposite is also true; if a creator offers positive perceptions of drag queens, their followers and commenters are more likely to also promote positivity. The larger implications of this are that social media can play a role in silencing and harming LGBTQIA+ voices, but it can also refute false accusations and create a safe online community for them.

Undergraduate Students

Misogyny: the Tragedy in Romeo and Juliet

Primary Author: Ashley Hale, English

Advisor: Kristen Deiter

This essay is a feminist reading of Romeo and Juliet by William Shakespeare, in which I examine the negative attitude exhibited towards women throughout the play. Both male and female characters of Romeo and Juliet progress the oppression of women that stems from the phallocentric society they live in. By applying a feminist approach to literary criticism, I find that Shakespeare's use of dialogue, figures of power, and symbols reveal the misogynistic nature of the play. I argue that although Shakespeare presents Romeo and Juliet as star-crossed lovers whose relationship is bound to end in tragedy by some supernatural force, patriarchal influences ultimately control their fate by minimizing womenâ€™s value and place in a relationship.

While conducting research for this paper, I found that the gender roles in Romeo and Juliet provide examples of how gender is a learned behavior rather than an inherent one. I pay close attention to how the Nurse and Lady Capulet teach Juliet how to perform gender. I also discovered that Simone De Beauvoirâ€™s coined term â€œthe Otherâ€ aligns closely with Juliet, as she is a character whose existence is defined by the dominant male. Because of this, I ultimately deduce that Shakespeare uses Romeo and Julietâ€™s love story to teach the lesson that women are bound to be defined by men.

Romeoâ€™s Love: Romantic or Delusion? A Psychoanalytic Approach to Romeo and Juliet

Primary Author: Hailey Reagan, English B.A.

Advisor: Kristen Deiter

This essay interprets William Shakespeareâ€™s Romeo and Juliet in a new manner. I apply Freudâ€™s psychoanalytic approach to analyze Romeoâ€™s psyche. I examine Romeoâ€™s relationship with Rosaline, as well as scenes in the play that allude to Romeoâ€™s unstable psyche, to explain his detrimental relationship with Juliet.

Relationships, truelove, the id, repression, subconscious actions, the pseudorealistic, and internal and external actions all contribute to my essay. This essay predominately focuses on these concepts to determine Romeoâ€™s opinions on love. Romeoâ€™s relationship with Juliet is a delusion to help him cope with the loss of his real love--Rosaline. I wrote this paper for my Introduction to English Methods and Research class.

Department of History

Undergraduate Student

Medicine in the Confederacy: Vaccination and Racism during the American Civil War

Primary Author: Cheyenne Douthitt, History, Interdisciplinary Studies

Advisor: Edward Driggers

CISE Recipient

As the United States was in the midst of a Civil War, a silent killer was taking lives on both sides. The smallpox epidemic spread rapidly through America during the latter 1800s, affecting both Union and Confederate soldiers alike. The goal of my research was to discover the similarities between the Civil War era and modern-day American vaccination rates along with the publicâ€™s reaction. I also researched the Confederacyâ€™s effort to vaccinate their soldiers and studied the effects of scientific racism on vaccination evolution. I used sources such as The National Library of Medicine, The National Museum of Civil War Medicine, and The Library of Congress. The data shows that the southern citizens were in favor of vaccination, going against the southern mindset during the Covid-19 pandemic. During the Civil War, families would send envelopes filled with their smallpox scabs to the front lines, so that the soldiers may administer the scabs amongst themselves. In some recorded cases, this caused other diseases to spread, due to families wrongfully labeling an illness as smallpox. My findings showed that the majority of the Confederacy was pro-vaccination, and African Americans were the largest group used to test new vaccines due to their poverty rates and lack of rights.

Department of Mathematics

Graduate Student

An extension of informatic polymatroids

Primary Author: Angus Bryant, Mathematics

Advisor: Michael Allen

Matroid theory, a field of combinatoric structures, has been used to understand the independence structure of collections of random variables.Specifically, a correspondence between the entropy of random vectors and matroids has been found, giving rise to â€˜entropicâ€™ and â€˜informaticâ€™ matroids. Such matroids have applications in coding, cryptography, and communication sciences. However, informatic matroids have so far been studied under the assumption of uniform i.i.d random variables as the inputs in a multiple access channel (MAC). This paper introduces a new class of informatic matroids, called non-uniformly informatic polymatroids, which extends the existing theory beyond this assumption. In addition, we characterize such polymatroids, their set function, and their associated polyhedra in m-dimensional spaces.

Department of Organic Chemistry

Undergraduate Student

1H-15N HMBC characterization of promazine DSILs

Primary Author: Diana Popa, Biochemistry

Co-Authors/Collaborators: Eva E. Etheridge; O. Andreea Cojocaru

Advisor: Oana Cojocaru

Promazine drugs are pharmaceuticals known for the management of psychotic disorders such as schizophrenia. One of the major drawbacks of these drugs is their conversion into various amorphous and crystalline structures (aka polymorphism) with different or no biological activity which impacts their efficacy. To address this issue, we previously showed that promazine, chlorpromazine, and triflupromazine drugs can be converted into a liquid state by combining these cations with multiple anions in various molar ratios. The resulting compounds are known as double salt ionic liquids (DSILs) and are multiplex liquid state compounds that retain the pharmacological properties of the constituent ions in addition to improving the aqueous solubility and bioavailability of these compounds. The work presented here focuses on using 1H-15N HMBC Spectroscopy to characterize new promazine DSILs obtained by combining promazine cations with ibuprofenate and docusate anions in three different molar ratios (1:0.1:0.9; 1:0.5:0.5; and 1:0.9:0.1).

Department of Physical Chemistry

Undergraduate Student

Electroanalytical and Negative Ion Photoelectron Spectroscopic Studies of 1,4-Naphthoquinone Radical Anion its Deprotonated Derivatives

Primary Author: Nolan White, Chemical Engineering

Co-Author/Collaborator: Jonathan Moldenhauer, Tennessee Tech Chem. Dept.

Advisor: Wilson Gichuhi

CISE Recipient
In this work, a multi-method approach involving electroanalytical technique based on solution cyclic voltammetry (CV), high-level quantum-chemical calculations, and the gas-phase negative ion photoelectron spectroscopy (NIPES) technique based on the calculation of Franck-Condon (FC) factors is implemented to study 1,4-napthoquinone (NQ) radical anion and NQ deprotonated derivatives. The CV experiments are utilized to deduce the nature of the electron-transfer processes involved in the condesed-phase. 1,4 NQ, an aromatic compounds with two oxygen atoms bonded to the benzyl ring as carbonyl groups, can successively undergo the first and second electron reduction steps to produce a quinone anion (Qâ€“) and quinone dianion (Q2â€“), respectively. The solution-phase reduction potentials have a direct correlation with the gas-phase adiabatic electron affinities (EAs) of the neutral radicals and the NIPES spectra. The adiabatic EA corresponding to the formation of neutral 1,4-NQ in its singlet electronic ground state (So) is calculated to be 2.035 eV. The lowest triplet state (T1) in 1,4-NQ is located 2.161 eV above the So state (?EST = 2.161 eV). The dehydro-1,4-NQ radical has an adiabatic EA of 2.11 eV and a ?EST of 2.393 eV. The NIPES corresponding to electron detachment in both the So and T1 states are characterized by dominant origin peaks, an indication of the subtle geometry changes involved as the electron detaches from the ground anion state to the corresponding neutral states.

Department of Physics

Undergraduate Student

In the study of rare event physics, such as neutrinoless double beta decay, it is important to understand the potential background events. Neutron-induced events can take place even deep underground. Experiments that study the neutrinoless double beta dec.

Primary Author: Luke Parsons, Physics

Co-Authors/Collaborators: Werner Tornow, Duke University/TUNL; Sean Finch, Duke University/TUNL

Advisor: Dr. Mary Kidd

Data Analysis of Neutron Capture on 134Xe

Department of Sociology & Political Science

Undergraduate Students

The Meeker Avenue Plume Superfund Site

Primary Author: Helen Williams, Sociology

Advisor: Dr. Lachelle Norris

In March 2022, the Environmental Protection Agency (EPA) announced they had placed an area of around 50 blocks in Greenpoint, Brooklyn; onto the National Priorities List (NPL). This area, named the "Meeker Avenue Plume," is a "groundwater contaminant plume." The EPA defines a groundwater plume as: An underground area where contaminants disperse," and in this case, vaporize. In their gaseous state, these contaminants are able to seep into buildings through cracks in basements, sewer lines, and other openings, where they contaminate the air supply. The Contaminants of Concern (COCs) in this case include three different Chlorinated Volatile Organic Compounds (CVOCs), as well as Vinyl Chloride. Long-terms exposure to these COCs have been shown to cause a host of serious health & problems. These health problems include, but are not limited to: developmental effects in children, reproductive effects in mothers, and cancer. Despite recent attention, knowledge of this issue is not new. The Greenpoint neighborhood, with its reputation as an enclave for working-class immigrants, has a long and sordid history concerning pollution and environmental disasters. Though the EPA has recently given precedence to the cleanup of the Meeker Avenue Plume, the fundamental sociological issues which have plagued this neighborhood for decades remain unaddressed. The question is, then, whether yet another cleanup will suffice in the ensuring the long-term health of Greenpoint and its inhabitants.

Mental Health in Teens: Women Portrayed in Media and Film

Primary Author: Elizabeth Andrews, Sociology

Advisor: Dr. Ada Haynes

Women in society are impacted by the way social media and films portray the â€œidealâ€ woman. The male gaze attempts to control and force women into roles desired by men that fuel the patriarchal society of America. With the rise of social media, young women who are easily susceptible to its bias are impacted and experience cyberbullying, hightened suicidal thoughts, and an increase in mentall illness (Berryman, et al. 2018). As I have researched this topic, an increase of representation of plus-sized women and people of color in pop culture would aid young women in their battle against mental illness. In addition, placing parental limits on screen time would also be a beneficial factor (Hatkevich, 2022). In hopes of decreasing mental illness in young women, the potential strategies discussed
to solve these issues can help children and parents use social media films as a platform for promotion of equality, mental stability, and expression.

Exploring Power-based Violence Experiences of women experiencing Homelessness: Impacts on Pathways to Prison and Policy Implications

Primary Author: Marlee Miller, History and Interdisciplinary Studies

Advisor: Nicole Cook

CISE Recipient

Prior to the Battered Womenâ€™s Movement of the 1960â€™s and 1970â€™s, women had few options for seeking shelter, assistance, and safety as they navigated an exit from an abusive partner. With approximately one in three women reporting being subjected to either physical or sexual violence by their intimate partner at some point in their lives, there is a clear need for the continuation of this and similar movements in hopes of impacting policy aimed at protecting survivors. As funding for domestic violence shelters dwindles (Olsen, Rollins and Billhardt 2013), many women are faced with the impossible decision between remaining in a dangerous home or living unsheltered. Using data collected by the National Network to End Domestic Violence (NNEDV) and the Rape, Abuse and Incest National Network (RAINN), this paper seeks to explore the complex and dynamic relationship between experiences of power-based violence, homelessness, and contact with the criminal justice system.

College of Business

Department of Accounting

Undergraduate Students

Corporate Social Responsibly Reporting, and Disney Company

Primary Author: Rebeka Alem, Accounting

Co-Authors/Collaborators: Emme Colwell, Ashley Griffith, Dawson Ledbetter, Joshua Richardson

Advisor: Wilbanks Robert

The concept of environmental, social, and governance (ESG) reporting emerged in the early 2000s. Since then, leaders in business and accounting have pushed public companies to include disclosures on a broader range of issues not traditionally included in annual financial statement reports. Stakeholders and investors are increasingly scrutinizing companyâ€™s societal impact and placing greater importance on developing globally consistent standards. In our study, we highlight current disclosures in Walt Disney Companyâ€™s most recent corporate social responsibility report to provide insights about this fast-evolving area of public company reporting. Our study should interest stakeholders and students wanting to learn more about ESG reporting.

Corporate Social Responsibility Reporting and Target

Primary Author: Clay Melton, Accounting

Co-Authors/Collaborators: Olivia Baldwin, Brooke Davenport, Bryson Hack, Jacob Self

Advisors: Dr. Robert Wilbanks

The concept of environmental, social, and governance (ESG) reporting emerged in the early 2000s.
Since then, leaders in business and accounting have pushed public companies to include disclosures on a broader range of issues not traditionally included in annual financial statement reports. Stakeholders and investors are increasingly scrutinizing companyâ€™s societal impact and placing greater importance on developing globally consistent standards. In our study, we highlight current disclosures in Targetâ€™s most recent corporate social responsibility report to provide insights about this fast-evolving area of public company reporting. Our study should interest stakeholders and students wanting to learn more about ESG reporting.

Corporate Social Responsibility Reporting and Amazon
Primary Author: Bailey Hooper, Accounting

Co-Authors/Collaborators: Benjamin Nixon, Casey Smith, Kendra Brown, Nicholas Fouche

Advisor: Dr. Robert Wilbanks

The concept of environmental, social, and governance (ESG) reporting emerged in the early 2000s.
Since then, leaders in business and accounting have pushed public companies to include disclosures on a broader range of issues not traditionally included in annual financial statement reports. Stakeholders and investors are increasingly scrutinizing companyâ€™s societal impact and placing greater importance on developing globally consistent standards.
In our study, we highlight current disclosures in Amazonâ€™s most recent corporate social responsibility report to provide insights about this fast-evolving area of public company reporting.
Our study should interest stakeholders and students wanting to learn more about ESG reporting.

College of Education

Department of Counseling & Psychology

Graduate Students

The Relationship between Vocational Decision-Making and Parental Attachment

Primary Author: Lara Strate, Counselor Education and Supervision

Co-Author/Collaborator: Tony Michael

Advisor: Dr. Tony Michael

Background Vocational decision-making has been linked to several psychological constructs, including career decision-making, identity development, and burnout. Additionally, attachment during childhood is a factor that has been associated with career development and vocational decision-making. Previous researchers have placed emphasis on developing future research to identify variables that influence the relationship between vocational decision-making and other factors, such as parental attachment.

Objective: This study explored the relationship of parental attachment on vocational decision-making of college students, proposing that vocational decision-making positively influences by parental attachment. Method For this study a regression focusing on vocational decision-making as outcome variable, and parental attachment as predictor was conducted.

Results: The regression indicated a significant relationship between vocational decision-making and parental attachment.

Conclusions: Implications from this study will be presented.

Early Childhood Attachment, Impulsivity, and Substance Use: The Role of Adverse and Benevolent Childhood Experiences

Primary Author: Stephanie Karlosky, Counseling & Supervision

Advisor: Dr. Tony Michael

Research on adverse childhood experiences (ACEs) provides insight into factors that influence early childhood development and behaviors across the lifespan. Previous research suggests ACEs influence attachment, impulsivity, and substance use; however, further research is warranted regarding BCEsâ€™ ability to moderate the relationships between ACEs and maladaptive outcomes. In lieu of this, the purpose of this study was to understand the relationships between early childhood attachment, ACEs, BCEs, impulsivity, and substance use trends in adulthood. The present study utilized multiple regression analyses to explore these relationships and trends. In a sample of 362 individuals, the data suggests all variables significantly influence substance use trends. Results suggest prevention may benefit from greater focus on prioritizing benevolent childhood experiences. Furthermore, substance use treatment and protocols could be specified and strengthened by considering the impact of early childhood experiences, attachment, and impulsivity.

Reimagining the High School Experience

Primary Author: Amanda DeBord, School Counseling

Advisor: Dr. Katherine Hermann-Turner

High school students in the Upper Cumberland lack preparation for job market growth. Research on local market needs and school performance data indicates growth in areas where students are unequipped. Data from various government agencies found the need to re-imagine the high school experience. Schools can address skill gaps through community partnerships to increase student readiness for careers. Grants are one avenue school systems could use to implement exploratory career courses and programs of study. Early career education courses could expand career awareness, exploration, planning and advising for seamless transitions into high school. Strategic partnerships with business and industry could increase exposure to job-related skills needed for the labor market. Programming funded by state grants could provide invaluable experiences that prepare students for success. For example, research in Van Buren County High School shows expanding to include an Audio/Visual Production Program would benefit students. Arts, Audio/Video Technology & Communications in the Upper Cumberland has a projected growth rate of 11%, additional grant funded projects could provide schools with opportunities for increased exposure to skills for a growing labor market. This presentation will provide data on labor market needs and present a model to address student skill gaps in hopes of providing schools with resources to boost student readiness for the workforce and post-secondary opportunities.

15 Week Group Counseling for Adolescents Experiencing Trauma Due to Parental Substance Use/ Abuse

Primary Author: Jacie Boyd, Clinical Mental Health Counseling

Advisor: Dr. Katherine Herman-Turner

Children of substance abusing parents are at an increased risk for physical and sexual abuse (Ashenberg & Fewell, 2011), neglect, mental and behavioral problems, and poor health outcomes (Dandona, 2016; Gance-Cleveland et al., 2007). Trauma-Focused Cognitive Behavioral Therapy (Cohen et al., 2012; Hoag & Burlingame, 1997), mindfulness (Ortiz & Sibinga, 2017), creative art therapy (Johan et al., 2022), and group counseling (Dore et al., 1999; Gance-Cleveland & Mays, 2008) have been proven to be effective in the treatment of adolescents experiencing trauma. Given the evidence to support that children of substance abusing parents have limited resources, poorer physical and mental health outcomes, and often feel isolated in their struggle, group counseling could be a beneficial intervention strategy to mitigate the negative impact of being the child of a substance abusing parent. This presentation will review literature on the prevalence, mental and physical health, barriers to treatment, and effective treatment modalities for children living in homes with parental substance abuse. A 15-week integrated group counseling plan will be outlined for use with adolescents who have experienced trauma due to their parents substance use. The goal of the group will be to decrease feelings of loneliness, isolation, trauma symptoms, depression, and anxiety, while increasing coping mechanisms,
close relationships, social skills, protective factors, and resiliency among the adolescents.

Nature's Therapeutic Impact on College Students with ADHD

Primary Author: Jessica Mitchell, Clinical Mental Health Counseling/MA

Advisor: Dr. Katherine Hermann-Turner

ADHD (Attention-Deficit/Hyperactivity Disorder) diagnoses have become prevalent in younger populations, including young adults (Cutler & Mattingly, 2017). Adults are less likely to be diagnosed with ADHD than children in the United States, despite higher diagnostic rates (Stephens & Byrd, 2017).
The diagnosis for the disorder is divided into three subtypes inattentive, hyperactive, or impulsive, and combined. For college-aged students, the most common subtype is inattentiveness (Depue et al., 2010), which helps to better understand their ability to focus.

Currently, the main treatment for ADHD is pharmacotherapy, using stimulants. (Cutler & Mattingly, 2017). Commonly used medications affect college-aged students differently than children, because of the frequent misuse of medications, needing it longer throughout the day, and medications noncompliance. (Green & Rabiner, 2012). ADHD is a complex diagnosis to treat with medications, researchers are looking for other effective treatments such as spending time outdoors. According to Rakow and Eells, (2019), college students experience two main benefits from being in green spaces: increased concentration and reduced stress. Being outdoors and in nature can also improve blood pressure levels, aid in creativity, ADHD symptoms, and lower stress. (Harmon, 2008). This presentation will discuss literature on the effects of ADHD on college-aged students and nature-based therapeutic techniques as a means for supporting this population. The researcher will bring awareness to the needs of college students suffering from ADHD and present methods to help cope with the effects of the diagnosis.

Department of Curriculum & Instruction

Graduate Students

Educational Self-Actualization: Comparison of Moderation Analysis Prediction Models for Students with Different Levels of Academic Risk Factors
Primary Author: Kinsey Simone, Program Planning & Evaluation

Co-Author/Collaborator: George Chitiyo, Tennessee Tech University

Advisor: Dr. George Chitiyo

There exists a gap in studentsâ€™ fulfillment of educational expectations across characteristics such as race (Jang, 2018; Mello, 2008), gender (Ayub, 2010; Jang, 2018), and socioeconomic status (SES) (Andres et al., 2008; Boxer et al., 2011), as well as across constructs such as extrinsic or instrumental motivation (Ayub, 2010; Cigan, 2014), academic self-efficacy (Oyewo & Akanbi, 2021; Roy et al., 2018), and parentsâ€™ expectations (Agger et al., 2018; Malik, 2021; Tatlah et al., 2019). This study used data from the Education Longitudinal Study of 2002 to examine how a predictive model of educational self-actualization differed for a sample of students who reported zero academic risk factors from a sample who reported one to six risk factors. A binary logistic regression was conducted for each sample with race, gender, self-efficacy, motivation, and parentsâ€™ expectations, as well as the following interactions: (i) parental expectations and motivation; (ii) parental expectations and self-efficacy; (iii) self-efficacy and motivation; and (iv) parental expectations, motivation, and self-efficacy. Findings indicated that parental expectations are more important in expectation fulfillment for students with no risk factors, while self-efficacy and motivation play a stronger role for students with risk factors. Study significance partly lies in the uniqueness of the regressand of self-actualization versus the societally desirable levels of educational attainment.

Got STEM Education? A Content Analysis of Four STEM Education Journals

Primary Author: Carey Wilson, Exceptional Learning

Co-Author/Collaborator: Dr. Holly Anthony, Tennessee Technological University

Advisor: Dr. Holly Anthony

Dugger (2010) stated, â€œin the past few years, the integration of... [STEM] has gained momentum in education in the United Statesâ€ (p. 1). However, progress in STEM education reform is slowed by the many definitions in STEM education research, practice, and policy. Although the movement to STEM education seems slow, it is vital to the future competitiveness of the U.S. STEM workforce. The following research questions were developed to guide this content analysis of articles published from 2018 to 2023 in four international STEM journals: (RQ1.) How many research articles defined STEM as integrated versus siloed? (RQ2.) How many research articles were focused (at least, in part) on studying STEM learners and learning practices? (RQ2a.) What research methods were used to study student learning? (RQ2b.) How many research articles were focused on student characteristics? (RQ2c.) How many research articles on STEM learners/learning examined studentsâ€™ self-efficacy? Like Bengtsson (2016), I used an enumerative approach to explore trends in STEM education research and will share these results.

References

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. NursingPlus Open, 2, 8 â€“14. https://doi.org/10.1016/j.npls.2016.01.001

Dugger, W. E. (2010, December). Evolution of STEM in the United States [Paper presentation]. The 6th Biennial International Conference on Technology Education Research, Gold Coast, Queensland, Australia.

Involvement with Diverse Others as Predictors of Reflective and Integrative Learning

Primary Author: Hannah Willis, Exceptional Learning

Advisor: George Chitiyo

The purpose of this descriptive, correlational study was to examine the extent to which interaction/discussion with diverse others predicted reflective and integrative learning factors among college students, controlling for key demographic variables. Diverse others included people with different religious beliefs, economic backgrounds, political views, and/or ethnicities, among others. An understanding of the relationships among these variables could potentially have implications for curriculum development and instruction. Data were obtained from the 2021 National Survey of Student Engagement among Tennessee Tech students, and the sample consisted of 1,085 freshmen and seniors. Data were analyzed using hierarchical multiple regression. The results suggested that higher engagement with diverse others was associated with higher levels of reflective and integrative learning. The model explained a statistically significant and moderate proportion of variance in reflective and integrative learning outcomes [R2 = 0.24, F(12, 803) = 21.25, p < .001, adj. R2 = 0.23).

Is STEM education special?

Primary Author: Lisa Salvato, Exceptional Learning (ELPhD)

Advisor: Holly Anthony, Ph.D.

The U.S. Department of Education's Individuals with Disabilities Education Act (IDEA) website (2022) states IDEA "is a law that makes available a free appropriate public education to eligible children with disabilities throughout the nation and ensures special education and related services to those children" (About IDEA, para. 1). A goal in the U.S. is to give disabled students an optimal education (Cook & Schirmer, 2003). National Science Foundation (2019) reported those with disabilities are underrepresented in STEM and have a higher rate of unemployment (Hamrick, 2021). Best practices in STEM education are required to optimize learning experiences and examine barricades to disabled students' participation (Klimaitis & Mullen, 2021). STEM identity contributes to one's beliefs about how they contribute to STEM (Bell et al., 2018). Analysis of five STEM education research journals determined the scope of the research project. Six research questions were asked.

1. How many articles were devoted to STEM education in special education?
2. How many articles focused on understanding the role of identity?
3. How many articles focused on understanding equity?
4. What percentage of articles applied theoretical ways to improving science instruction in special education?
5. Where was STEM education research being conducted geographically?
6. Who were the participants?
   Results indicated a gap of special education in STEM education research.

Keywords: STEM, special education, identity

Is Argument Driven Inquiry Associated with Improved Student Achievement in High School Science?
Primary Author: Autezia Sellers, Ph.D. in Exceptional Learning

Co-Author/Collaborator: Rebecca Yates

Advisor: Dr. George Chitiyo

The purpose of this study was to examine the relationship between instructional strategy (Argument-Driven Inquiry versus traditional instruction) and high school chemistry achievement scores. The study design was quasi experimental, specifically the nonequivalent control group design, and the sample consisted of 28 honors students in a chemistry course. A two-way analysis of covariance was used to analyze differences on a posttest assessment, with instructional strategy and sex (male and female) as independent variables, and a premeasure of aptitude scores as the covariate. Results indicated no significant differences in achievement between the ADI and control groups, controlling for the other variables in the model. Also, the interaction between instructional method and gender was not significant. However, teacher observations tended to show students were enthusiastic about ADI.

Perceptions of Mathematics and Science Utility as Predictors of Studentsâ€™ Future STEM Occupations

Primary Author: Gideon Eduah, Program Planning and Evaluation

Advisor: Dr. George Chitiyo

Over the last decade, there has been rapid growth in science, technology, engineering, and mathematics (STEM) occupations (Fayer, et al., 2017; Langdon, et al., 2011). Federal and state governments have dedicated budgets to help expand STEM education and its opportunities (Hwang & Taylor, 2016). Research has shown that the lack of interest in taking advanced courses in mathematics and science by students in high school strongly influences the studentsâ€™ choice of STEM courses in post-secondary education (Harackiewicz, et al., 2012; Darolia, et al., 2020). Also, research suggests that studentsâ€™ perceptions of the usefulness of STEM related courses can influence their decision to pursue careers in STEM fields (Harackiewicz, et al., 2012). The purpose of this study is to examine the relationship between high school studentsâ€™ perceptions of the mathematics and science utility with their future career or occupational choices.

This quantitative study used logistic regression to analyze data from the High School Longitudinal Study of 2009 obtained from the National Center for Education Statistics. Findings could have potential implications for educators in ensuring that curriculum and instruction for STEM related subjects emphasize connections to the real world to increase studentsâ€™ perceptions of utility of math and science subjects.

Preservice Teacher Perceptions of Preparedness to Teach Diverse Students

Primary Author: Brandi Kriebel, Exceptional Learning - Ph.D.

Advisor: Dr. George Chitiyo

The purpose of this study was to assess the perceptions of preservice teachers in terms of their preparedness to teach students of diverse backgrounds. Given the changing demographics of students in schools across the nation (National Center for Education Statistics, 2020), it is necessary for educators to be well prepared to teach students with different cultures in terms of culture, language, origin, ethnicity, nationality, special needs, religion, socioeconomic status, and so forth. This study aimed to assess the level of preparedness of teacher candidates who are ready to be placed in school settings to teach with regards to how ready they are to teach students with different characteristics. The study employed a comprehensive survey developed by the researchers. Using a sample size of 125 students at Tennessee Tech University, results showed that the majority of preservice teachers indicated that their teacher preparation program prepared them well to deal with diverse students.

Areas addressed in the study include:

- Preparedness for awareness and understanding of different cultures;
- Preparedness for teaching students of diverse backgrounds;
- Attitudes and opinions about students of different cultures;
- Teaching students with special needs;
- Confidence level about their preparation to teach students who differ in any respect.
- Implications for the Teacher Preparation Program are discussed.

Department of Exercise Science

Undergraduate Student

Sleep and Recovery

Primary Author: Daniel Silvernail, Exercise Science

Advisor: Ajit Korgaokar

URECA CISE Recipient

Sleep is one of the most researched methods for recovery and is one of the few recovery modalities supported by the evidence. For that reason, it is crucial that athletes get the correct amount and quality of sleep to enable their bodies to achieve optimal recovery, enhance performance, and balance other important physiological functions such as hormonal balance and the immune system. The main objective of this presentation is to demonstrate the impact sleep has on physiological function, as well as provide information on correct sleep hygiene to enhance recovery in athletes.

Foam Rolling for Recovery

Primary Author: Blaine Beaty, Exercise Science

Advisor: Dr. Ajit Korgaokar

Foam rolling has its roots in physical therapy being first used by Dr. Moshe Feldenkrais and was originally known as the Feldenkrais method. However, foam rolling has gone beyond physical therapy and is now one of the most popular methods for recovery after strenuous physical activity. Foam rolling is a form of self-myofascial release, which has the potential to speed the recovery process. After a session of foam rolling there can be many beneficial physiological effects to the body such as increased blood flow and release of fascial adhesions, which have other beneficial effects on the body themselves. The main objective of this presentation is to introduce the physiological benefits that foam rolling can potentially have on recovery.

Underwater Treadmill Therapy for Children with Muscular Dystrophy: A Quasi Meta Analysis

Primary Author: Salem Swallows, College of Education

Advisor: Dr. Derek Potter

Underwater treadmill therapy has become more widely used in therapeutic methods in recent years (Raghu 2021). Underwater treadmill therapy started in the 1970s as a treatment for racehorses but is currently used for multiple medical purposes, such as for treating those with muscular dystrophy (MD) (Macdermid 2017). MD is a genetic disease that can cause aggressive muscle weakness and atrophy (Putten 2019). The current quasi meta analysis examined findings from quasi-experimental research studies which explored outcomes associated with using underwater treadmill therapy for implementing a new approach to weight bearing activities with MD patients. This research study serves to bring together the concepts of underwater treadmill therapy and Muscular dystrophy to further implement with further research studys, as well as inform professionals in the field.

Blood Flow Restriction (BFR) Training

Primary Author: Faith Moorhead, Exercise Science

Advisor: Ajit Korgaokar

Blood Flow Restriction (BFR) is a training modality that has become popular in recent decades that is now being used beyond the rehabilitation setting. This form of training has been used since the 1970s, originally known as Kaatsu resistance training, and is now being used by the general population for hypertrophy and increasing aerobic capacity. This type of training is also used for athletes when it comes to recovery to improve training capacity and competition performance. The main purpose of this presentation is to provide an introduction to BFR training and the benefit of this novel approach.

Creatine monohydrate Supplementation

Primary Author: Spencer Stiles, Exercise Science

Advisor: Ajit Korgaokar

Creatine monohydrate is a commonly used dietary supplement known for its benefits in improving athletic performance, particularly in strength and power-based sports. The research indicates that creatine supplementation may also have cognitive benefits, such as improving working memory and cognitive processing speed, particularly in populations who may have lower levels of creatine in their diet (e.g. vegans and vegetarians). The first known use of creatine as a dietary supplement was by Soviet athletes in the 1970s, who reportedly used it to enhance their performance in international sporting events. It wasn't until the early 1990s that creatine became widely available in North America. Recent research has also suggested that creatine may have potential benefits in improving post-exercise recovery, specifically in reducing muscle damage and inflammation. This presentation aims to introduce and inform the reader about the muscle recovery benefits gained from creatine supplementation.

HMB Supplementation

Primary Author: Andrew Thomason, Exercise Science
Advisor: Ajit Korgaokar

Although it took time for Hydroxymethylbutyrate (HMB) to get its name out in the vast world of athletic supplements, it is now starting to grow in popularity due to the ergogenic effect not just in recovery, but muscle growth and athletic performance. The once skeptical supplement is now being used in combination with creatine and carbohydrate supplements to further improve the aspects of recovery and performance. The main objective of this poster presentation is to inform the reader of the potential benefits of HMB alone and combined with creatine, and the impact on training and athletic performance.

College of Engineering

Center for Manufacturing Research

Undergraduate Student

Electricity-Theft Detection in Smart Grids with Optimal Multichannel CNN

Primary Author: Omar Abdelsalam, Computer Science

Co-Author/Collaborators: Magdy Abdullah Eissa

Advisor: Guo Nan

CISE Recipient

Abstract: Smart meters are widely used in the power grid to measure electricity consumption. However, they also introduce a new type of fraud, where customers tamper with their smart meters to alter the signals and lower their electricity bills. This type of fraud causes financial losses for the utility companies and compromises the security of the smart grid. In this study, we propose an optimal multichannel convolutional neural network (MCNN) approach for detecting electricity-theft in smart grid advanced metering infrastructure (AMI). We also present an optimization strategy that uses the random search method to find the optimal hyperparameters of MCNN and improve its performance. We use a dataset of 130 customers with 1,072 days of samples each, where each sample contains 48 readings. We inject false reading attacks into the

dataset and train the MCNN model for binary classification of these attacks. We conduct a comprehensive evaluation of the modelâ€™s performance and show that it can effectively identify fraudulent activities in the smart grid. Our approach can help prevent financial losses due to fraud and enhance the security of the smart grid.

Department of Chemical Engineering

Undergraduate Student

Evaluation of the Microplastic Particles Occurrence in a Main Municipal Wastewater- Case Study: Treatment Plant located in West of Iran

Primary Author: Shafieh Karami, Chemical Engineering

Co-Authors/Collaborators: Rashed Rashidi, Shahid Beheshti University; Pedro Arce, Tennessee Technological University; Negar Saraei, Lamar University

Advisor: Dr. Pedro Arce

Large amounts of microplastics (MPs) are discharged daily into freshwater via wastewater treatment plants (WWTPs) around the world. Serious health and environmental threats could potentially occur due to their presence in waterbodies and yet, the available data concerning the sources responsible for occurrence of the MPs is limited. This case study investigates the final effluent and sewage sludge from the Sanandajâ€™s WWTP with the treatment capacity of 100,000 m3 of sewage per day. Samples from different units across the plant were taken: in?uent, degritted outflow, post-primary, and post-secondary e?uent. Sludge samples were also taken and investigated to evaluate the possibility of the application of dried sludge as fertilizer in agricultural soils and the associated potential risk. Samples were filtered through a set of sieves and, afterward, they were counted and classified according to their shape and size utilizing visual investigation. The results confirm the presence of MPs in WWTPâ€™s various units; the most dominant particles were fibers followed by fragments. This data indicates that despite high separation efficacy (>90%), about 30.7Ã— 1010 and 67.3Ã— 1010 MPs are released into the receiving environment annually by spreading the final effluent and dried sludge, respectively. Therefore, the study validates that WWTPs could be a pathway by which MPs are discharged to the environment and it may be replicated at other WWTPs such as the one located in Cookeville, TN.

Dynamic Rheology of Portland Cement Paste â€“ Review and Analysis

Primary Author: Matthew Webb, M.S. in chemical engineering

Advisor: Dr. Joseph J. Biernacki

Portland cement paste rheology is shown to experimentally exhibit reversible, time-dependent behaviors that include thixotropic and anti-thixotropic flow, which have not been fully discussed in prior works. A review of rheological models and their applications for various fluid flow behaviors is presented, with a focus on viscoelasticity, plasticity, and thixotropy. Rheological models that incorporate all of these elements are called thixotropic elasto-viscoplastic (TEVP) models, and a review of established TEVP models is presented. Rheological models are then further categorized into either a Type 1 or Type 2 framework that describes each modelâ€™s physical interpretation and ability to produce time-dependent rheological results. Select model frameworks were further evaluated to determine their suitability for modeling portland cement rheology. Computational flow tests were conducted with cyclical shear rate protocols to analyze the model behaviors and fit flow test results from experimental data. Results of these tests show that existing TEVP models can exhibit the thixotropic to anti-thixotropic flow transition seen in portland cement as well reversibility showing that rheological models developed outside the domain of cements research have the potential to be applied to portland cement.

Investigating the Impact of Crosslinker Concentration and Bentonite on Native Gel Electrophoresis of Ovalbumin and Carbonic Anhydrase

Primary Author: Abayomi Adeleke, Chemical Engineering

Advisors: Dr. Arce, Dr. Sanders

Native gel electrophoresis is a powerful technique for the separation of proteins based on their size and shape that also enables subsequent assessments of protein function (such as through Western blotting). Such assessments are important in many areas including in bio-health applications such as medical diagnostics. In this study, we examined the impact of bisacrylamide concentration and bentonite nanoparticles on the native gel electrophoresis of two model proteins, ovalbumin and carbonic anhydrase. The experiments involve varying the concentration of bisacrylamide in the presence and absence of bentonite nanoparticles (a mineral ubiquitous in clay) in the gel matrix. The research is relevant to fostering understanding of the role of the hydrogel structure on the separation performance of proteins. For example, we hypothesize that the results would reveal that increasing the concentration of bisacrylamide leads to a decrease in the mobility of both proteins. Furthermore, the addition of bentonite should result in a more pronounced retardation effect on ovalbumin when compared to the relatively smaller carbonic anhydrase. These findings would be a first step in understanding the impact of crosslinker and the presence of additives in polyacrylamide gel electrophoresis (PAGE) and can significantly impact the separation efficacy and characterization of proteins by native gel electrophoresis.

Modelling a fiber reactor using COMSOL

Primary Author: Oluwaseyi Ayeni, Chemical Engineering

Co-Author/Collaborator: Dr. A Vasel-be-haghFluid Mechanics Research Lab, Tennessee Tech University

Advisor: Dr. H.A Stretz

Fiber reactors (FR) are a novel reactor for contacting two phase flows in multiphase reactions that have been used in oil refining, metal extraction, and chemical synthesis. The flows are microfluidic in nature because of low Reynolds number (Re<1) and Capillary number (Ca < 0.1). Microfluidic flows are a well-researched subject, although the majority deal solely with single channels whereas the FR platform can be said to comprise thousands of channels. The computational modelling of microfluidic flows in single micro channels have been done in many studies none has specifically attempted to model the flows in the massively arrayed channels that make up a FR. The aim of this research is to model the fluidic dynamics and mass transfer characteristics of the FR. We present results of modelling flow around a single fiber using symmetry boundary conditions. The flow pattern develops as a plug flow similar to computation models in single channels without injection conditions. Results are presented showing the effects of the channel wall wettability and total flow rates (dispersed and continuous) on the equivalent droplet diameter, slug length, and specific area of the dispersed phase.

Egyptian Blue/Gold Nanocomposite Supramarbles, a Platform for IR Emission Enhancement

Primary Author: Agoston Kiss, Ph.D.

Advisor: Dr. Holly Stretz

The platform â€“ a supramarble (SM) â€“ introduced in this work is a cross-linked polymer core with a coating (or corona) of hydrophobic micro- and nanoparticles. A photoactive 2-D nanoparticulate pigment, Egyptian Blue (EB) has gained tremendous popularity in sensing applications recently due to its intense near-infrared emission at ~900 nm. Gold nanoparticles (AuNPs) have been reported to modify the spontaneous emission of other adjacent fluorophores in a remarkable way. By combining near-infrared emitting EB NPs and AuNP decorated fumed silica powder (Au-FS) as the corona of an SM, significant fluorescence enhancement is demonstrated in this work. The influence of Au-FS on the fluorescent emission of EB was also investigated. A maximum in fluorescent intensity was shown at 30 wt% Au-FS. Enhancement was attributed to AuNPs' generation of a localized electric field.

Developing the Sustainability Focused, Holistic-Style T-Shaped Engineering Professional: An Exploration of the Pedagogical Alignment of the EOP Model with the Renaissance Foundry Framework

Primary Author: Dipendra Wagale, Doctoral student, Chemical Engineering

Co-Author/Collaborators: Pedro E Arce, Andrea Arce-Trigatti, J Robby Sanders

Advisor: Dr. Pedro E Arce

In this contribution, we explore the alignment of the pedagogical aspects of the Engineering-for-One-Planet (EOP) Framework with the Renaissance Foundry Model (i.e., Foundry, Arce et al., 2015). The EOP is a framework that outlines over ninety learning outcomes related to nine sustainability elements, wherein the Foundry is an innovation-driven learning platform geared towards collaboration and design. Exploring the alignment between the EOP and Foundry is important to understand how both pedagogical strategies can effectively support studentsâ€™ development of a Prototype of Innovative Technology (PIT) that not only addresses societal challenges created by rapid urbanization and modernization demands but is also sustainability centered. Specifically, this contribution leverages work implemented in ChE 3550, Transfer Sciences II (Fluids) during the 2023 Spring semester based on the BioFoundry Initiative where student-teams will receive EOP guidance as part of their development of the required PIT with the focus on developing a sustainable technology prototype that helps to preserve our Earth environment. The contribution

will review the alignment and integration of both the EOP, and Foundry and present details related to the implementation in the ChE 3550 course as it relates to the development of the T-Shaped Engineering Professional.

Physicochemical Characterization and Water Quality Assessment of the Cane Creek Lake: A Potential Freshwater Resource Located in Cookeville, TN

Primary Author: Meagan Burtch, PhD Candidate

Co-Authors/Collaborators: Shafieh Karami; Dr. Avera, Tennessee Technological University

Advisor: Dr. Arce

Cane Creek Lake is a freshwater reservoir located in Cookeville, TN-USA. The lake covers an area of approximately 270 acres and it is at the heart of the Cane Creek Recreational Park collecting water from the surrounding hills located near the City of Cookeville. In order to assess whether it could be used to support a community with a population of 200 people, a preliminary investigation into the lakesâ€™ water quality must be conducted using various physicochemical parameters, such as pH, conductivity, TSS, DO, COD, alkalinity, turbity and hardness, both upstream and downstream. Once the water quality is assessed both in dry and wet seasons, a treatment plan for any identified issues will be proposed so as to make the water suitable for consumption.

Reconsidering the Li-ion Battery Model

Primary Author: Nathan Duran-Ledezma, Engineering (Chemistry)

Co-Authors/Collaborators: Pedro Arce, Tennessee Technological University; Ali Alouani, Tennessee Technological University; Tarek Elfouly, Tennessee Technological University

Advisor: Dr. Joseph Biernacki

Li-ion batteries are known to charge faster and have higher power density than traditional batteries. However, Li-ion batteries have experienced several instances of thermal runaway resulting at times in fires and explosions. Recent high-profile incidents involve fires on airplanes and an explosion of an E-bike. Motivated by finding a solution to the runaway issue, this in-progress work reexamines the Li-ion battery modeling and control challenge. The objective is to find an accurate model for the prediction of thermal runaway for real-time integration with battery management systems. The Li-ion battery is generally modeled as a system of partial differential equations coupled with algebraic constraints to capture the electrochemical characteristics of the oxidation and reduction in the electrodes, and their relationship with the driving forces in energy conservation.
This study reconsiders the mathematical representation of the ion transport and attempts to reconcile electrochemical practices with an approach based on chemical engineering scaling principles in contrast to the aforementioned method.

Developing F.U.E.L. - Facilitating Understanding for Exploratory Learning

Primary Author: Bobby Adams, Engineering Education, PhD

Co-Author/Collaborator: Dr. Andrea Arce-Trigatti

Advisor: Pedro Arce

The purpose of this contribution is to provide a theoretical illustration of the significance of the Resource Element of the Renaissance Foundry Model in terms of generating engineering design components. Specifically, the goal is to highlight the components of the constructivist and constructionist approaches to learning that the Resource Element encompasses and present a new idea for how this element of the Foundry in actuality is Facilitating Understanding for Exploratory Learning (FUEL).
In developing this aspect, focus is provided on the role of the facilitator of learning, collaborative learning, and both internal and external factors of learning that are all relevant in the design process associated with Foundry-designed courses. Further, as part of this contribution, we present illustrations of the central role played by FUEL (within the Foundry engine) in undergraduate chemical engineering courses that actively charge students with the development of prototypes of innovative technology as part of the requirements of the course. As part of this contribution, implications for pedagogical strategies to emphasize (and leverage successfully) the Resources Element in Foundry-designed courses will be provided.

Role of Glycine in Improving Protein Separation: Preliminary Results of New Evidence

Primary Author: Anfal Haris, PhD

Co-Author/Collaborators: Dr. Robby Sanders, Tennessee Tech University; Dr. Pedro Arce, Tennessee Tech University

Advisor: Pedro Arce

Polyacrylamide gel electrophoresis (PAGE) is a versatile tool widely used in biochemistry and research laboratories to separate protein and other polypeptide molecules. Proteins are charged molecules that can be separated based on their size, charges, and shape. The SDS-PAGE technique is developed to separate denatured proteins based on their size only. Although, the SDS-PAGE is very common with the use of the SDS-Tris-glycine buffer system and the role of glycine in the running buffer is well known, the influence of adding amino acids, e.g., glycine, to the polyacrylamide gel is a relatively new area of research.

In this project, we studied the incorporation of glycine into polyacrylamide. The effort included the introduction of glycine into the gel by using a pre-electrophoresis technique from the running buffer and instant mixing of glycine with other gel solution materials. Furthermore, the characterization of the new gels was performed using scanning electron microscopy for visualization of the internal structure and rheological tests including time sweep and frequency sweep were conducted. The performance of the polyacrylamide-glycine gel as a supporting media and enhancement of its molecular sieving was investigated by conducting various runs of protein separation with varying glycine levels and/ or polymer concentrations. The preliminary results achieved indicated some significant improvement in protein separation when using the newly experimentally modified gels.

Aggregation behavior and particle sizes of natural organic matter in response to changes of ionic strength

Primary Author: Kathlyn Mealio, M.S Chemical Engineering

Co-Author/Collaborators: Martha J.M. Wells, EnviroChem Services; Holly Stretz, Department of Chemical Engineering

Advisor: Holly Stretz

Natural organic matter is a common foulant in membrane separation processes such as reverse osmosis applications in water treatment. Understanding the fundamental behavior of these foulants could have implications in the reduction of energy costs associated with pumping. In this study, sodium or calcium was added to Aldrich humic acid or environmental carbon sources in a concentration range of 0.0M-0.5M. Shear was induced at 400s-1, followed by two hours of particle size measurement via Dynamic Light Scattering (DLS). Aggregation time was approximated as the appearance of 4.48Âµm or 5.56Âµm particles. The aggregation time was analyzed as a function of cation choice and cation concentration. Analysis shows varying responses and the potential size class ranges for different populations.

A Didactic Systematization for Conservation Principles in Transport Phenomena via the Renaissance Foundry Model: The Case of Total Mass Conservation

Primary Author: Seyed Seyed Sabour, Chemical Engineering, PhD

Co-Authors/Collaborators: Dipendra Wagle, Dr. Andrea Arce-Trigatti, Dr. J. Robby Sanders, Dr. J. Biernacki

Advisor: Dr. Pedro E. Arce

The introduction of the conservation principles related to total mass, energy, and momentum involved in transport phenomena to students and needed in core courses in engineering disciplines presents a demanding learning challenge for the students and it requires a critically important effort from the facilitator of learning. Although a useful organization of the subject was originally proposed by the pioneering work of Robert B. Bird and colleagues in 1960, the presentation of the material does not address a didactic systematization for the description of the principles to novice learners; further, subsequent textbooks follow a similar approach that also overlooks this aspect. In this contribution, we address this gap and offer a tentative systematization based on three key concepts: a-The conservation lemma, b- The Scales and Control Domains, and c- The Balances Equations associated with the conservation principles. Illustrations are offered for the case of the total mass conservation principle with preliminary observations based on the implementation in ChE 3550, Transfer Sciences II (Fluids) at Tennessee Tech University during the spring 2023 semester.

Undergraduate Students

Role of Scales in Understanding Transport of Chemotherapy Processes Applied to Cancer Tumor Treatment: Renaissance Foundry Guided Approach

Primary Author: Sahera Abumariam Gabrie, Chemical Engineering

Advisor: Dr. Pedro E. Arce

Understanding the role of transport phenomena in chemotherapy processes applied to cancer tumor treatment is a complex learning challenge. First, the domain, i.e., the tumor tissue is an intricated porous media with several scales present from molecular, microscopic, and macroscopic levels that require a detailed description of the different transport mechanisms found at the different scales. Second, the transport of drugs toward the targeted site, i.e., the tumor cells is driven by convective and diffusive transport that take place at the different continuum-based scales of the tumor domain. Finally, the chemotherapy action takes place by the different chemical reactions occurring at the targeted site, i.e., the cancer tumor cells. In this contribution, using a guided-inquired approach coupled with the Renaissance Foundry Model and the Catalytic Pellet Model, we focus on aiding the students in describing the role of the different scales, modes of transport, and reaction taking place within the tumor domain. This contribution connects the various learning pieces associated with, for example, scales, selection of control domains (within these scales), formulation of the differential models based on conservation principles of species mass, selection of boundary conditions and up-scaling procedures. The analysis for this case study is assumed under isothermal conditions.

Student Perceptions of the Application of the Foundry Model to guide STEM-Centered Activities: A Wound Healing Modeling Efforts Case Study

Primary Author: Phoebe Dawson, Chemical Engineering

Co-Authos/Collaborators: Steffano Oyanader; Andrea Arce-Trigatti, Ph.D, College of Education, Tennessee Technological University; Robby Sanders, Ph.D, Department of Chemical Engineering, Tennessee Technological University; Pedro Arce, Ph.D, Department of Chemical Engineering, Tennessee Technological University

Advisor: Pedro Arce

The introduction of students to areas of research and mathematical modeling in STEM disciplines is generally a challenging pedagogical situation for both students and the facilitator of learning. Scholars Arce et. al., (2005) have indicated that to be successful in the mathematical modeling of STEM situations, a student needs to become proficient in both, the Art and the Science of engineering modeling. One of the difficulties is the lack of a guiding approach to introduce students systematically to these aspects. In this contribution we explore the use of the Renaissance Foundry Model as a guiding protocol to introduce undergraduate students into the modeling of transport centered on would healing process assisted by electrical fields as a case study. We also explore the role of the graduate student mentor as part of this Foundry-guided learning process. Two research questions guide this work: 1) What are undergraduate student perceptions regarding the use of the Foundry to guide the introduction to the research topic? 2) What are graduate student perceptions as facilitating mentors for undergraduate students as part of a Foundry-guided learning process? Building on previous work, this contribution will offer a detailed analysis of the methodology used to discuss ill-structured problems in Chemical Engineering when introducing undergraduate students to research methods, centering on role of the graduate mentor and implementation process on Foundry-guided approaches.

Advanced Oxidative Degradation of Acetaminophen by Titanium Dioxide-Based Photocatalytic Methods: Role of Intermediaries

Primary Author: Silas Boyd, Chemical Engineering

Co-Authors/Collaborators: Luke Horne, Dipendra Wagale, Robby Sanders, Meagan Burtch, Sabrina Buer, Tennessee Technological University

Advisor: Pedro Arce

Acetaminophen (ACE) is one of the most common over-the-counter analgesic and anti-pyretic drugs used to treat minor body aches and fevers in humans. Based on its widespread use and inability to be fully metabolized by the human body, undesirable amounts of the drug reach wastewater treatment plants via city sewer systems. Even after secondary phase microbial treatment in the wastewater facility, ACE is unable to reach complete mineralization. As a result, the partially treated wastewater effluent is recycled back into the receiving streams. As there are currently no treatment processes readily available to completely remove ACE from wastewater at treatment facilities, the situation represents an important health hazard that needs to be addressed. This contribution is based on preliminary studies conducted in the Environmental Photocatalysis research group to test the feasibility of photocatalytic degradation of acetaminophen using titanium dioxide (TiO2)-based methods. Furthermore, one aspect that deserves additional effort is to identify and understand the role played by potential intermediates produced during the degradation of ACE and their possible interference in the efficacy of the mineralization process. This exploratory preliminary study will review potential degradation pathways known in the literature and offer guidelines for further research to completely eliminate these intermediaries.

Advanced oxidation processes (AOPs) for the mineralization of emerging wastewater biopharmaceuticals: Current Trends and Recommendations

Primary Author: Claire Myers, BS Chemical Engineering, Bio-molecular focus

Co-Author(s)/Collaborators: Dipendra Wagale, Dr. Robby Sanders, Luke Horne

Advisor: Dr. Pedro Arce

Advanced oxidation processes (AOPs) have become widespread methods for the effective and efficient disinfection of microbial populations as well as mineralization of a large class of wastewater contaminants such as pharmaceuticals, dyes, pesticides, insecticides, and other organic contaminants. AOP methods hinge on the generation of a highly oxidizing hydroxyl free radical (â€¢OH) that not only attacks and disrupts the microbes but also non-selectively oxidizes the complex and stable organic contaminants present in the water. In this work, we will present a brief overview of the literature analyzing the outcome of different types of AOPs, including chemical, photochemical, electrochemical, photoelectrochemical, and promising photocatalytic methods, and their applications for water remediation. We will also present a classification of the AOP methods based on the mechanistic pathways for â€¢OH radical generation, treatment efficiencies by these different approaches, operating conditions, and chemical and physical properties of the organic contaminants. In addition, this summary will highlight the removal effectiveness and degradation mechanisms of typical biopharmaceuticals by titanium dioxide (TiO2) based photocatalytic methods.

Investigating Atherosclerosis: The role of the Lubrication Approximation to obtain Analytical Solutions of the Navier-Stokes equation inside the Stenosis Domain

Primary Author: Luke Horne, Chemical Engineering

Co-Authors/Collaborators: Dipendra Wagle, Silas Boyd, Claire Meyers

Advisors: Dr. Robby Sanders, Dr. Pedro Arce, and Dr. Sabrina Buer

Atherosclerosis is the build-up of plaque materials (e.g., Cholesterol, fats, etc.) in the arterial walls over time. This is due to mass transfer phenomena resulting in stenosis or narrowing of the arteries that results in plaque build-up. This is the cause of various health problems such as strokes and heart attacks. According to the National Heart, Lung, and Blood Institute (NHLBI), atherosclerosis is a common occurrence in adults between the ages of 45 and 84, happening in around half of the individuals in this age group. This project intends on exploring the application of fluid mechanics principles to present a mathematical model of blood flow in the stenosis region. This model is useful information for the analysis of the transport of cholesterol inside the arteries. In a literature-based review correlating to the previous concepts established in reported literature as well as potential applications to specific conditions, the research will focus on investigating the role of the lubrication approximation to obtain analytical solutions of the Navier-Stokes equation inside the stenosis domain.

Kinematics of Fluid Flow: Role in Determining Fluid Velocity Profiles- A Renaissance Foundry Guided Approach

Primary Author: Katlyn Rogers, Chemical engineering

Co-Authors/Collaborators: Phuong Tran, Dipendra Wagle, Mohamed Seyed

Advisor: Pedro Arce

In the analysis of fluid flows, the velocity of the fluid plays a critical role in determining the behavior of the fluid flow and must satisfy important conservation constraints. In general, textbooks focus primarily on the application of the conservation of momentum and pedagogical presentation goes directly to the calculation of the velocity profile. Then they discuss important constraints that velocity of the fluids must satisfy. In a recent publication, (Tijaro-Rojas et. al., 2016), a methodology termed SISA (Systematic and Integrative, Sequential Approach) called for a systematic incorporation of the constraints as a building block of knowledge for the students. However, the role of the kinematic of fluid flow isnâ€™t discussed in detail. In this contribution, we expand on the critical role played by this subject in guiding the students towards the application of observation skills, geometry, flow dimensions and total mass conservation in predicting the type

of velocity functions. We will use the Renaissance Foundry Model as the pedagogical tool. Thus, we will review literature to identify the Challenge, then we will review the fundamentals of the kinematics of a particle to formulate the Organization Tools and identify Resources. Subsequently, Knowledge Acquisition will guide the understanding of important connections with the kinematic of flow and then, we will apply the Transfer of Knowledge to develop the fundamental aspects of the Prototype of Innovative Technology.

Quantifying Diffusion of Microbial Respiration Through Hydrophobic Membranes

Primary Author: Marton Varga, Chemical Engineering

Co-Author/Collaborator: Shaina Larsen

Advisor: Dr. Holly Stretz

The agricultural industry utilizes crop rotation to take advantage of crop species differing in nutrient requirements to lessen the adverse impacts of successive crop planting on soil quality. As the need for more sustainable and efficient agriculture develops, a deeper understanding of the influence of soil characteristics on crop production and quality is necessary. Few tools are currently available for farmers to profile their soil, particularly on a molecular level where microbial decomposition synthesizes the nutrients that crops require. The research group focuses on the qualification of gas diffusion through hydrophobic membranes for use in a subsurface soil sensor profiling the gaseous byproducts of organic decomposition by microbes. Prior to data collection, the project requires the development and construction of a membrane testing structure and standardized protocol to evaluate diffusive properties of hydrophobic membranes. FTIR spectroscopy, NDIR sensors, and other techniques offer the opportunity for data analysis regarding diffusive capability.

Alignment Between Foundry Guided Courses in Chemical Engineering and the Eagle Work Competition at Tennessee Technological University

Primary Author: Renie Morrow, Chemical Engineering

Co-Authors/Collaborators: Dipendra Wagale Mohammad Seyed Sabour;

Advisor: Pedro E. Arce

This contribution focuses on the collaborative, experiential, and active learning processes associated with the integration of marketing and business strategies to guide student teams in the development of a marketing strategy associated with the team-centered Prototype of Innovative Technology (PIT) in the engineering curricula at the Department of Chemical Engineering of the Tennessee Technological University. Furthermore, the contribution explores the alignment between this training and the one required at the Eagle Works competition to successfully pitch the PIT to potential investors. Using the Renaissance Foundry Model (i.e., the Foundry) student teams develop prototypes of innovative technology to address societal challenges as required outcomes in the course, i.e.. ChE 3551. As part of their training, students acquire knowledge via participation in a focused workshop where fundamental marketing techniques are introduced and illustrated. In addition, students are exposed to Responsible Business and Economy elements in the Engineering for One Planet (EOP) Framework used as a guidance relating to efforts made to magnify the focus on Sustainability as a guide to the improvement efforts related to the marketing aspects of this course. Finally, the contribution will explore in detail the alignment in the training offered in the course with those skills required to successfully participate in the Eagle Works competition at TTU.

Department of Computer Science

Graduate Students

A convolutional neural network approach for predicting flood inundation depth

Primary Author: Faria Nur, MS Program

Co-Author/Collaborator: Dr. Alfred Kalyanapu

Advisor: Dr. Doug Talbert

In recent years, innovative modeling approaches such as machine learning applications are being developed to make the best use of available data. The current study implements machine learning techniques to develop a surrogate model to an existing flood inundation model called TRITON (Two-dimensional Runoff Inundation Toolkit for Operational Needs). It is a physics-based inundation model that solves 2D shallow water equations through parallel computation using multiple graphics processing units. Despite TRITONâ€™s enhanced speed and accuracy, it may still be computationally expensive to implement a large-scale 2D hydrodynamic model. Though machine learning models may not capture large-scale flood events, they may provide a sufficient and efficient approximation under most flow conditions. This study aims to assess the feasibility of developing a CNN (convolutional neural network) model and the CNN predictions are compared favorably with the outputs produced by TRITON. This model will be developed and tested for the â€œCoahulla Creek Headwatersâ€ watershed located in southeastern Tennessee, using existing ensemble TRITON simulations from prior studies. Above all, the developed CNN model shall perform a key role to improve the application of 2D hydrodynamic model simulations for effective flood risk and hazard information.

Explaining Dynamic-Feature Malware Detection Models with SHAP

Primary Author: Daniel Simpson, Computer Science

Advisor: Maanak Gupta

Machine learning has made its way into many fields, yielding new and useful models and taking advantage of data which was previously too difficult to process by hand. One such use case is the application of malware-detecting models in the field of Cybersecurity. There are many different possible data representations for programs and applications themselves, their behaviors, and their similarities and differences to known families of malware. Of these, API call data can be extracted from dynamic analysis of malicious and benign programs using the Cuckoo sandboxing software such that it can be collected and used to train machine learning models to differentiate malicious and benign programs based on those behaviors. This research seeks to take one classical model and one deep learning model, both trained for this use case, and to apply SHAP (SHapely Additive exPlanations) to them so that we can analyze which features contributed most heavily to the conclusion that a program was malicious or benign. This will help strengthen our understanding of malware detecting models based on this paradigm as well as to foster greater confidence in the conclusions these models reach.

Performance of Various Convolutional Neural Networks for Real Time Semantic Segmentation of Sidewalks for an Autonomous Wheelchair

Primary Author: Kaydn Brady, Master of Engineering

Advisor: Doug Talbert

This study evaluates the effectiveness of several Convolutional Neural Network (CNN) models for real-time semantic segmentation, using a dataset of sidewalk images captured from the perspective of an electric wheelchair. The goal is to accurately assign each pixel in an input image to one of two classes, sidewalk or background, to enable autonomous navigation on sidewalks. While existing research has focused on CNN models trained on datasets like Cityscapes and Pascal VOC for autonomous vehicles, our study utilizes a dataset with a different perspective. The results show that CNN-based semantic segmentation is a promising approach for sidewalk navigation by autonomous electric wheelchairs, with BiseNetV2 emerging as the most suitable model for this application.
The study underscores the importance of high-quality, diverse datasets, as well as effective hyperparameter tuning and model selection, in achieving optimal performance. Here we assume optimal performance to be an accurate model that can run in real time on a computer such as the Raspberry Pi 4 or a Jetson Nano. Overall, the findings can inform the development of autonomous mobility systems that can navigate sidewalks safely and efficiently, and can also guide future research on semantic segmentation for this and other applications. These insights have the potential to advance the development of more advanced and effective computer vision techniques for autonomous mobility systems.

Credit Card Fraud Detection using Machine Learning Techniques

Primary Author: Farhat Barsha, Ph.D.

Advisor: Dr. Doug Talbert

Banking transactions are becoming popular day by day with the continuous growth of information technology and its application in the financial industry. Online transactions bring great convenience to people as they can easily do their shopping using credit cards. In this digital and paperless economy, a credit card becomes a necessity for transactions. Credit cards bring the facility of more accessible, safer, and faster transactions, but these transactions are also subject to different kinds of fraudulent activities. Credit card fraud is a type of financial fraud that involves the unauthorized use of someone else's credit card or card information to make purchases or obtain cash advances. Experts are developing new techniques every day to analyze, detect and prevent credit card fraud, but there are still some existing limitations in these techniques. In December 2022, The Nilson Report predicted global losses from card fraud to total $397.4 billion globally over the following ten years, with $165.1 billion of those losses occurring in the United States. So credit card fraud detection is

an alarming concern in today's world. This work aims to provide a comparative study of different machine learning techniques concerning finding out the best techniques for credit card fraud detection. In this work, we have applied different machine-learning techniques to the same dataset to compare their performance in credit card fraud detection.

An Analysis of Image-based Malware Classification Using Convolutional Neural Networks

Primary Author: Matthew Brotherton, Computer Science

Advisor: William Eberle

Cyberwarfare is becoming increasingly prevalent due to the potential for substantial monetary gain and political and economic manipulation. As the impacts of cyber attacks become more severe and ill-intentioned groups realize the prospective payoffs, novel attacks are likely to originate from previously undocumented sources. Many of these attacks can be grouped under the designation of malware. This umbrella term includes viruses, worms, trojans, ransomware, spyware, and many others. These attacks do not occur unchecked, though. Just as traditional crime necessitates forensics specialists, cybercrime requires malware analysts who dissect malware and devise a protection strategy against subsequent attacks. However, due to the volume and frequency of attacks, many institutions are seeking help from machine learning models to perform the malware family classification. This information may permit attribution of the attack, as cybercriminals are likely to develop malware within one or a few families. For this reason, malware variants are cataloged so they can be repurposed as training data for malware classifiers. This research demonstrates that accurate malware classification is achievable by examining three datasets containing malware binaries that have been transformed into grayscale images, which are then used as training data for a convolutional neural network to learn the textural subtleties that uniquely identify a particular malware family.

Disease Prediction using Privacy-Preserving Federated Machine Learning

Primary Author: Islam Elgarhy, Ph.D.

Advisor: Prof. Doug Talbert

Cardiovascular diseases (CVDs) are a leading cause of early deaths and disability, so early prediction is crucial for individuals at higher risk of developing CVDs. Machine learning techniques used for disease prediction rely on centralized data. However, due to data security and privacy concerns, medical providers are unable to share their patients' data. To address these concerns, federated machine learning is a promising solution that enables collaborative training while each node trains a local model on its data, and the local models are then aggregated to form a global model by exchanging model parameters instead of raw data to overcome issues related to data privacy and security. In this paper, we investigate the use of a federated averaging approach to train machine learning algorithm for detecting CVDs. Furthermore, the most valuable features have been considered for the training phase by using dataset preprocessing and dataset feature weighting techniques, which leads to an improvement in the model's performance.

Electrical Outlet Detection with YOLOv5 Algorithm

Primary Author: John Harris, Electrical Engineering

Advisor: Dr. Talbert

Machine learning is a powerful technology that is capable of training computers to do tasks usually performed humans. However, there is a large part of the population for whom doing every day tasks like plugging in an electrical cord is an impossible task without assistance. This challenge motivates an application for machine learning using computer vision, which can extract information from images and videos. Object detection is a type of computer vision whose goal is to identify objects in images and videos. Identifying objects like electrical outlets could assist visually disabled persons in their day-to-day life and improve their self-reliance. However, the issues of speed and accuracy are a challenge for real world application. Y.O.L.O. stands for You Only Look Once is an algorithm for image detection that can provide fast, and accurate detection of Electrical Outlets that can be applied to assist visually disabled people. This research focused on developing a model to identify electrical outlets using the YOLOv5 Algorithm.

Neural Network for Determining the Minimum Number of Turns Required to Solve a Rubikâ€™s Cube

Primary Author: Jacob Gable, Computer Science

Advisor: Dr. Doug Talbert

With over 43 quintillion different permutations, the Rubikâ€™s Cube is a challenging puzzle to solve. Computers have a much easier time solving the cube than humans, but they can even have difficulties finding solutions. Most programs use heuristic approaches to find sub-optimal solutions. While these solutions are much better than what humans can find, they are still not optimal. Finding an optimal solution mostly requires brute-force computation. That is problematic, because there is an exponential relationship between the minimum number of turns it takes to solve a given scramble and the number of permutations that exist within that number of turns, and each of those permutations must be searched. However, if we could use a machine learning model such as a neural network to make an educated guess as to how far away the cube is from being solved, we could reduce the problem size, which would speed up the time to find the solution. In this project, we aim to make a neural network that can accurately predict how far away a scrambled cube is from being solved, in terms of turns required. Due to the nature of Rubikâ€™s Cubes, we can easily generate our own dataset. If the model is effective, it could potentially be used to create a solving program that can output better solutions than traditional solving programs but hopefully with a similar running time, and it will be the first step in creating an AI that can efficiently solve Rubikâ€™s Cubes.

Network Attack Detector

Primary Author: Anjana Ashokkumar, Masters

Advisor: Dr.Eberle

The popularity of the internet and its usage has led to an increase in several cyber-related threats. These threats pose a major issue for organizations and their infrastructure. In particular, network security problems force organizations to deploy a variety of defenses against network security attacks. In this work, we present an approach that can apply a variety of machine learning models for the detection of cyber-security risks. We demonstrate our approach on data collected from not only a simulated test environment, but also from actual Internet-of-Things (IoT) devices. The simulation allows to create a live network that will validate our models in a practical, real-world environment. Various supervised machine learning algorithms and ensembles are used in our experiments to help us quantify which models are the most accurate. Using a variety of scenarios, including when the attack occurs and the type of attack, we implement our model using various parameters, which is then visualized to the end user on a Graphical User Interface (GUI). The GUI also provides a visual alarm indicator when an attack is discovered. One of the key, novel features of our open source machine learning tool, is that it can handle ensembles, providing the end user with a higher accuracy for detecting network attacks.

Balanced Versus Imbalanced Classification Comparison Using ReLU Activation Function

Primary Author: Cristina Radian, Computer Science

Advisor: Muhammad Ismail

Rectified Linear Unit (ReLU) activation function has a very easy implementation, which only requires a max function, and a linear behavior which allows for easier optimization of neural networks, generally avoiding the vanishing gradient problem. These advantages make ReLU a preferred activation function in modern neural networks over the earlier logistic sigmoid and hyperbolic tangent activation functions. A dataset is imbalanced if the classification categories are not approximately equally represented. Many real-world datasets and classification problems are imbalanced, and the underrepresented is the class of interest. Medicine, ecology, cybersecurity, and fraud detection are several domains where a correct classification of the minority class is highly desirable. We train four public datasets, two balanced and two imbalanced, using neural nets with ReLU activation function. Evaluation of the classifiers is done using the holdout method, cross-validation, precision and recall, and ROC curve. Comparisons with Zero Rule Algorithm and Support Vector Machine (SVM) are performed.

Scheduling HPC jobs using Reinforcement Learning

Primary Author: Rajat Bhattarai, Ph.D.

Advisor: Dr. Sheikh Ghafoor

The varying nature of resource requirements and number of jobs make the scheduling of applications in large scale HPC system challenging. Finding an optimal scheduling for a HPC system is NP-hard. Traditional scheduling methods are based on heuristics and static rules that make up priority functions configured by system administrators, which may not always be most efficient and usually do not adapt to changing workload characteristics and system conditions. Reinforcement Learning (RL) may be a promising method for HPC scheduling because it can learn to make decisions based on feedback from the environment. In this research, we investigate application of RL for HPC scheduling in order to learn good scheduling policies through trial and errors. We train an RL agent to learn a

policy that maximizes the system's performance by minimizing the job's waiting time and maximizing the resource utilization by reducing resourceâ€™s idle time. We evaluate the RL based approach with a set of realistic workloads and compare it with the traditional scheduling methods. Our research highlights the potential of RL-based scheduling approaches for enhancing the performance of large-scale computing systems. Furthermore, we discuss the prospect of using RL-based scheduling in elastic workload scenarios, the workload containing jobs that can fluctuate the number of processors while being executed.

Malware Detection With Machine Learning

Primary Author: Bethanie Williams, Doctoral of Computer Science

Advisor: Muhammad Ismail

In todayâ€™s world of technology, zero-day attacks play a major role in data breaches, ransomware, and other malicious software. The detection of zero-day attacks and vulnerabilities is a challenging problem that many organizations face on a regular basis since no reliable signatures have been developed for these malware's, hence zero-day. Cybersecurity professionals and researchers need to have the ability to protect their technologies from such threats. It is of utmost importance for organizations to identify, detect, and mitigate a systemâ€™s vulnerabilities or potential threats with high accuracy. By using machine learning, we can develop models that discover new patterns and signatures to accurately detect and identify zero-day malwares. This research focuses on developing different machine learning models to detect file-based malware potentially containing zero-day exploits and to differentiate it from benign files. In simpler terms, we will be able to determine whether a file is legitimate or malicious. It is our hope to build various machine learning programs that obtain high accuracy and perform efficiently in detecting malware files.

Applying Neural Networks to Road Infrastructure

Primary Author: Brandon Vandergriff, Data Science and AI

Advisor: Doug Talbert

The importance of transit infrastructure in our society cannot be overstated, where transit plays a crucial role in our daily lives. Potholes pose a serious threat to the safety of drivers and pedestrians alike. Due to the possibility of damages, it is imperative to take preventative measures, such as early detection. The dataset used within this project is originally from a 2022 hackathon hosted by Analytics Vidhya. It contains images of roads with or without potholes, and the images are further augmented with rotations, noise, and cropping. The goal of this project is to maximize the pothole detection rate in images using pre-trained deep neural networks such as VGG-16, ResNet50, Inceptionv3, and EfficientNet. By implementing an image recognition system to identify potholes, two objectives can be met: the time taken to repair said potholes can be minimized, and excessive damage and risks can be prevented.

Optimal Triple Phase Shift Control of the Dual Active Bridge Converter for On-Boarding Charging System of Electric Vehicles using Machine Learning.

Primary Author: Olivia Nnadi, PhD

Advisor: Talbert Dough

Battery chargers play a critical role in the development of Electric Vehicles. On-board chargers allow Electric Vehicle owners to charge their vehicles from any suitable electric source and allow for bidirectional power flow capability, that is, energy can be injected back to the grid from the battery of the car, called Vehicle to Grid (V2G). Dual Active Bridge (DAB) converters are commonly used in on-board chargers for power conversion because they have high power density, provide galvanic isolation, have higher efficiency, better controllability and current limiting capabilities. The control of DAB is challenging because of the different parameters used for duty cycle and phase shift controls. The Triple Phase Shift Control (TPSC) is a preferable control mechanism for the DAB because it limits the amount of current that flows through the high frequency transformer. In this work, Artificial Neural Network Model is employed to replace the look up table that is generally used in TPSC of the DAB.

Keywords: Dual Active Bridge (DAB), Triple Phase Shift Control (TPSC), Electric Vehicle (EV), Machine Learning (ML).

Automatic Detection of Dust Deposition in Solar Photovoltaic Panels using CNN algorithm

Primary Author: Sohag Kumar Saha, Ph.D. in Engineering

Advisor: Doug Talbert

In recent years, the use of solar photovoltaic (PV) has increased rapidly to generate renewable energy resources for reduction of global carbon emissions. The performance of PV is directly dependent on several environmental factors such as irradiance of sun, temperature, shading, altitude, deposition of dust and debris. In this work, the deposition of dust on PV panels is considered which is one of the most critical parameters for a significant reduction in the output power and efficiency of solar PV. To mitigate this issue, there are several strategies are commonly used for dust detection such as dust sensors, IoT integrated camera, image processing, infrared thermography, V-I characteristics, machine learning (ML) and deep learning (DL) strategies. A deep learning based Convolutional Neural Network (CNN) technique is used to automatically detect dust accumulation in solar PV panels based on a dataset consisting of clean and dusty images. This algorithm employs features learned from images of solar PV panels to determine whether or not the panels are clean. Data collection, pre-processing, model architecture design, training, evaluation, and deployment are all essential parts of putting the CNN algorithm into practice. To sum up, utilizing a CNN method for autonomous detection of dust deposition in solar PV panels is a potentially useful step toward maximizing the efficiency of solar power.

Machine Learning Assisted Phishing Detection

Primary Author: Kaitlyn Cottrell, Master of Science

Advisor: Doug Talbert

Phishing is a common form of social engineering attack where an attacker crafts a malicious link, under the guise of a reputable source, that ultimately leads to a fraudulent website. The purpose of the fake website is to trick the user into entering personal or sensitive information. Phishing websites are becoming increasingly sophisticated and difficult to spot, especially due to the lack of user security training in most cases. This research seeks to formulate a variety of tree-based machine learning models that assist in determining if a URL is potentially part of a malicious attack by taking various URL attributes as input and outputting a binary classification of whether the URL is phishing or not phishing.

Design and Development of XiveNet, a Hybrid CAN Testbed

Primary Author: William Lambert, Doctoral

Co-Authors/Collaborators: Haley Burnell, Siyapa Chanhorn

Advisor: Dr. Sheikh Ghafoor

We have designed a low cost hybrid testbed for in-vehicle security research that combines the flexibility of simulators as well as the real time ECU characteristics of real vehicles. The test bed consists of ECU chips used in vehicles, raspberry Pis and is integrated with Bus master simulator. Experiments with CAN (controller area network) traffic from real vehicles (Oak Ridge National Laboratories Road Data Set) in our testbed shows that our testbed emulates the characteristics of real vehicle very closely. We have further validated our testbed by implementing SecCAN, a secure CAN algorithm, and evaluating its security by injecting invalid frames. Additionally, we tested ORNL's timing-based detector on our testbed and successfully generated alerts. Finally, we implemented Named Data Networking (NDN) capable nodes, so that researchers have an additional tool when designing next generation in-vehicle security solutions. We believe XiveNet furthers vehicle security research by providing an inexpensive platform allowing for a wide variety of hardware and software configurations using real CAN data.

Diabetes Prediction using Machine Learning

Primary Author: Anurag Dwivedi, Computer Science

Advisor: Dr. Doug Talbert

Diabetes is a chronic metabolic disorder characterized by an increased blood glucose level brought on by insufficient insulin production, and it affects millions of people worldwide. According to statistics, 415 million people are living with diabetes, and it is predicted that more than half a billion will have diabetes by 2040. Early detection of diabetes can significantly improve patient outcomes and reduce healthcare costs. Machine learning has the potential to improve diabetes prediction by identifying high-risk individuals based on a combination of patient characteristics, lifestyle factors, and genetic markers. This research project explores the use of machine learning algorithms to predict the onset of diabetes in individuals and evaluates the performance of several machine learning models, including k-nearest neighbors (KNN), decision tree, and random forest algorithms. These algorithms will be used to train on the Kaggle dataset of diabetes from the National Institute of Diabetes and Digestive and Kidney Diseases, which consists of females from the Pima Indian heritage. Research on diabetes prediction has significant implications for healthcare providers and policymakers, as it can help identify individuals at high risk of developing diabetes, allowing for earlier interventions and preventative measures.

Moreover, it can also inform public health policies aimed at reducing the incidence of diabetes by identifying risk factors and addressing them proactively.

HOUSING PRICE Prediction Project

Primary Author: Amr Elshazly, Master's Program

Advisor: Dr. Doug Talbert

The real estate sector is an important industry with many stakeholders ranging from regulatory bodies to private companies and investors. Today there is a large amount of data available on relevant statistics, and it is natural to try to make use of these to improve our understanding of the industry. In some cases, non-traditional variables have proved to be useful predictors of real estate trends. This project can be considered as a further step towards more evidence-based decision making for the benefit of these stakeholders. The aim of our project was to build a predictive model for optimize the sale prices of the properties based on important factors such as Longitude, Latitude, housing_median_age, total_ rooms, etc., And we will cover the difference between two types of Models and compare the accuracy for both. So, we will essentially focus on: Identifying the variables affecting house prices, creating a model that quantitatively relates house prices with variables and knowing the accuracy of the model.

TRANSFER LEARNING APPROACH FOR FLOOD FORECASTING USING DEEP LEARNING-BASED MODELS

Primary Author: George Fordjour, Civil and Environmental Engineering

Co-Authors/Collaborators: Alfred Kalyanapu, Tech-Warms Tennessee Technological University

Advisor: Dr Talbert Doug

Flood disasters continue to be a significant type of natural disasters worldwide, with their scope varying from neighborhood scale to continental scale. The use of deep learning in hydrology has shown promising results for tasks such as flood forecasting. Deep learning-based models are currently utilized as quick-response flood models. However, these successes typically occur in watersheds with well-developed monitoring programs that provide relatively plentiful observation data to train the deep learning models. Deep learning-based models are data-hungry. If the data is scarce or does not cover varieties of the task, learning ability of the deep learning models falls short, and hence, they cannot perform well when they are put into work. As a result, alternative approaches to assess the capability of deep learning models to generalize on different tasks are needed and this will depend on how well the trained system can predict cases it was not trained for, i.e., whether it can predict beyond the range of the training dataset. Thus, the application of the transfer-learning approach to deep learning-based flood models is presented as a solution to this limitation.

Machine Learning-based Categorization of Cybersecurity Vulnerabilities.

Primary Author: Ocheme Anthony Ekle, Phd Computer Science

Advisor: Dr. Denis Ulybyshev

The Common Vulnerabilities and Exposures (CVE) database is a repository of discovered and registered cybersecurity vulnerabilities in software and hardware products provided by the National Vulnerability Database (NVD). These CVE entries continue to increase on a daily basis as new vulnerabilities are being discovered and registered in the NVD.
It is not always easy to classify the different types of vulnerabilities. This challenge has motivated researchers to apply machine learning algorithms to address this classification task. In this study, we will focus on exploring the performance of different Machine Learning (ML) classification algorithms in categorizing the types of cybersecurity vulnerabilities in the CVE database, including logistic regression, decision trees, Na Â¨ive Bayes, Support Vector Machines (SVM), and Random Forest classifiers. This research project will also explore different feature selection and engineering techniques to improve the performance of the models. The performance of our models will be evaluated based on the following metrics: accuracy, recall, precision, and F1 Score. Previous related works attempted to investigate whether machine learning techniques are applicable to solving this task.
Our research aims to apply different ML classifier algorithms to improve the categorization performance for different vulnerability types by applying feature selection techniques and detailed hyper-parameter tuning.

Detection the difference between Large Language Model (LLM) generated text and human generated text

Primary Author: Sanjida Akter Sharna, PhD

Advisor: Dr. William Eberle

In recent years, with advantage of technology the use of large language model (LLM) has become increasingly common in various industries, including customer service, social media, and e-commerce platforms. However, the rise of these LLMs has also raised concerns about their potential to deceive and manipulate people by producing text that is indistinguishable from human-generated text. Moreover, Using LLMs in these ways can create several issues, causing challenges in conducting fair assessments of students, hindering the learning process, and contributing to the spread of news articles that are compelling but not entirely accurate. In This work, we explore approaches that differentiate between LLM generated text and human-generated text. We plan to explore both supervised approaches such as fined-tuned language models, and unsupervised approaches that are based on curvature-based criterion. We have tested our approaches on a number of datasets addressing problems such as fake news detection, machine-generated creative writing detection etc.

A Deep Learning Approach for Invasive Faults Detection and Severity Prediction in Electric Vehicles

Primary Author: Ejikeme Amako, Ph.D. in Electrical Engineering

Advisor: Professor Doug Talbert

This research presents a deep learning approach for detecting invasive faults and predicting their severity in electric vehicles. The purpose of this study is to improve the safety and reliability of electric vehicles by developing a system that can detect and predict the severity of faults in real-time. The study uses a combination of Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM) machine learning algorithms to process and analyze data collected from a Typhoon HIL simulator. The results show that the deep learning approach can effectively detect invasive faults and accurately predict their severity to the electric vehicle, while demonstrating the potential of this approach for enhancing the safety and reliability of electric vehicles.

Prediction of Mushroom Edibility

Primary Author: Glen Cathey, Data Science

Advisor: Douglas Talbert

A mushroom may be encountered on the shelf of a supermarket, the forest floor, or even your front lawn; in any case, it would be nice to know if it is safe to eat. Mushroom identification can be a difficult task for a mycologistâ€"much less an amateur foragerâ€"and is made additionally difficult by the physical variance with which mushrooms present. This research explores the ability of multiple machine learning models such as decision trees, random forests, and K-nearest neighbors to predict the edibility of an unidentified mushroom based on 22 physical attributes. These models are trained on a dataset including descriptions of hypothetical samples corresponding to 23 species of gilled mushrooms in the Agaricus and Lepiota family.

Undergraduate Students

Food Demand Forecasting

Primary Author: Mohammed Alturki, Computer Science

Co-Authors/Collaborators: Ahmed Kashif, Sho Sakane, Chern Chao Tai

Advisor: William Eberle

The food and beverage manufacturing industry faces a critical challenge in predicting customer demand, which affects planning, supply chain management, and inventory control. To solve this problem, accurate demand forecasting is essential to improve operational efficiency, reduce waste, and increase service levels. Many techniques have been attempted to predict the demand, including linear regression, SVM, gradient boosting, and k nearest neighbor.
In this project, we used decision tree and random forest models to forecast the number of orders required in a specific period, such as a week.
To validate the success of our models, we compare the predicted results with the actual sales data in the provided test dataset. Effective demand forecasting and management lead to proactive and timely adjustments to market changes, resulting in optimal production planning and ingredient allocation.
Such proactive measures can significantly reduce food waste, overstocking, stock shortages, and customer churn, leading to improved customer satisfaction and loyalty. The goal of this work is to provide food and beverage manufacturers with an accurate and efficient solution to their demand forecasting problems. By incorporating historical sales data and other factors that can impact demand, our models can provide actionable insights that can help manufacturers optimize their production schedules and resource allocation.

Cancer Survival Times

Primary Author: Eli Parker, Computer Science

Co-Authors/Collaborators: Pooja Patel, Christopher Wilhite

Advisor: Dr. William Eberle

This project involves predicting the survival times for patients with Non-Small Cell Lung Cancer (NSCLS), which is the most common type of Lung Cancer, making up 80% of cases. Using clinical data and CT scans provided by Owkin, a biotech company, we attempt to predict how long a patient may live. The results of this work can then be used to determine the best type of treatment through pattern discovery, allowing medical personnel to predict treatment reactions. Better solutions to the treatment of Lung Cancer could lead to a higher quality of life for the patients as well as a longer life expectancy. To the best of our knowledge, previous work in this area is limited, and understanding lung cancer or the models used to predict survival times is complicated. In this work, we build a supervised learning model to predict survival times from the two datasets. To validate our success, we will compare our predicted survival times with the given output from the challenge provided by Owkin.

Stock Market Data Abstract

Primary Author: John Taylor, Computer Science

Co-Authors/Collaborators: Austin Lane, Phonethep Nakhonekhong

Advisor: William Eberle

The stock market is a vital part of our financial ecosystem. For millions, it is their primary source of income, yet millions more have lost their fortunes due to sudden changes in stock market trends. The stock market is inherently unstable, and this poses a problem for investors. Investors use tactics such as trend analysis and earnings algorithms, but these methods are not fail-safe. In this work, we will use anomaly detection to predict when sudden changes occur in stock market data. Using the dataset from Autorite Des Marches Financiers, a French investment company, we observe that instead of trends over a long course of time, the data provides small anomalies that indicate massive changes in the direction of the stock market. Our project intends to predict when these small anomalies occur so that we know when the stock market may either crash or enter a bull market.

Electric Vehicle Charging Station

Primary Author: Ethan Owens, Computer Science

Co-Authors/Collaborators: Daniel Jordans, Hunter Sawyer

Advisor: William Eberle

As our society shifts from the mainstream use of gas vehicles to electric vehicles, the ability to moderate the bandwidth of electric vehicle charging stations becomes crucial knowledge to diminishing energy consumption. Our work provides an accurate model which predicts when an electric vehicle charging station needs to be online to meet user capacity. Unlike many classification problems with one target feature to predict, in this work, we use data from over 270 charging stations, classified as multiple independent features. In order to do this, we isolate every spatiotemporal target feature and tune a unique model for each feature independently. With an accurate cluster of classification models, we provide a practical tool to dynamically estimate the required capacity of charging stations at any given time.

Movie Review Sentiment

Primary Author: Isaac Bland, Computer Science

Co-Authors/Collaborators: Tyler Bang, Matthew Beech;

Advisor: William Eberle

One of the most prevalent components of society is the entertainment industry, which can be viewed as a big data problem. In order to understand this type of data, one needs tools that can provide insights and easy to understand results. An example of this is the vast number of movie reviews that vary greatly in sentiment, and review sites want to be able to concisely capture a movie's overall sentiment. Considerable research and work has been done in industry to address this problem, including using deep learning approaches (among others) to perform sentiment analysis on reviews using binary and multi-class classification. In this work, we develop tools to classify the sentiment of movie reviews using a dataset from a Challenge Data competition containing approximately 10,000 textual movie reviews. First, a substantial amount of data cleaning is needed to obtain any meaningful results, including the use of stemming, removal of stop words, vectorization, and character replacement to vastly reduce review lengths while retaining information pertinent to the sentiment. Then, to classify reviews as "good" or "bad", we use decision tree and logistic regression models along with the help of the Natural Language Toolkit. The fastText library is used as a baseline to compare against the other modelsâ€™ performance, using accuracy as the main evaluation metric. We are able to confirm our hypothesis that a decision tree would be able to outperform both logistic regression and fastText.

Using Group-Specific Models to Improve Trust in Machine Learning Models for Trauma Triage

Primary Author: Katherine Phillips, Computer Science

Advisor: Doug Talbert

Improving trust in machine learning is a multi-objective optimization problem involving metrics that can have an inverse relationship (e.g., model explainability and accuracy). Understanding such tradeoffs is important because a lack of explainability can hinder adoption of machine learning-based decision support models. Previous results examined the trust-related tradeoffs among model complexity, accuracy, and bias in a single-model approach to computerized trauma triage decision support. Those results showed that, in this domain, the highest performing models were consistently among the most complex and that the least biased models tended to have lower complexity and lower accuracy. In this poster, we further explore these important tradeoffs by similarly examining the performance of group-specific machine learning models to see what role they might have in improving trust-related tradeoffs through the construction of a trustworthiness-informed decision forest.

Probabilistic Split-Point Decision Trees

Primary Author: Matthew Beech, Computer Science

Co-Authors/Collaborators: Ethan Owens, Doug Talbert; Tennessee Tech University

Advisors: Doug Talbert

Engendering trust in machine learning models can involve several model characteristics, such as accuracy, transparency, stability, and fairness. We introduce a new variant of decision tree induction to support domains in which transparency and stability have high value, such as medicine. Decision trees provide absolute transparency in regard to the rule used to classify an instance. The rules in traditional decision trees, however, have some drawbacks that can degrade trust, such as unrealistic hard decision boundaries for continuous attributes and rule instability caused by small perturbations in the data. Our novel Probabilistic Split Point Decision Tree (PSPDT) algorithm is a combination of two approaches designed to address stability and decision boundary variance. This poster presents the PSPDT algorithm and compares it to existing decision tree algorithms.

Department of Electrical & Computer Engineering

Graduate Students

Quantum Entanglement via Conservative Reversible Logic gates

Primary Author: Joshua Adams, M.S. Electrical and Computer Engineering

Co-Author/Collaborator: J. W. Bruce, Tennessee Technological University

Advisor: Dr. J. W. Bruce

Quantum entanglement is a phenomenon that challenges our understanding of the universe. With the potential to revolutionize computing and cryptography, the implications of quantum entanglement are vast. In the case of quantum computing, entanglement is the key resource that sets quantum apart from classical. Enumeration and classification of quantum entangled states is mandatory for the viability of quantum computing. Conservative reversible logic gates (CRL) are a type of gate suitable for quantum technology, and are a subclass of controlled unitary gates. Controlled unitary gates create entangled states when the control line is placed into a superposition. Therefore, CRL gates can create entangled states. Previous work demonstrated that the smallest CRL gate, the Fredkin gate, can create four of the eight maximally entangled Greene-Horne-Zellinger (GHZ) states. GHZ states are useful for quantum communication protocols such as superdense coding and quantum teleportation. To date, no CRL gate other than the Fredkin gate has been shown capable of entangling quantum states. Using a set of generalized CRL gates, this work introduces more than 7x{10}^{16} methods for entangling 130,348 unique quantum states similar to GHZ states. An example quantum superdense coding protocol using strictly CRL entangled states is provided.

Inhibiting Phase Transition in P2-type Sodium-ion Batteries by Incorporating K+ Doping on Na-ion Sites

Primary Author: Trapa Banik, PhD

Co-Author/Collaborator: Indranil Bhattacharya

Advisor: Indranil Bhattacharya

URECA Recipient

The sodium-ion battery (SIB) has the potential to become a direct alternative for lithium-ion battery (LIB) technology in the rapidly growing energy storage industry for its combination of homogenous abundance on earth and similar intercalation chemistry to LIB. Despite this, SIB is still a work in progress, since its energy density is somewhat lower than LIB. To maximize cycle life, energy density, and safety, it is essential to choose an appropriate cathode for facilitating easy Na-ion transport. This investigation focuses on P2 type quaternary Na0.67Fe0.48Mn0.5Ti0.01V0.01O2 (NFMTV) cathode material, which exhibits high capacity and high voltage while also suppressing Jahn-Teller effect. Nevertheless, during discharge, inevitable phase change is triggered at higher voltage window when Na content decreases. This study shows that lattice orientation is unaltered by replacing some of the Na-ions between the TMO2 layers with potassium (K) ions. This research shows that K+ into Na+ ion layers sustain the stacking pattern at higher voltage with very low Na concentration. SEM and EDS indicated that low K doping did not affect surface appearance or particle shape. Besides, placement of K+ ions in Na sites in NFMTV is found to significantly improve the lattice parameters, as shown by XRD and Rietveld refinement studies. Furthermore, the gliding phenomena is halted by K+ ions doping, which slows down the phase transition, leading to better cycling performance.

A Two Degree of Freedom Reinforcement Learning Control Algorithm for Optimizing Building HVAC Controls

Primary Author: Junaid Anwar, Electrical Engineering

Advisor: Syed Ali Asad Rizvi

Buildings account for around 76% of electricity consumption in the US. People spend almost 85% of their time inside buildings. A promising approach to making buildings both comfortable for occupants and energy efficient is through optimal control of the heating, ventilation, and air conditioning (HVAC) system. Traditional optimal control approaches for HVAC systems are primarily model-based that involve a complex design process requiring reasonably accurate equipment models and estimate of external disturbances arising from unknown heat gains, occupancy variations, light sources, and outside weather changes. To address such challenges, we present a two degree of freedom reinforcement learning approach that consists of learning the optimal feedback and feedforward terms of the control law for building HVAC zones. It is shown that the proposed adaptive algorithm is model-free and converges to the optimal solution of the algebraic Riccati equation (used for computing the feedback gain) and the Sylvester equation (used for computing the feedforward gain) without explicitly solving them which would otherwise invoke the knowledge of HVAC dynamics. Simulation results demonstrate the effectiveness of the proposed scheme.

DESIGN OF AN AUTONOMOUS NAVIGATION AND CONTROL SYSTEM FOR AN OUTDOOR ELECTRIC WHEELCHAIR

Primary Author: Kaydn Brady, Electrical Engineering

Advisor: Dr. Ali Alouani

Today, thousands rely on assistive technology to help them complete day-to-day tasks. One such system, the wheelchair, allows for a higher level of mobility for handicapped people. These systems cater to a substantial range of different disabilities such as sickness, weakness, amputees, blindness, paralysis, and obesity. While the basic design of a wheelchair, electrical or not, proves to be valuable to those physically capable of maneuvering a wheelchair or those with a nondisabled person to push them, there is still much to be done to design a device that allows complete autonomy. One solution is an autonomous electric wheelchair, allowing the device to do all the decision-making with minimal user input. This research describes the design of an autonomous navigation and control system for outdoor electric wheelchairs that is both affordable and safe. This design uses a digital map of all walkable paths in an area with a stereoscopic camera, GPS, IMU, and LIDAR to ensure the device remains unhindered as it travels to its destination. The proposed design can be implemented on almost any electric wheelchair using two-wheel drive. Experimental testing was carried out along the sidewalks around Tech campus. Preliminary results show the wheelchair able to successfully navigate from various locations to different destinations. It is believed that this work allows another level of mobility to disabled persons and pushes the design of autonomous wheelchairs further forward.

An Argument for the Dynamic Ether of Cosmic Space

Primary Author: Zack Bikakis, Electrical and Computer Engineering

Advisor: Indranil Bhattacharya

In 1901, Nikola Tesla began construction on his Wardenclyffe Tower which was one station intended to provide power and communication to the entire world. How is this possible? As it turns out, the answer to this question lies in the fact that Tesla had a very different conception of space, time, matter, and energy than we do today. My research involves going back in time and revisiting the ideas of the famous electrical experimenters such as Faraday, Maxwell, Heaviside, Tesla, etcâ€¦ and attempting to understand their conceptions of nature. I found that, even though we use still their mathematical models and technologies to this day, science has discarded the main essence of these discoveries and theories which drove their innovation and insight. The focus of this research revolves around the development of ideas pertaining to the ether, an all-pervading medium which is singularly responsible for the carrying out of physical phenomena. Most of these experimenters considered the ether as a philosophical necessity to carry out observed physical interactions. There is one experimenter, Wilhelm Reich, who accidentally discovered the existence of a universal medium and developed these ideas into a more mature science. One of Reichâ€™s demonstrations of the existence of this medium was the existence of a spontaneous heat generation in a box with a specific structure and layering of materials. This experiment is an attempt to replicate this thermal anomaly discovered by Reich.

A Pressure and Temperature Monitoring System of Lithium Ion Batteries in Electric Vehicles

Primary Author: Michael Miner, Electrical Engineering

Advisor: Dr. Ali Alouani

Real time monitoring of the health of a battery can prevent possible catastrophic incidents such as a thermal runaway, possibly leading to battery fire or in worst case explosion. This is of critical importance for electrical vehicles and public safety. This research deals with the monitoring of two important variables, namely battery pressure and temperature, with the purpose of improving short term safety and State of Charge estimation, and long-term swelling effects for State of Health indication. A cheap, practical, cell-level monitoring system for electric vehicles to improve safety with the prospect of improving State of Charge and State of Health estimations is proposed. Short term and long-term cycling were performed on small-format Lithium-Ion Polymer pouch cells inside an apparatus to simulate battery pack conditions while charging and discharging. A charging system was designed to cycle the battery at multiple charge rates. Thin film pressure sensors are used for real-time pressure monitoring, and thin film thermistors are used for temperature monitoring. Normal swelling from low-rate charging and discharging is captured by the pressure sensor, as well as irreversible swelling from long-term cycling of the Lithium-Ion battery.

GaN Marx Inverter for Wideband, High Frequency Applications

Primary Author: Christopher Johnson, Electrical and Computer Engineering

Co-Authors/Collaborators: Tyler Marcrum, Michael Tidwell, William Stump, Dr. Charles Van Neste; Dr. Matthew Pearce, University of Auckland

Advisor: Dr. Charles Van Neste

Recent applications in power electronics are demanding inverters to operate at higher switching rates and over broader frequency ranges. Most contemporary inverters are designed to switch at a single, fixed frequency with limitations appearing in applicational use. To address this fixed frequency limitation, a modified Marx inverter circuit design is presented that is broadband up to 8MHz. Four gallium nitride (GaN) MOSFETs are used, making the inverterâ€™s component count comparable to an H-bridge. The time domain response of the modified-Marx inverter is derived, yielding a unique solution when terminated with a capacitive load. This unique solution explains the functionality of the Marx inverter with large capacitive loads, which seems to be lacking in prior literature.

Improving the ionic conductivity and electrochemical performance of NASICON based NZSP solid-state electrolyte for solid state sodium batteries

Primary Author: Khushi Patel, MS - Electrical Engineering

Advisor: Indranil Bhattacharya

Major efforts have been made in the search for high-energy and power density batteries to keep up

with the demands of the rapidly growing portable electronics market and EV industry. Though lithium-ion batteries have dominated this field, sodium-ion batteries (SIB) are increasing in popularity due itâ€™s wide availability and low cost. Conventional SIBs with liquid electrolyte usually have several problems, including limited electrochemical window, flammability, and leakages, making it a safety hazard. One of the most promising approaches to improve the safety is to replace the liquid ion conducting electrolyte with a solid one. Nevertheless, to develop such a high-performance solid-state electrolyte (SSE) that is compatible with both the anode and cathode interfaces is still challenging. Furthermore, low ionic conductivity, dendrite formation and poor cycling capabilities make it more challenging. To address these challenges and improve electrochemical performance of the battery, cation substitution can be considered. Here, NASICON based Na_(1+x) Zr_2 Si_x P_(3-x) O_12 (NZSP) SSE, and its performances in solid state batteries are summarized. Current trends & perspectives on interface engineering and Ca^+ substitution of the NZSP electrolyte is also discussed. The development of solid-state sodium electrolytes leads to a future where all solid-state sodium batteries can be used to power EV, electronic devices and contribute towards large scale storage.

Passive AC-DC Single Phase Charge Converter for Wireless Power Transfer Applications

Primary Author: Tyler Marcrum, Engineering

Advisor: Dr. Charles Van Neste

Single wire Wireless Power Transfer (WPT) uses one conductor and a quarter wave resonator (QWR) as a wireless return path to the source. An issue with this system is the transformer used to step down the high voltage to produce a higher current. This causes the system to become lossy due to a change in the QWR's transmission line's electrical length. This research presents a system that utilizes a network of capacitors and diodes in series with a buck boost converter to allow for transformation and rectification of the single wire WPT technique.

A SIMPLIFIED APPROACH TO THE ANALYSIS OF HIGH ORDER BIDIRECTIONAL INDUCTIVE POWER TRANSFER SYSTEMS

Primary Author: Joshua Lolonyo Korku Avornyo, Masters Electrical Engineering

Advisor: Prof. Joseph Ojo

Wireless power transfer is increasingly becoming the preferred mode of charging in most systems that require safe and convenient charging. In electric vehicles (EV), inductive power transfer, which is the widely used wireless power transfer mechanism, introduces different resonant topologies to cater for design needs such as maximum power transfer efficiency, proper output voltage regulation and minimum peak current in the transmitter and receiver coils. Bidirectional flow of electric power between battery storage systems (electric vehicles) and electric grids have also been talked about in literature. This technology enables grids to charge EV's when needed and receive power from the EV's when there is an increase in demand for power from consumers. Bidirectional Inductive power transfer has hence become key in research that involves interfacing electric grids and electric vehicles. This work presents a simplified approach to analyzing a high order bidirectional inductive wireless power transfer system operating at resonance. The system is simulated in PLECS, and the results are compared to verify the feasibility of the method for rapid circuit analysis.

Control of a Swarm of Drones in Turbulent Environments

Primary Author: Chijioke Ekechi, Master of Science

Advisor: Dr. Tarek Elfouly

Research is currently increasing in unmanned aerial, terrestrial, and water vehicles. With the technological advancement of controllers, unmanned aerial vehicles became relatively easy to implement. Machine Learning algorithms made it even more possible and easier to control autonomous vehicle systems with high precision and accuracy. Drones are light weight unmanned aerial vehicles that are used by both individuals and businesses to perform certain specific tasks such as delivering merchandise to customers in a timely manner, monitoring traffic in a certain area, etc. One of the major challenges faced when making use of these drones is their performance when they are subjected to winds of high speeds in a turbulent environment. The weight of drones makes them highly susceptible to high winds. From a control standpoint, how can we get a swarm of drones to perform optimally and optimize their energy usage during their mission? This article answers the previous questions, using an algorithm which accounts for the formation and energy optimisation, along with the swarm stability.

Image Enhancement to Improve CNN Performance

Primary Author: Jonathan Sanderson, M.S. in Electrical and Computer Engineering

Advisor: Dr. Syed Hasan

From facial recognition on a cell phone to crash avoidance in self-driving cars, applications of Computer Vision (CV) have become embedded in our lives. Convolutional Neural Networks (CNNs) are widely used for accomplishing CV tasks. CNNs learn to perform CV tasks by training on datasets in a controlled environment. The performance of a CNN depends on several factors, one key factor being, how well the dataset represents the real world environment. When CNNs encounter an image that is not similar to the domain they were trained in, such as a low-light or high-glare environment, their performance can be degraded to an unsatisfactory level. One solution is to re-train the CNN on a modified training set; however, this can be a computationally expensive process, especially for large networks, and in many cases not feasible at all. In this work, we explore an alternative solution of improving the CNN performance by using image enhancement techniques, including histogram equalization. This will help in improving the real time performance of CNN inference, especially in edge computing environments.

An Exploration of Knowledge Distillation for Edge AI

Primary Author: Parth Patel, M.S. in Electrical and Computer Engineering

Advisor: Syed Hasan

Convolutional Neural Networks (CNNs) and computer vision, particularly object detection, are integral in many applications like autonomous vehicles and robotics. However, many state-of-the-art models are large containing numerous parameters making them computationally expensive to run and difficult to deploy on resource-constrained edge devices. We explore a solution for this issue by focusing on a particular model compression technique known as knowledge distillation, where the behavior of a large and complex model, also known as the teacher model, is transferred into a smaller student model. We implement knowledge distillation using the YOLOv5 object detection model as the teacher to train a smaller student model. Our experiment measures the performance of both the teacher and student models on the MS-COCO object detection dataset and compares their relative performance. This work shows that the student model performs comparably to the teacher model while maintaining a faster inference time and significantly fewer parameters, thus creating a model that can be deployed on edge devices.

Smart-Agent based Microgrid System for Improved Performance

Primary Author: Nabil Shuva, Electrical Engineering

Co-Authors/Collaborators: Michael Ezelle, Robert Craven; Tennessee Tech University

Advisor: Dr. Satish M. Mahajan

Smart agents are essential components of a modern smart grid system, enabling real-time monitoring and control of energy consumption, demand response, fault detection and correction, and integration of renewable energy sources. This research project aims to convert the previously designed CESR lab-scale grid into a smart agent-based microgrid incorporating 4-bus system and distributed energy resources for academic research purposes. The goal is to improve the grid's resilience and stability and reduce the overall carbon footprint by focusing on design, implementation, and optimization. Load flow analysis of the 4-bus system shows voltage drop across different segments of the line, particularly at bus 2.1, due to increased line impedance. Therefore, the grid's operating parameters are set to ensure a gradual reduction in voltage levels from 120V at the source to 110V at the end of the grid, considering the load characteristics of the system. The results based on LabVIEW HMI show that the smart agent provides essential information on grid voltage, frequency, phase angles, and fault detection.

Design and Testing of a multilayer structure for Radar stealth applications.

Primary Author: Jordan Thomas, Master's degree in electrical and computer engineering

Advisor: Dr. Indranil Bhattacharya

Stealth technology plays an important role in the security of our country. In order to obtain vital information on an enemy we must be able to conduct surveillance without being detected. This means that we need to continue to develop stealth technology in order to keep up with the modern devices in object detection and tracking. The main method used for object detection and tracking is Radar detection. Radar relies on the reflection of electromagnetic waves from an object. For radar stealth the object

needs low reflectivity and high absorptivity so that minimal power from the radar wave is reflected. The solution may be found in the creation of engineered materials which have tuned properties to produce maximum power absorption. My research is related to creating a multilayer structure comprised of different tuned materials that will improve the amount of power that can be absorbed as well as the bandwidth of absorption. The design will focus on the effects that different materials have on the wanted properties as well as the effects of element shaping. These structures will act like filters for different frequencies, and only have the wanted properties for a limited bandwidth. This research will aid in the creation of an affective radar stealth structure which is vital for modern electromagnetic camouflage.

Developing an Electric Vehicle Driving Dataset for Driving Behavior Research

Primary Author: Weston Beebe, M.S. Electrical and Computer Engineering

Co-Author/Collaborator: Dr. J.W. Bruce

Advisor: Dr. J.W. Bruce

Electric vehicles (EVs) have been gaining market share over recent years. With EV technology advancement and the reduction of cost of ownership, EVs prove to be a viable alternative to the internal combustion engine with higher efficiency and reduced emissions. Owning and operating an EV requires special consideration with the different means of energy storage and consumption in an EV. It is important to be able to provide EV drivers with accurate information about the vehicle. Studies of EV driving behavior can be utilized in constructing accurate EV models. This work presents an EV dataset with data recorded from various EVs, drivers, and driving conditions in the Upper Cumberland. Data was logged from the vehicles using OBD-II loggers. Data points were recorded on a per second basis and the fields include vehicle and motor speed, motor torque, high voltage battery voltage and current, and outside air temperature. This data can be used in data-driven EV modeling based on different driving behavior and driving conditions.

Predicting Smartphone Prices Using a Random Forest

Primary Author: Samuel Sylvester, M.S. in Electrical and Computer Engineering

Advisor: Dr. Syed Hasan

Smartphones are a staple of modern-day technology. Nowadays everyone carries a mobile phone for daily use. However, choosing a smartphone has many factors attached to it such as price, battery life, camera quality, Bluetooth, size, weight, screen size and several more. Something to consider is how all of the other factors account for the listed price of a smartphone. In this research, we intend to expand upon a recent work by Hu et al., where a Mobile Phone Classification dataset is used to predict the price of smartphones based on features of the phone with the help of SVM, KNN, Decision Tree and NaÃ¯ve Bayes algorithms. In this work we plan to extend this work by implementing a Random Forest algorithm on the same dataset. Due to the fact that the Random Forest algorithm implements several decision trees to improve the robustness of the results, we expect the results to improve. However, there are various parameters that need to be explored in order to make sure that the Random Forest algorithm is not taking an exceedingly long time to classify, such as number of trees in the forest and ability of implemented algorithm to run threads in parallel.

Minimization of Stray Field and Coupling Coefficient for a Double-D pad Wireless Power Transfer Using an Analytical Approach.

Primary Author: Taiye Owu, M.Sc Electrical and Computer Engineering

Advisor: Dr. Ojo Olorunfemi

Two critical key objectives in optimizing pad structure design for wireless power transfer are the coupling coefficient and stray magnetic field. While it is necessary to keep the coupling coefficient high enough for maximum power transfer, it is imperative to minimize stray magnetic field for safety reasons. Achieving both is much dependent on the pad structure and its geometry. FEA methods and parametric sweeps have been mostly used for optimizing pad structures, including the Double D pad, but are known to be time consuming and without clear fundamentals. This work proposes a simple and purely fundamental approach to optimize the coupling coefficient and the stray field. Derivations are well generalized and can be suitable for wide range of designs for the double D pad. Results show that the preliminary design pad structures for wireless power transfer, can be arrived at from purely analytical approach.

Novel P2-type Na_0.6Fe_0.5-2xMn_0.5Ti_xV_xO_2 Cathode Material for Sodium Ion Batteries

Primary Author: Joshua Thomas, Master's Degree in Electrical and Computer Engineering

Advisor: Dr. Indranil Bhattacharya

Research in Sodium-ion batteries (SIBs) has become popular in recent years. This is due to their lower cost and higher sustainability when compared to current Lithium-ion batteries (LIBs). The abundance of Sodium makes Sodium-based batteries a viable long-term replacement for LIBs. Sodium-ion batteries are similar to LIBs so they can make use of the current battery infrastructure. Even though SIBs are a viable alternative to LIBs, improvements are still needed to make SIBs a worthwhile replacement for LIBs. Some improvements needed include an increase in cycle life, capacity, and voltage of the batteries. These improvements can be realized through the development of high-performance sodium-based transition metal oxide cathode materials. This research presents a cobalt-free ????0.6????0.5????0.5??2(NFM) based cathode material and several titanium and vanadium doped variants. The focus of this research is on improving the stability of the transition metal oxide cathode structure. One of the goals of this research is to minimize the effects of Jahn-Teller distortion on the transition metal oxide structure. Minimizing the stresses caused by Jahn-Teller distortion will promote higher cyclability of the battery and improve the stability of the cathode material. The idea is to dope the cathode structure with titanium and vanadium to induce Jahn-Teller distortion in the opposite direction than what occurs already to lower the overall stress in the structure.

BESS Microgrid Integration for Improved System Reliability: Sub-Transient Fault Control

Primary Author: Ejikeme Amako, Ph.D. in Electrical Engineering

Advisor: Dr. Satish Mahajan

This research presents the integration of Battery Energy Storage Systems (BESS) in microgrid systems for improved system reliability by controlling sub-transient faults. The proposed system is modelled and simulated using Typhoon HIL software. The BESS current controller adjusts and compensates for the high magnitudes of the sub-transient fault current by generating new sets of d and q-axis reference current values. This adjustment helps to control the transient current values produced by the inverter output, ultimately reducing the magnitude and impact of the fault. The results showed a reduction in sub-transient fault magnitude when the reference reactive power injected by the BESS is increased over three incremental steps (Q1 = 0 VAR, Q2 = 500 VAR and Q3 = 750 VAR). The system is evaluated through three cases to observe the influence of the BESS on the Point of Common Coupling (PCC) fault parameters. The importance of using BESS inverters to inject reactive power for grid integrity is clearly demonstrated. Overall, in addition to its uses for load curtailment and peak shaving, the proposed BESS microgrid integration system has the potential to enhance the reliability and stability of power systems during fault scenarios.

Explainable ICS Anomaly Detection based on COPOD Continuous Wavelet Transform-Based EEG Motor Algorithm

Primary Author: Emmanuel Aboah Boateng, Electrical and Computer Engineering

Co-Author/Collaborator: J.W. Bruce; Tennessee Technological University

Advisor: J.W. Bruce

Industrial control systems (ICS) control critical infrastructure in society and ensure the proper functioning of many industries. However, they are vulnerable to various cyber-attacks and system malfunctioning, and as a result, anomaly detection is a crucial task in ICS stability and security. However, traditional ICS anomaly detection methods often lack transparency and interpretability, making it difficult for practitioners to understand and trust the results. This work addresses the problem by employing an efficient, parameter-free, and explainable anomaly detection method known as Copula-based Outlier Detection (COPOD). The method uses copula functions to model the dependence structure between the ICS data features and identifies anomalies based on the deviations from the estimated joint distribution. The method provides a clear and understandable explanation for detected ICS anomalies. The effectiveness of the method is demonstrated using publicly available ICS datasets and comparing the performance with previous work. The COPOD method outperforms traditional ICS anomaly detection techniques in terms of recall and explainability. By providing clear explanations for detected anomalies, the approach can help practitioners better understand and mitigate the potential threats to ICS.

Grid-Induced Telluric Currents for Non-Contact Load Monitoring and Fault Detection

Primary Author: Abigail Farris, Electrical and Computer Engineering

Co-Author/Collaborator: Charles Van Neste;

Advisor: Charles Van Neste

Grid-Induced ground currents occur when line-imbalances flow into theearth, creating a form of man-made telluric current. At the soil surface, a 2-dimensional current density exists that is directional and follows the time varying load profile of local power distribution system. The directional nature of the induced telluric current adds information that may be useful in developing low-cost monitoring systems that can pin-point the exact location of a fault while simultaneously monitor load profiles at a distance. Presented here is a non-invasive, in situ, sensing technique that allows direct measurements of a substationâ€™s load profile at a distance of 0.8km. Identification of the direction of the induced current in the soil is explored. A discussion on the sensorâ€™s key parameters, such as signal to noise and positional sensitivity is given.

Continuous Wavelet Transform-Based EEG Motor Imagery Time-Frequency Image Classification Using Attention-Based Transformer Mechanism

Primary Author: Mamunur Rashid, PhD

Advisor: Dr. Nan Chen

Electroencephalogram (EEG) signals are extensively used to classify the motor imagery (MI), which is a crucial control signal in developing brain-computer interface (BCI) systems. It is challenging to interpret these signals due to their unstable and noisy properties. The use of deep learning models for EEG MI classification has shown encouraging results in recent years. Although the transformer architecture has been considered as the gold standard for NLP tasks, it has huge opportunity in the fields like biological signal processing and computer vision, where this approach is very rarely used. In this study, we present a novel attention-based transformer mechanism for classifying EEG MI on the basis of their time-frequency images generated by continuous wavelet transform (CWT). The current framework is made up of an embedding layer, a series of self-attentional transformer encoder layers, a learnable attention mechanism, and a classification layer. The encoder is fed the CWT-based time-frequency image to obtain the spectral-temporal dependencies of the EEG MI signals. The attention mechanism is then utilized to selectively concentrate on the most relevant parts of the spectral-temporal images for precise classification. We evaluate our proposed method on some public EEG MI datasets, achieving competitive results compared to existing state-of-the-art methods. The proposed model provides a new approach for improving the performance of EEG MI classification in BCI technology.

Undergraduate Students

A Viable Machine Learning Dataset for Academic Dishonesty Detection in Computer-based Testing

Primary Author: Austin Jerrolds, Computer Engineering

Co-Author/Collaborator: J.W. Bruce

Advisor: Dr. J.W Bruce

With universities beginning to take strides towards computer-based testing environments, academic dishonesty is at an all-time high. Testing a studentâ€™s knowledge of the course material is arguably the most integral part of a university. Proctoring a computer testing environment proves to be difficult without being invasive of a studentâ€™s privacy. Computer based testing environments collect data that are indicative of academic misconduct. For example, computer-based testing environments can collect, exam duration, how many problems skipped, and how many perusal direction changes. Using the learning management systems logs, machine learning systems can be trained to recognize the student actions indicative of dishonest behavior. Machine learning algorithms require extensive training data sets. Sizeable data sets of honest and dishonest exam logs are extremely difficult to obtain. This work creates a synthetic data simulating honest and dishonest test taking strategies used by students in computer-based testing.

Real-Time Train Crowding Forecast

Primary Author: Marc Ebersberger, Computer Science

Co-Authors/Collaborators: Daniel Harnden, Shelby Smith, Cristina Radian

Advisor: Dr. William Eberle

The goal of this project is to forecast the train occupancy rate, defined as the number of passengers on-board the train divided by the total capacity of the train, of a given train at a given station for SNCF-Transilien, a French transit company. Forecasting occupancy rate improves operational performance and services the 3,400,000 passengers per day. Our model analyzed the history of a given train and station to forecast the occupancy rate. The standard performance metrics include mean absolute error (MSE) and root mean square error (RMSE). We compared different models based on these errors. Four factors are used to train our model: Past Trains: How the crowding factor varies from the three previous trains at the current station. Past Stations: How the crowding factor varies at three previous stations for the current train. Station: Current station of our target train.Hour: Current hour of our target train.

Department of Manufacturing & Engineering Technology

Graduate Students

Using Regression Machine Learning to Predict Mechanical Properties of Additively Manufactured Specimens with Imbalanced Data

Primary Author: Mohammad Alshaikh Ali, Mechanical Engineering

Advisor: Ismail Fidan

Additive Manufacturing (AM) is a relatively new manufacturing process that is frequently utilized for its versatility and accessibility. In broad terms, Machine Learning (ML) is a subcategory of Artificial Intelligence which uses data to obtain a predictive model. In this study, experimental testing is performed on tensile specimens fabricated by Material Extrusion (ME). The experimental data is then used to test the ability of predictive modeling using ML algorithms. The tensile specimens are fabricated using three different materials: CF-PETG, PA-CF, and NGEN. The process parameters used are: nozzle diameter, layer height, infill pattern, infill density, shells, and top/bottom layers. The process parameter values are different and imbalanced for each material. The ML regression algorithms are tested and produced using WEKA with Tensile Strength as the class to be predicted. The algorithm used is Random Forest with 10-fold cross validation applied to the data. The predictive model has an root mean square error of 5 MPa. This indicates that the ML algorithm can be used to predict using imbalanced data with moderate accuracy.

CNN-based real-time anomaly monitoring from voltage waveform data in wire arc additive manufacturing

Primary Author: Md. Abdul Karim, Ph.D. in Engineering

Co-Author/Collaborator: Dr. DuckBong Kim

Advisor: Dr. DuckBong Kim

Wire and arc additive manufacturing (WAAM), a direct energy deposition (DED)-based additive manufacturing (AM) technology, facilitates the creation of large structures, rapid deposition rates, and cheap equipment costs. The WAAM technique, however, can lead to poor-quality parts and process unpredictability because of the substantial thermal gradient it involves. The quality of the manufactured components can be improved through post-processing, but it is costly and time-consuming. To reduce the need for post-processing procedures, it is essential to detect irregularities in real-time. In this study, a convolutional neural network (CNN)-based technique for identifying anomalous WAAM processes in real-time applications has been developed. The proposed algorithm includes three modules: image conversion, CNN prediction, and real-time monitoring. The image conversion module converts a time series of voltage waveform data into voltage image data. The CNN prediction module classifies each voltage image into either a normal or abnormal image. The real-time monitoring module displays the CNN prediction model's findings. To verify the effectiveness of the proposed algorithm, experiments for single-bead material deposition were carried out. It was found that anomalous WAAM processes are accurately and instantly recognized, and the CNN classifiers are adequately trained to capture the critical regions in the voltage data for both normal and abnormal cases.

Real-time anomaly detection using convolutional neural network in wire arc additive manufacturing

Primary Author: Saiful Islam, Ph.D. in Mechanical Engineering

Co-Author/Collaborator: Dr. DuckBong Kim

Advisor: Dr. DuckBong Kim

Wire Arc Additive Manufacturing (WAAM) is a direct energy deposition technique that offers numerous advantages over other additive manufacturing processes, such as high deposition rates, large build volumes, low equipment costs, and high material utilization rates. However, due to the non-equilibrium thermal cycles and large thermal gradient, the WAAM process can result in poor part quality and process variability since the design rules are still being established. Although post-processing can enhance the quality of fabricated components, it is time-consuming and costly, making it unsuitable for

industrial applications. Therefore, it is essential to detect anomalies in real-time to reduce the need for post-process treatments. This study proposes a real-time anomaly detection approach utilizing a Convolutional Neural Network (CNN) for the WAAM process. The CNN-based models are trained on melt pool image data for various 1D process parameters to recognize anomalies. The study focuses on two types of abnormalities, balling and bead-cut flaws. The pre-processing of images has been performed to improve data quality during the learning process. The performance of the model has been evaluated based on classification accuracy and processing time.

Statistical Prediction of Fatigue Life of Functionally Graded Materials using Material Extrusion Process: A Data-Driven Approach

Primary Author: Suhas Alkunte, PhD in Mechanical Engineering

Co-Author/Collaborator: Dr. Ismail Fidan

Advisor: Dr. Ismail Fidan

Functionally gradient materials (FGMs) have received considerable attention in industrial applications owing to their potential to enhance material performance through engineered properties. In particular, the use of FGMs in additive manufacturing has shown promise. This study focuses on predicting the fatigue life of polymeric composite components under cyclic loading conditions using an artificial neural network (ANN) model. Tension-tension (T-T) fatigue test is performed at various stress levels, ranging from 100% to 40% of Ultimate Tensile Strength (UTS). The accuracy of the ANN's predictions is assessed by comparing them with actual fatigue life values obtained from testing. The utilization of ANN models for fatigue life prediction can significantly reduce the time and cost associated with traditional testing methods. The results demonstrate that the model can effectively predict the fatigue response of FGM parts with nominal error percentage. This work is unique as it predicts the fatigue life for polymeric FGMs, which has not been previously reported in the literature. This study highlights the efficacy of the ANN model for predicting fatigue life of polymeric FGMs and its potential for optimizing the design and manufacturing of FGM components for robotic gripper applications.

Knowledge Base Development and Prediction of Electrical properties for Additively Manufactured composites of High-Iron/Low-PLA by Neural network approach.

Primary Author: Joji Jeevan Kumar Dasari, Additive Manufacturing

Advisor: Dr. Ismail Fidan

Additive Manufacturing (AM) is one of the latest production technologies. It builds the parts layer by layer based on the digital data sent by any computer. Wide variety of materials (i.e. Plastics, Ceramics, Metals, and Composites) is fabricated in this advanced technology. There are several types of AM technologies. In recent years, Low-Cost Metal Material Extrusion (LCMME) process has been developed and implemented to produce metallic parts. The goal of this research is to produce Iron-made parts using the LCMME process. In this study, the research team has taken three different kinds of parameters to estimate the properties of the test specimens, they are Infill Density (100%, 60%, 20%), Layer Height (0.1, 0.2), and Print Speed (60, 45). The filament containing Iron and PLA is fabricated into rectangular samples with dimensions of 50mmx25mmx2.5mm to explore the properties of Electrical and Magnetic. And also, this investigation provides the information on prediction of Electrical properties of the Iron/PLA samples by using the Artificial Neural Network (ANN) techniques. Finally, the research concludes the knowledge base developed for the Electrical properties of the AM composites.

Keywords: LCMME, Electrical, Magnetic, ANN.

Machine-learning Based Study of the Print Quality in Material Extrusion Process

Primary Author: Orkhan Huseynov, PhD

Co-Author/Collaborator: Ismail Fidan

Advisor: Dr. Ismail Fidan

URECA Recipient

Material Extrusion is a cutting-edge manufacturing process that utilizes predefined machine codes to deposit filaments layer-by-layer, fusing the polymer layers together. This process creates thermal gradients that can alter the microstructure of the printed parts and affect the surface roughness of the final product. In this study, various Machine Learning algorithms were implemented and compared to predict the surface quality of printed parts with different levels of complexity. The specimens were manufactured using material of Polylactic Acid (PLA) with varying process parameters such as layer height, infill density, and fan speed. The findings of this study can facilitate the optimization of additive manufacturing processes and improve the surface quality of additively manufactured parts.

Keywords: Additive Manufacturing, Material Extrusion, Surface Roughness, Print Quality, Machine Learning

Prediction of Fatigue Behavior of Carbon-Fiber Reinforced PETG components manufactured by Material Extrusion with an aid of Machine Learning

Primary Author: Mithila Rajeshirke, Mechanical Engineering

Co-Author/Collaborator: Dr. Ismail Fidan

Advisor: Dr. Ismail Fidan

Recent advancements in material extrusion (ME) made it applicable for using polymeric and composite structures in various structural and load-bearing applications. Cyclic loads cause fatigue, which is the development of structural damage, which leads to catastrophic failure at lower stress if compared with normal mechanical loading. So, it is of utmost importance to study the fatigue behavior of the composite parts manufactured by ME. In polymeric composite components, fatigue life prediction is a challenging process. The objective of this research is to perform the fatigue prediction of short carbon fiber-reinforced Polyethylene Terephthalate Glycol (SCF-PETG) components manufactured by the ME process with the aid of machine learning. An important aspect in analyzing the results of fatigue tests is the use of Machine Learning. The goal of machine learning is to create models that can automatically identify patterns in data and make predictions or decisions based on those patterns. For predicting fatigue life, several researchers have focused on several statistical methodologies. In this study, Artificial Neural Network (ANN) machine learning algorithm is employed. The stress Vs. Number of cycles (S-N) curves are developed by these models using experimental fatigue data to forecast fatigue life at various stress levels.

Undergraduate Students

Efforts to standardized uniaxial load test of well-preserved human tissue

Primary Author: Miguel Fuentes Garcia, Mechanical Engineering

Advisor: Steven Anton, PhD

URECA Recipient, CISE Recipient

The development of prosthetics for human tissue is limited by the existing techniques used to characterize its material properties. The performance of the traditional stress-strain test is affected by the loss of mechanical properties due to the moisture of the tissue and failure within the clamping area of standard clamp designs. However, thank to the incursion of the 3D printer into the field, the use of 3D printed clamps seems to present a solid success in preventing the failure of the tissue during testing. Due to the tissue's nonhomogeneous characteristics, the mechanical properties vary along its length. Non-contact techniques quantify deformation during the test to measure it in different regions of the sample. Currently, methods for standardizing stress-strain tests of human tendons combined with DIC typically use an airbrush to create a random pattern on the tendon surface. The replica of this existing technique can be challenged by the lack of control of the paint applied by the airbrush. This work presents a technique to approach the stress-strain test of well-preserved tissue using 3D printed clamps and DIC. The samples for this work included Planter Fascia and Achilles tendons to analyze the performance of the proposed clamp design in thin and thick human tissue. These results can be used in the future to repeat this technique with human tendons to use a more consistent random pattern technique for DIC.

Department of Mechanical Engineering

Graduate Students

Indoor Impact Event Localization via Energy Ratio Mapping Function in Dispersive Media

Primary Author: Andrew Gothard, PhD in Engineering

Advisor: Dr. Steven Anton

In this work, a new energy ratio mapping (ERM) algorithm is proposed to improve impact event localization in vibration-based smart building applications and is compared to the performance of a k-nearest neighbor (KNN) algorithm. Impact event localization is an essential area of smart building research for applications such as occupancy estimation, patient monitoring, and intruder tracking.

Previous energy-based methods have been shown to give sub-meter accuracy for measurement systems with accelerometers mounted on the surface of the floor as well as systems with accelerometers mounted under the floor. However, available energy-based methods are limited to exponential decay models, which are only applicable to homogeneous floor structures. Supporting floor structures create inhomogeneities, which causes the wave to decay differently in each direction and requires a more complex model to describe. This work proposes a new energy ratio mapping (ERM) algorithm to overcome this limitation. The ERM algorithm computes ratios of response energy between pairs of sensors for impact locations across the floor structure to be monitored. The energy ratio maps act as a complex decay model of a mechanical wave in two dimensions and are used to predict the potential locations of an impact event. A KNN algorithm is also trained using energy ratio and time difference of arrival (TDOA) features and to see if a classical machine learning algorithm can be used to outperform the ERM algorithm.

Genetic Algorithm Optimization of Transducer Locations in a Realistic, Compartmental Force Sensing Total Knee Replacement

Primary Author: Brandon Hines, PhD Mechanical Engineering

Co-Author/Collaborator: Dr. Steven Anton; TTU Faculty

Advisor: Dr. Steven Anton

Total knee arthroplasty is one of the most common and successful orthopedic procedures performed in the United States, but a number of patients still report some level of post-operative pain. A lack of an in vivo method for tracking forces and alignment presents the challenge of non-invasive diagnosis of potential failure mechanisms in total knee replacements (TKR). Our research group seeks to solve this problem by developing an in vivo sensing system that will include piezoelectric transducers to measure the location and magnitude of compartmental forces in a TKR. A challenge presented by this task is identifying transducer locations that minimize error in the sensed compartmental force locations over the duration of the total gait cycle. This work presents a genetic algorithm to increase the performance of six piezoelectric transducers, embedded in the polyethylene component of a TKR, by optimizing the location of the transducers. We seek to simulate the behavior of a relevant point during the gait cycle, so the proposed genetic algorithm optimization simulates an axial force applied to the femoral component rotated at 14Â° which corresponds to the point of max load. The study will compute the forces transmitted to each transducer, and the forces will be used to calculate the location of compartmental forces as applied through the femoral component. The algorithm will converge on the locations with minimum error to be identified as the optimal locations.

Predicting Upstream Boundary Conditions in a Turbulent Flow using CNN

Primary Author: Reza Nouri, Ph.D.

Advisor: Ahmad Vasel-Be-Hagh

This study presents a novel approach for predicting the shape of bluff bodies in a turbulent flow using convolutional neural network (CNN). The modified GoogLeNet architecture was trained on scalograms obtained from velocity signals downstream of circular, square, and triangular bluff bodies. The hyperparameters of the CNN model were optimized using Bayesian optimization, with a focus on determining the optimal dropout layer percentage, mini batch size, solver name, learning rate, and number of epochs. The study also investigated the effect of the number of signals and the size of the probing area on the accuracy of the CNN model. Results showed that the model was highly accurate for unknown signals within the training box, but less accurate for unseen signals outside the box. The simulations were conducted on the HPC using OpenFOAM. This research provides a promising approach for predicting the shape of bluff bodies in turbulent flow using CNNs.

Optimization of Vehicle Fuel Use for Micro-HEV with Passive SCR System

Primary Author: Sachin Joshi, Ph.D

Advisor: Pingen Chen

Lean-burn gasoline engines have shown significant fuel-saving benefits. With help of passive selective catalytic reduction system (p-SCR) challenge of NOx emission can be tackled. However, fuel penalty associated for ammonia regeneration is still a challenge. This study is focused on optimization of fuel use by introducing micro-HEV vehicle that integrates lean-burn gasoline engine and p-SCR system for optimal fuel penalty associated with ammonia regeneration. Simulation results demonstrated that, by implementing the micro-HEV, the fuel penalty is reduced by up to 71% comparison to traditional conventional powertrain.

Balancing Authority Regional Estimation

Primary Author: Craig Bowen, Master's

Advisor: Dr. Pingen Chen

Electrical power management in the United States is organized into subregions, each monitored and controlled by a Balancing Authority (BA). It is the BAâ€™s objective to adjust the production of energy to meet current energy demands of its local region. This power is produced by utilizing a balance of multiple methods, such as coal, natural gas, hydro, wind, etc., each producing varying amounts of CO2 emissions. Operational data is collected and provided by the United States Energy Information Administration (EIA), which includes power production and demand, generation balancing, and emission generation and balancing. The purpose of this study is to analyze the data provided by the EIA and build a classification model, using boosted decision trees in MATLABs Classification Learner application, to define the local operating BA region.

Identifying EV One Pedal Driving Use with Machine Learning

Primary Author: Caleb Dunlap, Ph.D

Advisor: Dr. Pingen Chen

One pedal driving is a feature in many plug-in hybrid and electric vehicles that allows the driver to use only the accelerator pedal to control the acceleration and braking of the vehicle. When the one pedal driving feature is activated, easing off the accelerator pedal will bring the EV to a complete stop by only using regenerative braking. This feature is important to use because the range of the EV is greatly increased by using regenerative braking. Identifying when one pedal driving is in use based on signals such as pedal position, motor torque, vehicle speed, etc. is essential to understanding EV driver behavior. To do this, a variety of machine learning algorithms are trained to identify one pedal driving usage based on data collected from real world EV drivers. After training, these algorithms can recognize one pedal driving usage in previously collected data sets. By identifying when one pedal driving is active, driver behaviors can be accessed more accurately, and the efficiency of the EV can be improved.

An Investigation of a Laboratory Scale Surrogate Model for the Design of Smart Buildings

Primary Author: Jacob Hott, Masters of Mechanical Engineering

Advisor: Dr. Steven Anton

In smart building infrastructure, the novel concept of instrumenting the underside of composite floors with a grid of dynamic sensors allows for the ability to localize footsteps, estimate occupancy levels, determine an individualâ€™s gender, and detect the discharge of firearms. These abilities show great potential to non-invasively expand upon existing smart building features in automation and security. However, works with these instrumented floors do not extensively cover the process utilized for the design and implementation of these measurement systems during a buildingâ€™s construction. This work aims to introduce a low-cost laboratory-scale surrogate model for the design of dynamic measurement systems for composite floor structures. The dynamic characteristics of the surrogate model are evaluated through the modal analysis of five different points spanning the length of the surrogate model. The gathered frequency response data is then compared to five representative points on a floor within a building containing the same cross-sectional floor geometry as the designed surrogate model. The building has been instrumented with dynamic sensors in the same manner as the surrogate model. Results show that the constructed surrogate model can determine the lower-bound sensitivity levels required for the measurement of floor vibrations resulting from footsteps and provide a conservative shock limit for sensors mounted to the floor.

Personalized Electric Vehicle Range Prediction Based on Driving Pattern Clustering

Primary Author: Magdy Abdulmagued, PhD

Advisor: Dr. Pingen Chen

Range anxiety and infrastructure limitations are major challenges for electric vehicle (EV) users. To address these challenges, accurate estimation of the remaining driving range (RDR) of EVs is essential. However, most existing methods for RDR estimation assume constant driving patterns throughout the trip, which is unrealistic in real-world scenarios. In this work, we propose a personalized EV range prediction system that accounts for the variability of driving patterns based on the userâ€™s speed profile. The proposed work utilizes machine learning algorithms to analyze historical driving data and cluster driving patterns into different segments. Based on the clustered driving patterns, the system predicts the range of the EV for each individual driver. The proposed system is evaluated using real-world driving data collected from a Nissan Leaf EV. The proposed RDR predication system can help to

alleviate range anxiety and enhance user confidence in EVs by enabling drivers to plan their trips and optimize their EV usage according to their own driving patterns.

Undergraduate Students

Efforts to Standardize Uniaxial Tensile Testing of Well-Preserved Human Tissue

Primary Author: Miguel Fuentes Garcia, Mechanical Engineering

Advisor: Steven Anton, PhD

URECA Recipient, CISE Recipient

The development of prosthetics for human tissue is limited by the existing techniques used to characterize material properties of tissue. The ability of traditional tensile tests to determine mechanical properties can be affected by several factors, which may include failure within the clamping area of standard clamp designs. The use of custom-designed 3D printed clamps seems to provide success in preventing tissue failure and minimizing slippage during testing. Non-contact imaging techniques can be used to quantify full-field deformation during the test, allowing behavior to be quantified in different regions of the sample. Digital image correlation (DIC) is investigated in this work and is able to calculate strain by comparing successive images taken during the sample deformation. In order to measure changes in the pictures, the analyzed surface must have a well-defined high-contrast random pattern. Currently, methods for standardizing tensile tests of human tissues combined with DIC typically use an airbrush to create a random pattern on the tissue surface. Replication of this existing technique can be challenging based on the lack of control of the paint applied by the airbrush. This work presents an approach for tensile testing of well-preserved human tissue using 3D printed clamps and DIC.

College of Fine Arts

School of Music

Undergraduate Student

Contrabasoon Restoration

Primary Author: Jacob Starker, Music Education/ Music Performance

Advisor: Dr. Jeff Womack

To have a fully functioning bassoon studio, a contrabassoon is necessary. As of 2020, the contrabassoon owned by the School of Music happened to be in an unplayable condition. The project undertook of a complete restoration benefitted the music school by providing it with a working contrabassoon and taught me basics of wind instrument repair and acoustics. Before the project could begin, location and supplies needed to be considered. The bassoon repair technician Jimmy Keyes provided access to his workshop located in Alexandria, Tennessee for the project. The supplies list was promptly figured out, submitted, and approved for a URECA grant, taking care of all tool expenses. With all of the supplies and contrabassoon at the workshop, we began disassembling the instrument. Each joint and piece was placed in an easily identifiable manner, allowing for easy reconstruction later. After some attention, the joints could be reattached easily and securely, sealing the contrabassoon. It should be noted that once set in, the joints can not be removed easily like with many other instruments. After the joints, we examined the pads for quality and positioning. If the pads were not pliable or up to a playable standard, they were replaced by higher quality pads. Finally, with everything put together, the contrabassoon went through a small testing phase. Each note was examined and, if a problem was found, adjusted as needed. After this short process, the contrabassoon was playable.

Notes

Tennessee TECH