# SUMMER UNDERGRADUATE RESEARCH POSTER SESSION

# ABSTRACT BOOK

## August 6-13, 2021

ForagerOne-Symposium Platform
(Virtual Presentations)

LAUNCH
UNDERGRADUATE RESEARCH

**Stability of Pyridinium Derivatives in Alkaline Media: A Model Study**

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*REU/SURE Program Name:* NSF-REU Chemistry

As a clean alternative to combustion energy sources, alkaline anion exchange membrane fuel cells (AAEMFCs) use hydrogen and liquid alcohols as fuel, therefore not producing carbon dioxide. One of the limitations of this type of fuel cell is the stability of the organic cationic membrane over time under the operating conditions (high pH, high tempertature). *N*-alkylpyridiniums are common moieties found in cationic membranes, however their use in AAEMFCs is limited due to the pyridinium's poor stability in alkaline media. A model study was conducted to determine the optimal functional group and substitution pattern on pyridinium cations that can later be translated to the fabrication of a stable pyridinium-based membrane. The synthesis of different *N*-alkylpyridiniums bearing different groups in the 2-, 4-, and 6- positions on the pyridine ring will be presented, and the stability of these molecules in alkaline solutions will be discussed.

**Circadian Clock Control of Valyl-tRNA Synthetase in *Neurospora crassa***

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The circadian clock is an endogenous time-keeping mechanism found in most living organisms such as mammals, insects, bacteria, and our lab model organism - the filamentous fungus - Neurospora crassa. The clock allows an organism to anticipate daily environmental changes corresponding with the day–night cycle, and adjust its physiology and behavior accordingly. About half of proteins synthesized in eukaryotic cells that are under the control of the endogenous circadian clock, arise from mRNAs that are not rhythmic, supporting a role for clock control of posttranscriptional mechanisms. The circadian clock in Neurospora crassa controls rhythmic mRNA translation through the regulation of the eIF2α kinase CPC-3, which phosphorylates and inactivates eIF2α. Rhythmic activation of CPC-3 was abolished under conditions in which the levels of charged tRNAs were altered, such as in the valyl-tRNA synthetase mutant, un-3ts which leads to 50% reduction in ValRS activity. This supported the possibility that rhythmic accumulation of ValRS is necessary for rhythmic P-eIF2a levels. To test this, ValRS was tagged with the HA epitope, and ValRS::HA was constitutively expressed from the copper-controlled tcu-1 promoter (Ptcu-1). We successfully generated heterokaryotic bar::Ptcu-1::valrs::ha transformants. Experiments are currently underway to obtain a bar::Ptcu-1::valrs::ha homokaryotic strain and use this to examine P-eIF2α levels.

**$^{19}$F NMR Reveals Structural Perturbations in Cancer Associated Mutants of Pin1**

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Pin1 is a key protein involved in the regulation of cell development and is known to have various single nucleotide polymorphisms (SNPs) associated with diseased states such as cancer. Pin1 is overexpressed in about 60 known types of human cancers which makes Pin1 an interesting drug target. Understanding of the structural and dynamic changes of Pin1 caused by the SNPs are important for understanding the mechanisms behind Pin1 action and developing key therapeutics. Currently, it is unknown how the cancer related mutations perturb the structure and dynamics of Pin1. We employed $^{19}$F nuclear magnetic resonance ($^{19}$F NMR) with fluorine labeled tryptophan to investigate the effect of SNPs on the structural and dynamic changes in Pin1. Pin1 has three native tryptophan residues, and utilizing site directed mutagenesis, a fourth Trp site was introduced by mutating Met130. The $^{19}$F NMR spectra provided chemical shifts and linewidths for the fluorinated residues, which revealed structural and dynamic perturbations present in both domains of Pin1.

Interestingly, Trp-73 did not change throughout the experiments despite being in the PPIase domain. The perturbations in the two domains of Pin1 display that the SNPs cause a change structurally and impact the dynamics.

**A Novel Study on the Enhancement of Completion Fluids Corrosion Properties in Petroleum Production System**

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Corrosion is the natural and continuous degradation of materials caused by either chemical, mechanical, or electrochemical reactions. Corrosion inhibitors may be added to the completion fluids to address corrosion—the process of inhibiting corrosion assists the company in monetary profits and operators' safety.
This research concentrates on corrosion and corrosion inhibition treatments for several completion fluids such as Potassium Chloride, Sodium Chloride, Sodium Bromide, Calcium Chloride, and Calcium Bromide. Completion fluid has several properties and characteristics that may affect its efficiency. Two of these properties are salinity and pH level. High salinity levels in a completion fluid containing inorganic salts will lead to the corrosion of drill tools and casing. This corrosion process is not just restricted to reducing the life of the drill tools or the oil and gas well; instead, it may also cause formation damage.
In order to manage corrosion successfully, an economic analysis is required for the effectiveness of the cost. A mixture of Phosphate based corrosion inhibitor and Sulfite based corrosion inhibitor seems the most economical and efficient among the variety of tested inhibitors for different completion fluids. This study involved the use of monovalent and divalent brines. The divalent brines were identified as a better medium for lowering corrosion rate and conditions than the monovalent brines from the corrosion rate and type results.

**A Single-Camera Multi-Angle Imaging Apparatus for High-Rate Materials Testing Applications**

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Hypervelocity collisions present a significant difficulty in many outer-space exploration and national defense-related engineering applications. Such hypervelocity impact (HVI) events can be simulated, often using some form of a light-gas gun. Features of a HVI events studied by researchers include back face debris cloud propagation, shockwave propagation, impact temperature, and the failure mechanisms of the target materials. Ultrahigh-rate imaging techniques have found use in the study of HVI events, one of the few forms of in-situ diagnostics for such extreme test cases. However, this form of imaging provides two-dimensional projections of a three-dimensional event. To eliminate the uncertainty in the third dimension, and study anisotropic response, imaging from multiple viewing perspectives is required. Unfortunately, the highly-specialized cameras used to capture HVI events make an imaging setup with multiple cameras often costly and space-prohibitive. This situation is especially true when imaging a HVI created by a two-stage light gas gun (2SLGG), where there is little space available for diagnostics equipment. An optical multi-angle imaging device can overcome these challenges by splitting the pixel array of a camera chip into multiple sections, recording multiple views with one camera. An array of mirrors and prisms guide and image multiple viewing perspectives of the same object or event into a single camera. Each image is projected onto one of the individual sections of the pixel array created by the multiscope. This presentation details the process of designing and constructing a mount for the prisms on a dual-angle imaging device, as well as the geometry of the optical setup surrounding the imaged object. Tests conducted using a DSLR camera to image several stationary objects are described in detail before the multiscope was utilized to image a debris cloud formulated by an HVI event using a MHz-rate camera.

**A Neural Network to Categorize Behaviors in *Astyanax mexicanus***

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In reasonable levels, stress is an adaptive response to threat. Chronic and disproportionate stress responses are, however, maladaptive and are often described as anxiety disorders in humans. The fish species *Astyanax mexicanus* may be a natural model system in which to study stress. Previous research indicates the surface-dwelling morph of the fish species *A. mexicanus* exhibits higher anxiety levels than the cave-dwelling morph. These previous studies used time spent in the bottom of a novel tank as an anxiety metric. This metric often varies with unrelated factors and is thus a poor metric of anxiety. To establish whether *A. mexicanus* is truly an adequate model system for anxiety disorders, we developed a more robust metric for anxiety in fish. We created a neural network for automatically categorizing fish behaviors, trained this neural network to recognize *A. mexicanus* behaviors, validated the accuracy of this neural network, and determined whether *A. mexicanus* morphs differ in time spent on each behavior. We found the neural network to be as accurate as human classification and found that fast-turning differs between surface and cave morphs. Future research should identify which of these behaviors is associated with anxiety and determine whether the cave and surface-dwelling morphs differ in the amount of time spent on the anxiety-associated behaviors.

**AI Toolbox for Defect Detection**

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In today's age of advanced manufacturing technologies, quality control is playing a fundamental role in not only ensuring the standards to the products but also assists in improving the efficiency of technologies via predictive maintenance strategies. Most defects like scratches, holes, warping, slag etc. in the manufacturing domain are visually identifiable upon manual inspection or by the use of robust imaging techniques. However, this form of quality inspection is both time inefficient and results in traces of human error. In addition, there are defects that are only found on the microscopic level such as micro-cavities. Experimental results conducted by the University of Zilina conclude that such defects have a significant impact on the fatigue endurance of materials such as ductile cast iron (Novy, 2018). Therefore, it is necessary to be able to locate and isolate defects, specifically at a microscopic level, to ensure the functionality of material in the manufacturing process. The use of machine learning methods for quality control through defect segmentation helps in addressing these issues by improving efficiency in terms of time and accuracy of detection. Humans discern defects on a surface by observing and recognizing the color, intensity and textural changes on the surface. In this age of Industry 4.0, with deployment of sensors across the shop floor has given access to immense amount of data. Various efforts using advanced machine learning methods have been introduced for analysis of this information and optimization of manufacturing strategies. A main setback to these efforts is the difficulty in labelling the data for use of supervised learning methods. We aim to introduce an Imaging-Toolbox encompassing the capability of various image processing and unsupervised machine learning methods to perform defect segmentation on image samples collected from a confocal imaging camera (MC2) developed by STIL.

**Adapting tRNA Scaffolds for sgRNA Delivery from a Single Plasmid in *Aedes aegypti***
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Recent studies by Port and Bullock have led to the development of a multiplexed sgRNA vector, pCFD5. Each sgRNA within the plasmid is flanked by tRNAs which, upon self splicing, will release the sgRNAs to complex with expressed Cas9 in Drosophila models. This method proved effective at increasing the efficiency of knockout inheritance in single and multitarget constructs. An invaluable tool, we aim to adapt this construct and test its effectiveness in our model, *Ae.aegypti.*

**Additive Manufacturing of Stretchable Electronics by Aerosol Printing**
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As new advancements in additive manufacturing continue to arise, it is important to address the growing demand for innovation in the production of electronics. More specifically, the development of a scalable, efficient method for the manufacturing of flexible electronics is an attractive prospect with applications in multiple industries. In this research project, a method that employs aerosol printing is used to produce a highly conductive, sandwich-structured material which consists of encapsulated silver nanoparticles (Ag) with polyimide (PI) as the insulator. The PI/Ag/PI composites are first heated at a high annealing temperature which contributes to the conductivity of the silver nanoparticles while effectively bonding it with the surrounding polyimide layers. The composite is then transferred to a stretchable substrate by thiol-epoxy bonding. Additionally, the electric conductivity of the transferred conductor is retained upon deformation. This promising aerosol printing method for manufacturing stretchable electronics is a potential alternative to other current high-cost processes.

**Aggie Legacy Project with High School Collaboration**
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*REU/SURE Program Name:* Aggie Legacy Project

The Houston National Cemetery houses 394 Aggie veterans who are buried in the cemetery as of 2021. These Aggies contain little information in the SilverTaps Website and the veterans Legacy Memorial Website. Artificial Intelligence and the existing database provided by the veterans Association helped to facilitate the collection of data of Aggie veterans in the Houston National Cemetery, but these technologies can only reach a certain point before humans are needed for critical thinking. Addionatially, collaborating with Citizen Scientists, such as high school students, serve as a catalyst for quick obtainment of data to memorialize these Aggie veterans and to prolong their legacy for Texas A&M University. Through the creation of Transdisciplinary education knowledge, skills modules and experiential learning, the students were able to obtain a background understanding of the cemeteries and additional information crucial to the Aggie Legacy Project. Within the cemetery, the students were assigned to collect 8 headstones by completing a form via a Web Application, which was mapped on a Geospatial Online Database. Aggie veteran locations are portrayed as points of verified Aggie veteran headstones within the cemetery. Citizen Scientist students focused on assigned sections to collecting information on 25 Aggie veterans. Data collected included a current photograph of the headstones and other information. Additionally, the students researched the biography of the Aggie veteran about their military service, post-war life, and their student lives at Texas A&M. The current results of the involvement of the high school students include the obtaining of certificates upon completion of the modules, collection of 81 headstones on the ArcGIS Online map, and collecting biographical information on 21 Aggie veterans. One difficulty faced was the lack of initiative the students took in collecting data and participating in the project. This could indicate the necessity for a stronger incentive of participation than a gift card, t-shirt, etc. The involvement of the high schoolers proved the versatility of the project and quick capability to train them on the main portions of the project. This research provides a Transdisciplinary collaborative to collect data and create biographies accurately.

**Air Quality and Seaport Sustainability Within the Seattle/Tacoma and Houston Metropolitan Areas**

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*REU/SURE Program Name:* OCEANUS

As climate change presents great threats, decarbonization is a leading challenge in the maritime industry. This can be seen with the new regulations put out by the International Maritime Organization on fuel emissions (also known as IMO 2020 and IMO 2050). In this context, it is important to study and research the trends of port sustainability to analyze the health risks of continued air pollution produced by commercial shipping. In this research, we examined the situation of two major maritime clusters in the United States (Houston and Seattle/Tacoma), two of the largest ports in terms of container volumes (TEUs) each year. The data collection was based on reports, plans and strategies that were audited and made publicly available for both ports (The Northwest Seaport Alliance and the Port of Houston Authority). Taking a marketing perspective, the social media accounts of these ports were also analyzed to determine how clean air policies are being disseminated by the port community and to society at large. Because air pollution is not a short-term fix, updated performance results and data analyzation is typically reported in segments of five to six years. The year 2013 will serve as a baseline for the inventory collected. This research focused on nitrogen oxides (NOx) and fine particulate matter (PM2.5), as they are a primary source of pollution emitted by diesel engine combustion. Diesel engines power a majority of ocean-going vessels (OGV), harbor vessels (HV) cargo handling equipment (CHE), locomotives, and heavy-duty diesel vehicles (HDDV) within the maritime industry. This study will concentrate on these five sectors to track the tons per year (tpy) of NOx and PM2.5 emitted. Preliminary findings indicated that a high percentage of NOx and PM2.5 emissions were released by ocean-going vessels within both the Northwest Seaport Alliance and the Port of Houston Authority. These findings encourage the adoption of cleaner alternative marine fuels (like LNG) and the development of updated infrastructure within seaports. Further research is also needed to consider other regulatory aspects that may change the policies and the practice of alternative marine fuels in the United States.

**Alaska's Arctic Slope Regional Corporation has a Greater Focus on Economic Freedom than Enhancing Culture**

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*REU/SURE Program Name:* Multilevel Climate Governance in Alaska

Alaska Native Corporations (ANCs), formed by congress via the Alaska Natives Claims Settlement Act (ANCSA) in 1971, play a vital role in Alaskan livelihood. Arctic Slope Regional Corporation (ASRC) is the northern most corporation, and the most lucrative; having businesses in government contracting, petroleum refining and marketing, energy support services, industrial services, construction, and resource development. Through these, income is created and dispersed among the shareholders- native people who come from the region. ASRC has been the top Alaska-owned and operated corporation for over 25 years in a row. In 2019, they earned $3.8 billion dollars in revenue. Being a pillar of the community, it is imperative to know how true to their mission to "enhance culture and economic freedom" they are. Especially during a time in which the Arctic National Wildlife Refuge, an area in their region, has made global news for the possibility of oil extraction. We studied ASCR's website (including: about, philanthropy, business, leadership, advocacy, communities, land and history), companies, and newsletters from 2017-2021 to determine where they lay on the balance of economic freedom and enhancing culture. We conducted research by uploading material to QDA minor and doing a comparison analysis through an open coding scheme. We found economic freedom content more than twice as often than Iñupiaq culture content. We believe this serves as good preliminary data, as a company's website does not encompass all that it is and has to offer. The information gleaned from this analysis and further studies can inform the corporation itself, as well as its shareholders on the integrity of the company.

**Assessing the Relationship between Federal Disaster Funding and Social Vulnerability after Hurricane Harvey in Harris County, Texas**

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Post-disaster impacts from hurricanes pose a major long-term threat to flood-prone communities, despite the actual flood event lasting only a few days. Recovery efforts become more critical in socially vulnerable communities as they are often disproportionately affected by financial losses and a slower recovery time due to their limited capacity. Even though there are federal programs meant to provide disaster funding to vulnerable communities and individuals, it is vital to determine whether or not these populations are getting access to their fair share. To address this limitation in research, this study focuses on the relationship between a community's social vulnerability and disaster relief funding received after a major flood event. This case study utilizes t-tests to compare the average differences between the funding a community receives and their social vulnerability in Harris County, Texas, following Hurricane Harvey. This allows for statistical comparisons to be drawn between areas of high and low social vulnerability and see if and how disaster funding differs. Preliminary findings show that areas of higher social vulnerability are not receiving a significantly higher amount of aid than areas of lower social vulnerability. These findings provide insight for federal agencies to reassess their current strategies for reaching target communities and individuals, whom such programs are designed for, to apply and receive aid. Future studies should focus on applying a similar approach to other areas and assess the nuances in the system which prevent socially vulnerable groups from accessing federal disaster funding awareness regarding such services.

**Best-fit algorithm influences virtual casts and their alignment discrepancies.**

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Computer-based technologies play an important role in all aspects of our daily life as well as in dentistry. Intraoral scanners are progressively implemented in restorative dental procedures including computer-aided implant planning procedures, virtual diagnostic waxing, prostheses design methods, and virtual patient integration. Three main alignment techniques have been described to superimpose a patient's digital files namely best-fit algorithm (BF), reference or section-based best-fit (RBF), and landmark-based best-fit alignment (LA). The BF uses an iterative closest point (ICP) algorithm to align two meshes using an entire dataset. This minimizes the discrepancy between the two-point clouds and also iteratively revises the transformation required to minimize an error metric. The RBF method superimposes datasets by restricting alignment to operator-identified sections of the dataset. Lastly, the LA technique is performed by an operator who manually selects common landmarks or common points on each dataset, which are then superimposed by the software. The alignment of a patient's digital files is required when using a digital workflow for different restorative treatment procedures. The influence of errors produced during the alignment step has limited acknowledgment in dental literature; therefore, the complexities and accuracy discrepancies on this crucial digital workflow procedure remain uncertain. The purpose of the present in vitro study was to measure the influence on the BF algorithms (entire dataset, 3 or 6 points landmark-based, or section-based BF) on virtual casts' alignment discrepancies. The null hypothesis was that there would be no difference in alignment discrepancies amongst the virtual casts superimposed using the different BF algorithms tested.

**Binder Jetting Additive Manufacturing of Ceramics: Improvement of Part Quality**

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This study investigated possible improvements that can be made in the quality of ceramic parts using binder jetting additive manufacturing techniques with a particular focus on flexural strength and density. The purpose of the research was to test out how the final samples might be affected by different compaction thicknesses and layer thicknesses to discover improvements that can be made to the final parts. By examining the quality of the samples printed, made from Thethonite High Alumina (96% Alumina), using the ExOne Innovent+ binder jetting 3D printer, adjustments on the compaction thickness and layer thickness were made before printing the samples. For printing, the parameters were adjusted to improve the quality of the powder bed. For post-processing, curing, depowdering, debinding, and sintering techniques were used. After completing the steps of ceramic binder jetting (feedstock preparation, printing, curing, debinding, and sintering), the lapping technique was used to prepare the surface of the printed samples. Finally, the density and mechanical behavior of the final samples were investigated through the Archimedes' and the flexural strength methods, respectively. Other results suggest that having a high compaction thickness on only the upper and bottom half of the ceramic samples did not improve the mechanical behavior.

**Biomechanical Evaluation of a Novel Equine Hock Arthrodesis Technique**

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*REU/SURE Program Name:* BMEL-UGRP

Distal tarsal osteoarthritis is a common source of poor performance in equine athletes, with hindlimb lameness persisting in 25-50% of medically managed cases. Given the low long-term success rate of non-surgical treatments, veterinarians often perform arthrodesis to improve soundness. However, traditional arthrodesis, which installs three diverging 3.2mm screws across the distal intertarsal and tarsometatarsal joints, has yielded inconsistent results. Therefore, a novel technique is proposed to provide compression across the joint surface with trans-articular screws. The present study evaluates the biomechanical integrity of this novel arthrodesis technique in compressive and torsional loading regimes, compared to healthy and traditional arthrodesis control tarsi. Equine hock samples sectioned from mid femur to mid tibia are partially dissected to expose the ends of the bone. A 0.25" diameter through-hole is drilled in the distal tibia of the specimen to mount and center the hock on a custom jig. The femoral end is potted in 50lbf Labstone (#1053050), then flipped after curing to pot the tibial end. The equine hock undergoes an axial compression test to failure, simulating physiological loading with dorsoplantar bending. Failure loads are compared between trans-articular screw arthrodesis and control tarsi. A pilot study was conducted using a healthy hock to validate fixtures and methodology. Limitations of the study include the low loading of the healthy joint, attributable to the low resistance resulting from the expected lack of fusion and unsecured patellar tendon of the specimen. Additional limitations of the pilot study constitute inadequate seating of the tibial end into the Labstone due to insufficient distance between these and the critical hock joint region. These limitations will be addressed in future work by performing loading tests on the longer traditional and novel arthrodesis tarsi, which are expected to display higher resistances and have higher contact with the Labstone mixture.

***Key Words:*** tarsal osteoarthritis – arthrodesis – axial compression – steel pots – labstone – failure loads

**Building A Self-Driving Car**
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*Research Discipline:* Engineering (STEM), Technology (STEM)
*REU/SURE Program Name:* USRG

Self-driving vehicles are no longer a concept from a science fiction periodical. They are our new reality. The challenge that comes with this subject is not the possibility of engineering self-driving cars; the present challenge is to make self-driving cars reliable and safe. This challenge calls upon engineers to design vehicles that will detect and respond to an array of road signs, assess everchanging surroundings, react to different driving conditions and synthesize an array of other driving factors. And, while it is very challenging to create a car that will be able to detect road signs under ideal conditions, it is exponentially more challenging to engineer the same cars to detect the same road signs under poorer conditions (i.e., such as less than ideal weather, road and lighting conditions). In my project, I am developing an algorithm for a scale model car, which will be able to detect road signs and react accordingly. Previous studies have demonstrated the difficulty of recognizing road signs, when there are minor flaws in the signs such as graffiti, stickers, fading, wear and tear, or other conditions that might impair visibility. The issue with road sign detection is, of course, accuracy. There are many people, who use different sensors and cameras, in order to figure out what component will detect road signs in the most accurate way. I will employ a 1080p gamma-corrected camera attached to a Zybo-Z10 board, in order to capture road signs and convert these images into something that can be understood by a computer. My method of machine learning will be almost a modified version of Haar Cascade Classification. I will be doing this with Vivado 2019 (1st edition).

**Cardiovascular Functional Adaptation in Acute Respiratory Distress Syndrome**
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*REU/SURE Program Name:* USRG

**Introduction:** Acute respiratory distress syndrome (ARDS) is a life-threatening lung disease that can lead to severe hypoxemia due to fluid leaking to the lungs. ARDS can potentially lead to serious brain damage, organs failure, and eventually death. However, the effects of ARDS on cardiovascular functions remain to be investigated further. **Objective:** The overall arching goal of this study is to improve the understanding of the effects of ARDS on lung and cardiovascular functions using mathematical models and programming simulations. **Methods:** A closed-loop heart-lung bloc simulation was produced by integrating cardiovascular, inflammatory, and respiratory mathematical models. The modules generated the alveolar and pleural total pressures, alveolar volume, oxygen and carbon dioxide concentrations in alveoli and capillaries, as well as their pressure levels under the influence of inflammation. In addition, the model also predicted the pressure in the pulmonary, systemic, and cerebral arteries and veins over time to study the inflammation effects on cardiovascular functions. Implementation of the experimental rodent data onto the computational models will be analyzed to determine the effect of lung inflammation on the heart. **Conclusion:** Our study indicated both acute dysfunction and compensatory adaptation in RV's response to ARDS, with alterations ranging from moderate to comparable relative to typical RV dysfunctions observed in chronic pulmonary hypertension. Our findings highlight the significance of investigating the effect of pre-existing cardiopulmonary diseases on RV resilience and dysfunction in response to ARDS, including that induced by COVID-19.

**Characterization of MPC-BIS Zwitterionic Hydrogels as Matrix for Dispersing Enzymatic Microparticles**
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*REU/SURE Program Name:* USRG

Metabolites are intermediate chemical compounds produced as a result of biochemical reactions catalyzed by various enzymes in cells. Monitoring the physiological concentration of these molecules can help early diagnosis and treatment of various metabolic disorders and help prevent the onset of disease conditions. In spite of current developments that have led to market available metabolite sensors, there has been a persistent need for advanced, implantable sensing devices that allow for close monitoring of metabolites within the body. In the development of such implantable biosensors, there is a search for biocompatible materials for smooth functioning of the implanted sensors. Zwitterionic hydrogels have garnered attention of researchers for their appealing anti-fouling properties, minimal inflammatory responses, lack of foreign body reactions, and tunability to match the mechanical properties of surrounding tissues. In this study, we explores the synthesis and characterization of a zwitterionic hydrogel composed of 2-methacryloxyethyl phosphorylcholine (MPC) as the monomer and N,N'-Methylenebisacrylamide (BIS) as the cross-linking agent. Hydrogels of MPC-BIS were synthesized with 7 different cross-linking densities as well as both with and without the inclusion of biosensing glucose sensitive alginate microparticles. Properties of rheology, compression modulus, homogeneity, stability, swelling factor, and stability are studied. Overall, the information this study provides regarding an MPC-BIS zwitterionic hydrogel can be used for designing compatible delivery materials for implantable metabolite sensors.

**Characterization of NaI Scintillation Detectors on the Basis of Positional Response**

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*REU/SURE Program Name:* Cyclotron Institute

The Texas CsI Array for Astrophysical Measurements(TexCAAM) is a gamma-ray spectroscopy tool that is currently being utilized at the Texas A&M University Cyclotron Institute. However, recent access to large volume sodium iodide(NaI) detectors has created the motivation to replace the current experimental set up of the CsI detectors. These NaI scintillation detectors have the potential to produce significantly better energy resolution and timing resolution than CsI detectors. However, in order for this replacement to occur, these particular large volume NaI detectors must be characterized on the basis of positional response. To be useful, the photopeak height and energy resolution should not depend significantly on the interaction location. This characterization has been done through the use of two different gamma-ray sources for the sake of completeness, Cobalt-60 and Cesium-137. The differences in the photopeak channel readout across the faces of these detectors is normalized to visually show the variation from a chosen reference point. The test results show that the detectors have typical resolution of 5.11-11.0% with pulse-height dependence of 1.6-6.4% as per manufacturer specifications. Additional results explore how individual detectors perform.

**Characterizing Formation of Singlet Oxygen from Dissolved Organic Matter**

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*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* Independent Research Project

This research focuses on the quantum yield of singlet oxygen produced when exposing multiple different dissolved organic matters (DOMs) to UV light with a wavelength of 365 nm. Singlet oxygen is a photochemically-produced reactive intermediate generated via energy transfer from triplet states of DOMs. In a diverse environment singlet oxygen contributes to breaking down organic molecules in nature and recalcitrant pollutants that cannot be fully degraded from wastewater treatment plants. In order to quantically access the role in these processes, the concentrations of singlet oxygen have been measured inside both the DOM and in the aqueous solution, while the concentration of singlet oxygen at the near surface of the DOM remains undetermined. The overarching objective is to evaluate the microheterogeneous distribution of singlet oxygen produced from photolysis of DOMs. Furfurylamine (FFAM) is the proposed probe utilized to quantify the near surface singlet oxygen more effectively due to the electrostatic attraction between FFAM and the negatively-charged DOM. By using the referenced probe furfuryl alcohol, we can obtain the reaction rate of FFAM through competition reactions, and the results of this testing showed the singlet oxygen measured by cationic probe compounds is systematically larger than measured by neutral probes.

Synopsis: Singlet oxygen can predict the future of contaminants that are unable to be treated and released into the environment.

**Community Perceptions of Energy and Electrical Companies in the Penas Blancas Watershed in the Province of Alajuela, Costa Rica**

*Author:* Avriel Null
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*Research Discipline:* Science (STEM), Social and Behavioral Sciences
*REU/SURE Program Name:* NSF Costa Rica REU: Ecohydrology in the Tropical Montane Rainforest: DIVERSITY IN SCIENCE, INTERDISCIPLINARY BREADTH, AND GLOBAL AWARENESS

In Costa Rica, more than ninety-eight percent of electricity is generated from renewable energy sources such as hydropower, solar, wind, geothermal, and biomass. Our purpose was to investigate how energy and electrical companies are perceived by the communities within the Penas Blancas Watershed, mid-Alajuela province of Costa Rica. To answer this question, we conducted a thematic analysis based on thirty semi-structured interviews with residents of three Costa Rican communities within the watershed. Results indicated that electricity generated in our selected area was produced by hydropower; eighty-seven percent of participants were aware of this and were content with the service provided while being aware of the environmental problems surrounding hydroelectricity. Sixty-two percent of respondents stated they would prefer using solar power and they agreed with the fact that Costa Rica does not generate one hundred percent of its electricity from renewable energy sources. Seventy-eight percent of interviewees observed less rainfall now compared to five to ten years ago while others depicted how they experience larger amounts of rainfalls in shorter periods of time. It was apparent throughout every interview that renewable energy and mitigation against climate change is highly valued. The findings from this study can be used to provide insight into developing more efficient forms of communication between hydroelectric companies and residents, producing better suited energy policies, promoting community involvement, and expanding environmental education.

**Comparing the Proliferation Resistance of X-Energy's Xe-100, HALEU, TRISO Coated Fuel with that of the MOX used in an Existing Westinghouse AP1000 Reactor**

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X-Energy's 200MW, generation IV reactor has epitomized current technology to ensure that safety is held paramount throughout the entire lifespan of the reactor. As this technology becomes further developed and plans for implementation begin in multiple states, the issue of proliferation suddenly becomes relevant. Containing enough material at startup to theoretically create an excess of 23 devices, investigation was required to determine the utility and desirability of the reactors fuel, if diverted to create a nuclear device. As the most easily diverted material from the reactor will be the discarded waste, it must be determined if a sixth passthrough can be achieved with the implementation of a new sensor array, allowing the fuel to remain within the core for another 212 days (E.J. Mulder, 2019), whereupon it will be burnt to an extent where the material attractiveness is minimal. Attractiveness is determined through a Figure of Merit calculation as well as several other factors that aggregate to determine the potential threat that this waste product may pose.

**Computational Study of Choline Chloride-Based Deep Eutectic Solvent Mixtures**

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*Research Discipline:* Science (STEM)

Prediction of the physical properties of deep eutectic solvents (DESs) continues to be a challenge with heuristic chemical principles, due to the complexity of molecular interactions in DESs. In this work, we employed parameterized molecular dynamics simulations to identify in silico characterization data of solutes under different states of charge. The molecular dynamics simulations are based on the OPLS force field, as implemented in the GROMACS 2020.4 software package. Calculations were performed with hybrid density functional B3LYP with the 6-31G(d) basis set to further parameterize the systems. Physical properties were determined for phenothiazine and TEMPO derivatives in a choline chloride-ethylene glycol solvent. Mean square displacement and density analysis were performed to obtain an initial analysis of the physical properties of the system. The results of our calculations can help in understanding the relationship between structure and function of the deep eutectic solvents. We find in the preliminary simulation results that these derivatives have comparable properties. The data suggest a valid methodology for simulating the dynamic properties involving solutes in deep eutectic solvents.

**Correlation Between Fragment Lifetime, Angular Alignment, and Composition in Heavy Ion Collision Simulations**

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*REU/SURE Program Name:* Cyclotron Institute REU

When two nuclei collide at intermediate collision energies there is a tendency for a neck to form between the projectile and the target, and for this neck to be neutron-rich compared to the whole system. Following the neck rupture, the resulting excited projectile-like fragment (PLF*) and the target-like fragment are typically deformed and are likely to undergo dynamical decay. Because of the neutron-rich neck, the PLF* typically begins with a more neutron-rich side and a less neutron-rich side. The PLF* may further break into two more fragments (one more neutron-rich and one less neutron-rich). Of interest is the relationship between how long the PLF* lasts before breaking, the angular alignment of the two fragments it breaks into, and how much the neutron and proton density evens out across the PLF* while it exists. The time scales at which this process happens are on the order of zeptoseconds. While the timescale at which PLF* lasts cannot be measured directly in an experiment, the whole process can be simulated with molecular dynamics model calculations. Data from an Antisymmetrized Molecular Dynamics (AMD) simulation of a zinc-70 on zinc-70 collision with energy of 35MeV/nucleon was analyzed to determine the relationship between the lifetime of the PLF*, the angular alignment of the two largest fragments resulting from the PLF*, and the proton/neutron richness of the two fragments.

**Creation and Analysis of Semi-permeable Membranes for Dirty Water Purification using Calcium Sulfoaluminate and Glass Spheres**

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*REU/SURE Program Name:* USRG

Research was performed towards designing semi permeable membranes with calcium sulfoaluminate (CSA) and glass spheres (GS) on a stainless-steel substrate to function as a filter for removal of microparticles and oil droplets from byproduct water created in the oil industry. The oil industry creates 300 million barrels of waste water per day which cannot be reused due to its level of contamination. The goal of this project was to reduce the amount of waste water that is generated by the oil industry via filters made of inexpensive materials for cheap oil filtration. Steel mesh was spray coated with mixtures of CSA and glass spheres and then allowed to cure, adhering to the mesh. Water from 14 different wells across Texas were used to test the effectiveness of these membranes. Using Gas Chromatography and Mass Spectrometry, the water produced from filtration was then tested to determine the remaining amount of oils present in the water. Various coverages (5, 10, 15, 20 mg/cm2), ratios of CSA and glass spheres (1:1, 2:1, 4:1 respectively) and flow rates (8000, 10000, 12000, 40000 mL/hr) were tested in every combination to determine the best, most optimized combination for the filtration of produced water.

**DNA Modifications and their Binding Proteins**

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Interactions between DNA and proteins are essential to health and biology. DNA is traditionally composed of four nucleobases. These are cytosine, guanine, thymine, and adenine. These nucleobases hydrogen bond to one another in pairs to form the double helix shape of DNA. These nucleobases can be modified in the body. One common modification is methylation of the DNA strand at the fifth carbon of cytosine. This modified nucleobase is called 5-methylcytosine (5mC). Another modification is 5-hydroxymethylcytosine (HmC), which is an oxidation product of 5mC. In addition, modifications can also occur on other DNA bases, such as guanine. The presence of modified bases in DNA alters their interactions with proteins. Proteins that interact and bind well to specific modifications are known as "readers". Experimental studies have been conducted in the past to investigate DNA-protein interactions and to determine readers of certain modifications. These interactions can also be explored computationally. The goal of this paper is to investigate a particular reader of modified DNA using molecular dynamics (MD) simulations and energy calculations. The results of this study can aid in the improvement of predictive abilities for computational methods. This study can enable the development of additional computational tools to study DNA modifications and their binding proteins.

**Decellularized Liver Biomatrices as a Model for 3D Ovarian Cancer Metastasis and Drug Discovery**

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*REU/SURE Program Name:* USRG

Ovarian cancer often is metastatic at diagnosis, with the liver being one of the most common sites of metastasis. These liver metastases are resistant to chemotherapy and cannot be removed through optimal surgical removal. Additionally, the cancer cells interact with macrophages in the liver to establish metastatic colonies and increase cancer cell infiltration. Nano-immunotherapy can be utilized to target the interaction between macrophages and cancer cells. In vitro drug screening and dose optimization can be tested using decellularized liver biomatrices. The biomatrix provides a more accurate 3D model of the metastatic microenvironment. The liver biomatrices were manufactured via sectioning and decellularization with a Triton X-100 and Ammonium Hydroxide detergent solution. Ovarian cancer cell spheroids were then cultured with and without macrophages on hanging drop arrays and seeded onto the biomatrices to simulate metastasis. Samples were analyzed using DNA quantification and SEM imaging to study the influence of macrophages on the invasive properties of metastatic ovarian cancer cells. An MTS assay was then used to test the biomatrix model's ability to be used for drug testing. SEM image analysis shows a difference in cancer cell morphology and a trend towards increased invasion with the addition of macrophages into the biomatrix. The decellularized liver biomatrix can be used as a 3D model of the hepatic tumor microenvironment for the study of nano-immunotherapies for ovarian cancer liver metastasis.

**Deep Reinforcement Learning for Multi-Agent Cooperative Target Tracking**

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*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* USRG

Recent years have shown the exponential development of Unmanned Air Systems (UAS) for a multitude of applications in a multitude of fields. As the usage of UAS has expanded, there has been interest in cooperation between multiple agents. Previous research was successful in training a single UAS to track a single ground target in simulation, using Deep Reinforcement Learning. The objective of this project is to create an enhanced research tool for cooperatively following ground targets by incorporating multiple air vehicle agents to the existing fixed-wing air vehicle agent simulation, thus creating a multi-agent fleet capability. The two air vehicle agents must be able to share airspace while continuously tracking the targets in order to be successfully integrated with one another. Preliminary results to validate and verify the multi-agent learning environment use a single agent fixed-wing environment that is retrofitted to host multiple agents using rllib by Ray. The agents are trained using a Proximal Policy Optimization (PPO) algorithm. Based upon the simulation results presented in the paper, the rllib framework is shown to be effective in creating the desired multi-agent environment.

**Delineating the Reality of Flood Risk: A Comparison of Physics-Based and Machine Learning Models**

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*REU/SURE Program Name:* OCEANUS

Flood incidents are increasingly not aligning with the traditional indicator of flood hazard: The Federal Emergency Management Agency's (FEMA) 100-year floodplain. To stay resilient, homeowners need precise and reliable information concerning their home's flood risk. New models of flood risk have been proposed to help fill this gap, but validation of these models is difficult due to a lack of residential flood exposure information. In particular, a recently developed flood hazard model was created using historic flood insurance claims that can provide important flood hazard information to residents at the parcel level. This study is the first to validate such a model using survey results from residents in Southeast Texas. It is hypothesized that this new delineation of flood risk will show marked improvement in capturing residents' feedback regarding flood frequency as compared to the 100-year FEMA floodplain. The number of times a resident has been flooded in their current home was used as ground-truth information to test the accuracy of the new flood hazard model and FEMA's floodplain. This paper used exploratory data analyses of where flooding has occurred relative to the delineations, t-tests to cross-validate differences in model predictor variables, and a receiver operating characteristic (ROC) curve to test the accuracy of the newly developed flood hazard model. Though the surveys were sent out evenly to homes in and out of FEMA’s 100-year floodplain, the results received were not proportionate. Survey responses are still being received and will produce more reliable findings in the future. However, the additional analyses conducted still provide important information regarding the differences between these two delineations of risk. Initial results illustrate that the newly developed flood hazard model adequately captures respondents' experiences with floods and exhibits decent overall accuracy. Unlike FEMA’s binary 100-year floodplain, the flood hazard model uses a continuous spectrum to classify levels of flood risk further enhancing its effectiveness. Making this flood risk communication tool available in addition to FEMA’s floodplain information can help residents make better-informed choices for disaster resilience. Furthermore, it can assist decision-makers in determining areas where help is most crucial.

**Design and Optimization of a Wearable Device and Implantable Biosensor for Continuous Glucose Monitoring**

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*REU/SURE Program Name:* PATHS-UP

To those living with diabetes, monitoring one's own glucose levels is necessary to staying in good health. One way of doing so is using continuous glucose monitors (CGMs); however, these devices present issues in risk of infection and longevity. Improvements in these areas can be made through a redesigning of CGMs into two components: a wearable device and an implantable biosensor that sends signals in the form of fluorescence emissions to the wearable. An optics system was created to simulate the future wearable device, and it employs an LED, an excitation filter customized to transmit the wavelength of said LED, lenses, an emission filter customized to transmit our fluorescence emission, and a spectrometer. The biosensor is fabricated by binding Cy5.5, a dye, with PEGylated ConA, a protein modified with PEG to improve its stability, and injecting the solution into hydrogel rods. We found that a concentration of 25 µM Cy5.5 PEG-ConA produced the best signal by testing varying concentrations of Cy5.5 PEG-ConA in capillary tubes with our optics system. Testing of 25 µm Cy5.5 PEG-ConA solution in the biosensor beneath rat skin samples of 0.6mm and 1.0mm were conducted with our benchtop optics system. The results of this experimentation show that signal output was lower once rat skin samples were placed above the biosensor. We felt motivated by these results to find the loss of power at certain stages of the optics system. Several of the components such as the lenses and fiber optic cable were significantly reducing the power, however, these components will not be a factor for the final wearable design. Printed circuit boards (PCBs) were designed for the wearable device and basic testing of the LEDs and photodiodes was completed. Our results for basic testing of the LEDs and photodiodes show that our PCBs were functioning properly and receiving signals.

**Determining the Activation Energy for the Oxidation of Chromium**

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*REU/SURE Program Name:* USRG

Fuel cladding is an important aspect of the nuclear reactor. To avoid another mishap like what happened at the Fukushima nuclear power plant in 2011, some have suggested using a thin chromium coating over the zirconium fuel cladding. We determine the activation energy of oxygen into chromium through the annealing of several samples of chromium at various temperatures. From there we will use Rutherford backscattering (RBS) to measure the thickness of the oxide layer. This allows us to determine the diffusivity and activation energy of the oxidation of chromium.

**Developing Methods for Microstructural Control of Ni-Cr Binary Alloys**

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*REU/SURE Program Name:* USRG

High-temperature environments require corrosion-resistant materials that can withstand extreme environments without failure. Many materials have excellent mechanical properties however as temperatures rise the number of materials that are viable in these conditions begins to decrease. However irritated environments at high temperatures also require materials that are corrosion resistant. Control of microstructural properties through processing can lead to advanced radiation-tolerant materials with desirable mechanical properties in high-temperature environments and enhance corrosion resistance. For this work, processing methods pathways are examined for grain size control in binary Nickel-Chromium alloys. Different

methods of grain refinement were performed to develop repeatable procedures for fabricating alloys with prescribed grain sizes between 1 and 100 microns. Samples of Nickel 8, 16, and 24 wt% Chromium were fabricated by arc melting. Samples were treated by hot rolling, cold rolling, and heat treatments between 1150ºC - 950ºC as well as a final heat treatment at 900 ºC. Grains from the rolled samples were unsuccessfully observed and compared to the as-melted samples. This paper will discuss the expected manufacturing-property relationships between rolling, heat treatments, and grain size in Ni-Cr alloys, and present repeatable methods for tailoring prescribed microstructures in Ni-Cr alloys as the current work is incomplete as for writing.

**Development of Impact Testing Apparatus for Evaluating Femoral Broaching Devices in Canine Total Hip Arthroplasty**

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*REU/SURE Program Name:* BMEL-UGRP

Total Hip Arthroplasty (THA) is the gold-standard treatment for degenerative osteoarthritis in the canine hip. Critical to the success of the device is the security and integration of the stem into the femoral bone. Broaching is a process that creates an envelope in the femur to insert the stem. In patients with sclerotic bone, femoral broaching is a challenge since the high bone density makes it difficult to drive the broach and overdriving often leads to fracture. Novel broach teeth designs were developed to improve the success rate of broaching sclerotic bone and evaluated by driving them into mock polyurethane bone samples (SawBones). However, the quasistatic loading regime used does not replicate the clinical environment where surgeons insert the broach by repeatedly impacting it with a mallet. Thus, to best replicate the clinical environment, the broaches should be installed via repeatable impact force. To this end, a vertical drop test prototype was developed. The device is constructed from 80/20 aluminum extrusions and applies an impact load via a stainless steel weight attached to a low-friction slider from a maximum height of 60 inches. To limit human error and improve repeatability, the drop is controlled by a step motor linked to an Arduino Due with a single trigger. The weight is returned to the same height by a secondary step motor with a repeatability of 90%. Some limitations remain to be addressed in future work. First, the trigger currently linked to the drop mechanism will be linked to trigger a high-speed camera and impact force sensor to sync data collection. Second, after impact, the broach typically gets stuck in the sample; an automated broach extraction function will be included in future iterations. Lastly, all of the functions will be integrated into a user-friendly Labview control setup. In conclusion, the device is a successful works-like prototype.

**Development of Impact Testing Apparatus for Evaluation of Femoral Broaches in Canine Total Hip Arthroplasty**

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*REU/SURE Program Name:* BMEL-UGRP

Canine Total Hip Arthroplasty (THA) is a common procedure for treating various pathologies of the canine hip. During the THA procedure, a broaching tool is inserted into the femur to create an envelope in the bone for the stem insertion. While this process is widely used, complications arise, in particular, femoral fracture during broaching of higher density sclerotic bones. To address this, a broach with novel tooth design was developed. Previously conducted quasi-static insertion tests using model bone (SawBones 25pcf density) have shown promise; however, veterinarian surgeons drive the broach into the femur by repeatedly striking with a mallet. Thus the quasi-static loading regime is not comparable to the clinical environment. To this end, an impact testing apparatus was developed. For a realistic replication of the implantation process, an impact force up to 700lbf is generated by dropping a stainless steel weight in free fall. The process was made repeatable by

attaching a removable shelf for the drop and a separate winch and pulley system to retrieve the free falling weight automatically after each impact. Alignment of the SawBones sample is achieved by attaching a movable stage where the SawBones sample sits and is clamped to the apparatus for added stability. The data collected includes the impact force and displacement measurements of the broach into the SawBones sample measured from an impact sensor and high speed camera. Further improvements to the impact testing apparatus are to machine a clamp, refine the winch fabrication process, develop an extraction system with a rack and pinion, minimize friction for the weight drop, and begin data collection for the project.

**Development of Superhydrophobic, Bacterially Antifouling Titanium for Dental and Medical Implant Device Applications**

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*REU/SURE Program Name:* USRG Program

Grade V titanium alloy is one of the most commonly used metals in dental and medical implant devices such as tooth and hip replacements. This is due to its extreme corrosion resistance, enhanced strength, and fracture resistance. In order to minimize the risks of implant infections, a serious health concern, the wetting behavior of grade V titanium was modified to render it superhydrophobic and bacterially antifouling via fine-tuning of rough surface morphology and surface chemistry. The non-wetting, titanium was developed through a combination of surface texturing and decoration with alkyl ligand via silane condensation to siloxane bridges. This superhydrophobic titanium may prove promising as a material used in orthopedic and dental implant devices with bacterially antifouling properties, mitigating the risk of implant-associated infections.

**Developmental Restriction Alters the Composition of Neural Progenitor Grafts after Spinal Cord Injury**

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*REU/SURE Program Name:* Independent Research Project

Neural progenitor cell (NPC) transplantation has shown high therapeutic potential following spinal cord injury (SCI). However, there is limited understanding of how distinct subtypes of graft neurons can support the reestablishment of specific spinal circuitry. We have previously reported that neural progenitor cells from restricted regions of the embryonic rodent spinal cord differ in their dorsal/ventral neuronal identities upon maturation. We now show that the developmental stage of donor neural progenitor cells also significantly influences the neuronal subtypes populating mature grafts. In this study, donor neural progenitor cells were isolated from mouse embryonic spinal cords at E11.5, E12.5, and E13.5 and transplanted into sites of SCI (C4 dorsal column lesion). Four weeks post-transplantation, tissue was collected, sectioned, and analyzed using various neuronal cell type markers. We found that the earlier-stage grafts were enriched for ventral/motor-like neurons. Conversely, the later-stage grafts were enriched for dorsal/sensory-like neurons. Interestingly, this temporal effect on graft phenotype closely mirrors neurogenic ‘peaks’ differentially exhibited by distinct neural progenitor subtypes during normal spinal cord development. Overall, our findings suggest that developmental restriction could be a useful approach to engineering optimized grafts for the restoration of specific functions (i.e. motor vs sensory) following injury to the spinal cord.

**Does the Loss of SIM2s Affect the Relationship Between the Mitochondria and ER in HC11 Cells?**

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*REU/SURE Program Name:* Aggie Research Program

During pregnancy, metabolic transitions occur in the mammary gland in order for cell differentiation to occur. Research done on the metabolic transition of mammary epithelial cells, MEC, indicates cell differentiation during the transition from gestation to lactation utilizes mitophagy. Furthermore, inhibition of mitophagy was found to impair cell differentiation, displaying that mitophagy is crucial to the regulation of mammary cell differentiation to undergo proper lactation. Just as mitophagy is crucial for proper lactation, research has shown that SIM2s, a short splice variant transcribed from SIM2, a member of the basic helix-loop-helix-PAS family, is necessary for proper differentiation during mammary gland development. In addition, PRKN, a mitophagy mediator, was found to be expressed during mammary gland development, and when knocked down, cell apoptosis was displayed in the shPRKN cell line. Our lab has found that SIM2s interacts with PRKN during MEC differentiation, and that PRKN relocates to the mitochondria during mitophagy, but the role that SIM2s plays is yet to be observed in mitophagy. Other studies have found that PRKN drives mitophagy at mitochondria associated membranes. As PRKN and SIM2s have been shown to interact during MEC differentiation, and PRKN relocates to the mitochondria during MEC differentiation, we hypothesize that SIM2s plays a role in the relationship between MAMs and mitophagy during cell differentiation. Our research furthers the study of inter-organelle relationships through specific effect SIM2s has on the ER-Mitochondria site in the scope of mammary gland development.

**Effect of High Voltage Atmospheric ColdPlasma on Wheat Flour Contaminated with Microorganisms**

*Author:* Ahmir Nichols
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*Graduate Student Advisor:* Shikhadri Mahanta
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*REU/SURE Program Name:* USRG-REU

Who knew that hazardous and even life-threatening bacteria could be found sitting right in your kitchen or pantry? Wheat, which is one of the nation's most-produced field crops, could contain bacteria such as Escherichia coli (E.coli), yeast & molds, and more. According to the Centers for Disease Control and Prevention, in 2019 twenty-one people across nine states were infected with E. coli O26 from the use of raw wheat flour (CDC 2019). It is advised to wipe down all surfaces after use and wash hands thoroughly. Without proper medical care, this strain of E. coli can potentially be deadly. High voltage atmospheric cold plasma (HVACP) treatment has the capability to reduce or even rid microbial contamination in wheat flour. Some articles and experiments support the motives for this research. Previous research shows the effectiveness of HVACP on wheat kernels. While this information is viable, extensive research is still needed. Microorganisms could still contaminate the equipment used to mill kernels into ground flour. Using AACC Approved Methods of analysis, the focus will be more so on how effective the treatment is on the ground flour rather than the kernels. Cold plasma treatment has been proven to be effective in regards to eliminating microorganisms. It is expected that this treatment will be effective without negatively altering the properties of the flour.

**Effect of the Thernal Admixture on Setting Time and Compressive Strength of Cementitious Pastes**

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*REU/SURE Program Name:* USRG REU

Traditional concrete usually presents extended setting times and low strengths in the first few hours, which makes it not ideal for several applications such as road repair, precast elements and, accelerated bridge construction. This study evaluates the use of a new supplemental cementitious material in concrete mix design, which is capable of significantly increasing the setting times and early strength of concrete materials. In this study, this admixture known as THERNAL is used to partially replace ordinary portland cement (OPC) in contents up to 25% by mass to produce cementitious pastes. Cylinders of reduced dimensions were used to assess the compressive strength at early hours (1,3,6 and 24) while following the test procedure defined by ASTM C109. Setting times of each mixture were assessed through the Vicat test following ASTM C191-19. For a fixed water-to-cementitious ratio of 0.30 and a superplasticizer content of 1% by mass of cementitious powders, results obtained in this study indicate that replacing OPC with THERNAL in contents between 20 and 25% by mass enable setting times under one hour after adding water to the mixture. In addition, an average compressive strength of 15 MPa was obtained when testing the one-hour strength of a cementitious paste containing 20% of THERNAL replacing cement. Further studies should be done to extend these mixtures from pastes to concretes and to further improve the early fresh and hardened properties.

**Effective Disinfestation of Storage Pest Using Engineering High Voltage Atmospheric Cold Plasma Treatment**

*Author:* Grace Salau
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*Graduate Student Advisor:* Nahndi Kirk Bradley
*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* Independent Research Project

Storage pests are insects that damage and infest stored commodities like grains and processed meals. Storage pests, such as Callosobruchus maculatus (Cowpea Weevils), cause damage to more than 30% of crops worldwide. Pesticides and fumigants are commonly used to reduce infestations of these storage pests. However, pesticides contain harmful chemicals that aid in thinning the ozone layer because of the methyl bromide agent and fumigation methods, like phosphine, cause severe harm to humans through respiratory issues. This work uses a novel post-harvest treatment method, high voltage atmospheric cold plasma (ACP), as an alternative approach to eliminating storage pests. ACP is a non-thermal treatment produced by the input of electrical energy that is developed within a dielectric barrier. The system aids in eliminating microbiological problems and extending shelf life by transforming the packaged atmosphere into highly reactive gas species. We theorize that adopting this approach can help achieve a 90% mortality rate of the storage pests, cowpea weevils. Therefore, assisting in the control of infestations and possibly eradicating the problem. We treat cowpea weevils in any of the three key stages (eggs, larvae, adult) through the ACP system at 20, 5, and 70 kV for increments of one, two, and three minutes. Beforehand, we fill the bag with MAP gas and then run it through the ACP system, and then hold them in the bag for thirty minutes right before placing them into their homes and observing their mortality rate for eight days. The primary objective of this research was to discover a more ecologically and economically beneficial method of eliminating storage pests and protecting our commodities.

**Effects of ACP treatment of Coniferyl Alcohol**

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*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* REU-USRG

Believe it or not, agricultural waste holds tons of potential as a future fuel. Lignin is the second most abundant plant polymer in the world and derives its value from the 3 aromatic alcohols, coumaryl, sinapyl, and coniferyl alcohol, that form the polymer Lignin. Lignin is found in the cell walls of most plants and is already produced in large quantities as a by product of cellulose and bioethanol production. ("New Process" Boot) Coniferyl Alcohol is one of the monomers that makes up Lignin. Research on extracting these aromatic alcohols in a cost-effective and environmentally friendly way has been ongoing. Atmospheric Cold Plasma might be the solution. Also known as ACP, this treatment uses Oxygen gas and a high voltage transformer to produce reactive gas species and alter the identity and chemical structure of treated samples. ACP is a new technology with many applications and potential research areas. By treating Coniferyl Alcohol, one of the building blocks of lignin, with ACP, we hope to understand how ACP impacts the chemical and physical properties of Coniferyl alcohol which can hopefully be applied to our lignin research in the future. I expect that treating coniferyl alcohol with ACP will modify the structure of the coniferyl alcohol and result in changes that can be studied with HPLC and

NMR analysis. Treating Coniferyl is the first step in better understanding lignin and eventually treating lignin with ACP in future experiments.

**Effects of Developmental Restriction on Neural Progenitor Cell Differentiation in Vitro**

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*REU/SURE Program Name:* Independent Research Project

Neural progenitor cell (NPC) transplantation is a promising therapeutic strategy following spinal cord injury (SCI). In mouse transplantation studies, spinal cord NPCs isolated at embryonic day 12.5 (E12.5) have long been regarded as the 'golden standard'. However, spinal cord neurogenesis normally occurs over E9.5-E13.5, with distinct neural progenitor classes exhibiting different birthdates. Therefore, we hypothesized that varying the timepoint of NPC isolation would result in distinct cell phenotypes upon maturation. To test this, mouse spinal cord NPCs were isolated on days E11.5, E12.5, and E13.5, and cultured for 7 days. Then, the cells were fixed and characterized using molecular markers of distinct cell populations (including neurons, astrocytes, and oligodendrocytes), and quantified. Our results show that NPC proliferative capacity decreased over time, with earlier cultures producing more cells than later cultures. We also found that the proportion of neurons and oligodendrocytes decreased steadily from E11.5 to E13.5. The proportion of astrocytes was the highest in E11.5 cultures, with similar numbers at E12.5 and E13.5. Surprisingly, E12.5 cultures produced the lowest proportion of motor neurons. Collectively, these results indicate that developmental stage plays a significant role in NPC cell fate in vitro. Furthermore, this has important implications for experimental models, pointing to temporal restriction as an understudied approach to manipulating graft composition in vivo. We are testing this in ongoing studies by grafting developmentally-restricted NPCs into sites of SCI. Altogether, findings from this work will update guidelines for engineering new and effective cell sources for SCI clinical trials.

**Effects of Post-installed Mechanical Couplers on Strength and Deformability of Existing Lap Splices Vulnerable to Bond Failure**

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*REU/SURE Program Name:* USRG

Post-earthquake examination of reinforced concrete buildings constructed prior to seismic design provisions show structural damage resulting from bond failure of lap splices located in critical sections of both columns and walls. Bond failure of lap splices results in a brittle and abrupt loss of lateral and axial load-carrying capacity of these structural elements, resulting in possible building collapse. Replacement of buildings containing splices vulnerable to bond failure are unfeasible, nevertheless, the improvement of existing splices has potential. To prevent bond failure of existing splices, new mechanical coupler designs are proposed in this study as a method of repair. Emphasis was placed on a mechanical coupler that could be installed invasively on existing lap splices. The proposed couplers are hypothesized to increase both the strength and deformability of existing lap splices vulnerable to bond failure, which will provide structural elements with the toughness required to withstand seismic demands.

**Electrocatalytic Nitrogen Reduction on $Ti_3C_2$, $Ti_3CN$, and $Ti_2N$**

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*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* USRG

Synthesis of ammonia via the electrochemical reduction of atmospheric nitrogen ($N_2$) holds the potential to be less costly, more environmentally friendly, and less energy intensive than the traditional Haber-Bosch process.

In order to achieve this great feat, a powerful and efficient electrocatalyst is necessary. However, most catalysts tested for this application have shown low Faradaic efficiency and high overpotentials. The novel two-dimensional material, titanium nitride MXene ($Ti_nN_{n-1}T_x$, n = 2, 3 or 4) can potentially provide a unique supply method of nitrogen via the Mars van Krevelen (MvK) mechanism which could solve many of the problems associated with the electrochemical nitrogen reduction reaction (NRR). Here, the performance of $Ti_2N$, $Ti_3CN$, and $Ti_3C_2$ is reported on for ambient NRR. Electrochemical characterization is laid out for all three materials in 0.1 M HCl, and the voltage window for NRR is established for all three catalysts. The findings support $Ti_2N$ as the superior catalyst, since the material has a small but well-defined voltage window, where NRR dominates over the competing reaction, the hydrogen evolution reaction (HER). We achieved yields as high as 11.32 ug $h^{-1}$ $cm^{-2}$ with a faradaic efficiency of 19.85% at an applied potential of -0.2 V vs. RHE. Furthermore, preliminary evidence towards the support of the MvK mechanism on $Ti_2N$ is reported.

**Electrochemical Nitrogen Reduction Reaction on Nitride MXene**

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*REU/SURE Program Name:* Djire Summer Program

The Haber-Bosch Process is the primary industrial Nitrogen fixation process and is arguably the most impactful invention of the 20th century. Though the Haber process also plays a big role in the eyes of pollution to our planet, only half of the ammonia put in the ground is assimilated by plants. This leaves the remaining nitrogen as an unstable chemical compound in the world's water supplies. This process is also responsible for 1-3% of global energy consumption. Electrochemical ammonia synthesis has been a hot subject with the high potential for lower global energy consumption, and pollution levels. Carbide MXenes have been studied for Nitrogen Reduction but have shown low performance. MXenes are inorganic 2-D multi-layered nanomaterials that are highly conductive with a structure of $M_{n+1}X_nT_x$. M: early transition metals (Ti, Mo, V) , X: Carbon (C) and/or Nitrogen (N), $T_x$: termination group =O, -OH, and/or –F . Nitride MXenes are currently an unexplored material next to Carbide MXenes, with their only being 8 papers covering the material as of the summer of 2021. Here, we used a $Ti_2N$ Nitride MXene catalyst for the Nitrogen Reduction Reaction (NRR) in an Electrochemical set up. We also ran $Ti_3C_2$, alongside $Ti_2N$ for material comparisons, to be used as a catalyst for NRR. The set up was kept in a 0.1 M HCl electrolyte. The $Ti_2N$ catalyst displayed data with a Faradaic Efficiency (FE) of 19.85% with an $NH_3$ yield rate of 11.33 ug/$cm^2$/$h^1$, at -0.2 V vs. RHE. We also studied the application of the Mars-van Krevelen Mechanism, pumping in $N_2$ to replenish the catalyst. Though when $Ti_2N$ was run under Ar the set up produced a Faradaic Efficiency of 4.66% with an $NH_3$ yield rate of 5.24 ug/$cm^2$/$h^1$, at -0.2 V vs. RHE.

**Elucidating Putative Interacting Components of the Telomerase RNP.**

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Telomeres are repetitive sequences that cap the ends of chromosomes and act to protect the chromosomes from fusion, shortening, and degradation. Telomeric DNA is synthesized by telomerase, a large ribonuclear protein complex. The proteins that comprise the telomerase RNP in plants have not been fully discovered. Our lab seeks to identity the full of complement of telomerase-associated proteins in Arabidopsis thaliana. Towards this goal a quantitative mass spectrometry (qMS) experiment was carried out with plants overexpressing a tagged telomerase reverse transcriptase (TERT) protein and overexpressing the telomerase RNA (AtTR). The qMS experiment resulted in several proteins of interest, of those La1, AUXIN RESPONSE FACTOR 8 (ARF8), and ribosomal protein L10 (RPL10) were investigated further. Salk lines containing T-DNA inserts in ARF8 and RPL10A were obtained to observe the effects of mutations in these genes on telomerase activity and telomere function. Homozygous arf8 -/- plants were identified as well as heterozygous RPL10A +/- plants. Terminal Restriction Fragment (TRF) and Telomeric Repeat Amplification Protocol (TRAP) were performed on mutants to observe differences in telomere length and telomerase activity. Based on TRAP assays arf8 -/- and RPL10A +/- mutants showed a slight decrease in telomerase processivity. However, results from TRF and monochrome multiplex qPCR (MMQPCR) on arf8 -/- and RPL10A +/- mutants showed no significant change in telomere length when compared to wild-type plants. Together these findings suggest ARF8 and RPL10A may play a role in biogenesis of the telomerase RNP. Further studies are required to delineate their roles in plant telomerase activity.

**Environmental Factor Predictions and Power Forecasting for Wind Turbines**

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*REU/SURE Program Name:* Cyber-manufacturing

This work addresses two main areas in wind energy forecasting using data-driven methods. The first part of this work analyses the power forecasting models used in industry to gain insight into pre-existing industry models as a frame of reference when developing and reviewing our research group's models. The forecasting accuracy of the industry model is measured and compared to the performance of the power-based persistence model for multiple prediction periods. The second section of this work develops models for forecasting wind speed and power for wind turbines. Simple models such as the persistence and binning models are developed, with the persistence model serving as a baseline for this work. More complex models than these simple models should ideally produce more accurate predictions. A few complex models were developed, and their accuracy and performance are analyzed and compared for several time horizons in this work. Some of the complex models include the autoregressive moving average (ARMA) and the vector autoregression (VAR) models, which both are used to predict the wind speed. The VAR model is also used to predict the power produced. The data used in this work is real industry data obtained from the Elia Group in Belgium, National Renewable Energy Laboratory (NREL), and EDP Renewables (EDPR).

***Index Terms:*** wind energy, power forecasting, data driven

**Evaluating OpenRace on the DataRaceBench**

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*REU/SURE Program Name:* USRG

This study investigates the effectiveness of OpenRace in detecting data races in OpenMP C/C++ programs. OpenMP is an API for C/C++ and Fortran that allows programmers to easily write multithreaded software. With multithreaded programming comes data races, a bug in which two threads try to access the same memory space and one is performing a write. Detecting data races is a critical part of development, as they can cause correctness issues and critical security bugs. Several tools have been developed to detect these data races. Such tools use one of two different methods. Dynamic tools execute the program and detect races either on the fly or after execution, while static tools analyze the source code directly. OpenRace is an in development open source tool that uses static analysis to evaluate a program for data races. We tested OpenRace against the Lawrence Livermore National Laboratory DataRaceBench, a set of C/C++ scripts designed to evaluate a tool's ability to detect different types of data races. We ran tests over a period of 6 weeks, from June 21st to July 30th, while it was in active development to compare it against both previous iterations and other available data race detection tools. While initially OpenRace performed significantly worse than other tools, by the end of the study, OpenRace achieved 86% accuracy on the benchmark.

**Experimental Exploration of Electrochemical and Mechanical Phenomena in Zn-ion Battery Cathode**

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*Graduate Student Advisor:* Dimitrious Loufakis
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*REU/SURE Program Name:* USRG

For this research project, I will perform simultaneous electrochemical and mechanical tests on a structural cathode using a testing device developed by the Lagoudas and Lutkenhaus research labs to measure the dependence of the mechanical properties on the electrochemical properties and *vice versa*. I will prepare and test composite films that consist of reduced graphene oxide (rGO), manganese dioxide ($MnO_2$), and branched aramid nanofibers (BANF) *via* vacuum assisted filtration to determine: (a) how the electrochemical capacity of the Zn-ion structural battery changes as a function of the applied strain, (b) the developed stresses during the process of electrochemical charging, and (c) the cycling stability capability of the structural battery and how it is affected by the applied stress.

**Experimental Investigation of the Unsteady Aerodynamics of a Cycloidal Rotor**

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*REU/SURE Program Name:* USRG

The presentation investigates the unsteady force production on a UAV scale cycloidal rotor blade undergoing forward flight motion via experiments in a water tunnel. While time-averaged forces can shed light on cycloidal rotor performance, it is important to be able to accurately measure and predict the time history of forces on the blade in order to understand the highly nonlinear and unsteady fluid dynamics resulting from high-amplitude blade pitch kinematics, unsteady flow curvature effects and complex inflow distribution. Towards this, the instantaneous radial and tangential forces on a cycloidal rotor blade were measured in a water tunnel using a custom-built test-rig over a range of Reynolds numbers (Re = 30,000 – 100,000) while varying the rotor rotational speed, flow speed, blade cyclic pitch amplitude and pitch offset. The advance ratio was varied from 0 to 0.44. An unsteady aerodynamic model of the cycloidal rotor was developed and systematically validated with instantaneous force data from the water tunnel experiments. To further investigate the forward speed aerodynamics, a 2-D Particle Image Velocimetry (PIV) study was conducted. It is observed that the lift generated by cycloidal rotor increases continuously up to ±45° pitch amplitude for a low Reynolds number (Re = 29,000). However, this monotonic increase in lift plateaus at a pitch amplitude of ±30° for high Reynolds number (Re = 87,000). Moreover, a significant asymmetry was observed in the forces generated between the frontal half and rear half of the cycloidal rotor because of the dynamic virtual camber effect. A cycloidal rotor needs a phase offset angle in the vicinity of 90° to produce both a positive lift and propulsive force in forward flight. Additionally, this propulsive force was observed to decrease with increasing advance ratio due to a reduced effective angle of attack at all points along the azimuth. Moreover, at higher advance ratios the rotor begins extracting power from the flow over a large region at the frontal half of the cycle.

**Exploring the Thioester Intermediate Capture Strategy with Polyketide Synthase**

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*REU/SURE Program Name:* Chemistry REU

Azinomycins are natural products produced by the microorganism *Streptomyces sahachiroi.* These compounds show antitumor broad-spectrum activities against lymphoma cells in vitro and murine tumors in vivo. A hybrid biosynthetic origin was proposed where the naphthoate moiety formation indicated a polyketide synthase (PKS) machinery and the skeletal backbone was predicted to arise from the nonribosomal peptide synthase

(NRPS) machinery. Within these biosynthetic pathways, carrier proteins utilize thioester bonds to bind their substrates. The intent of this study was to understand the scheme of the azinomycin biosynthetic pathway with a strategy using capture agents to bind their thioester intermediates. The previous synthesis scheme has been modified and four capture agents with protecting groups were achieved. The PKS AziB from azinomycin biosynthetic pathway was selected to validate the thioester intermediate capture strategy with the four agents.

**Fabrication of Coatings with Precise Control of Wettability**

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*REU/SURE Program Name:* Chemistry REU Program

Nature has provided many examples of hydrophobic surfaces, most notably the lotus leaf. However, designing oleophobic surfaces is more challenging owing to the low surface tension of these liquids. Yet, precise control of wettability is crucial to a diverse range of applications where oil, water, or other fluids need to be repelled, such as in the transportation of oil through pipeline, truck, tanker, or rail car. Here we have demonstrated two methods of fabricating an oleophobic surface with functionalizing the surface of steel meshes with zinc oxide and the self-assembly of 1*H*,1*H*,2*H*,2*H*-perfluorooctanephosphonic acid (PFOPA) and with the incorporation of polytetrafluoroethylene (PTFE) within the electroless deposition of nickel. These methods show promise to improve the extraction and transportation of oil by removing the need for diluents to lower the oil's viscosity and by mitigating the loss of profits due to unrecovered oil residue. However, these omniphobic coatings are limited by their flexibility as they are deposited on steel mesh and steel coupons. Therefore, we also discuss the engineering of coatings with precise control of their wettability on flexible, fabric substrates. Here, we explore the functionalization of fabric surfaces with electroless nickel, varying nanoparticle loading and surface treatment concentration and time. Coating properties such as water and oil contact angles and morphology were explored. These coatings have the potential for significant impact in a variety of applications, for instance, as flexible liners in midstream oil industry operations to enable facile integration within shipping vessels.

**Fabrication of Nanocomposite Membranes for Water Filtration**

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*Graduate Student Advisor:* Ajinkya Raut
*Research Discipline:* Engineering (STEM), Science (STEM), Technology (STEM)

One of the major issues facing water treatment today is the filtration methods found in wastewater treatment plants. Reusability of filtration methods, longevity, and effectiveness are all factors that plague the industry. In order to accurately defend against these threats, researchers model large-scale plants, designing models in the lab that accurately depict what a water treatment plant might face from day-to-day. One of our goals this summer is to create a pumping system to accurately measure just how effective and how long one filtration method might last. Wastewater treatment plants usually are treating a liquid known as “activated sludge”, which is full of biological materials and microorganisms that end up as a very thick liquid. Most pumps are not able to handle such liquids and would clog quickly due to organic buildup. Fortunately, there are many pumps that offer no interaction with the liquid while still providing sufficient pressure. We plan to use a peristaltic pump, a pump that simply squeezes a tube containing the sludge. Peristaltic pumps are very easy to work on, as no part is ever actually touching liquid-the only thing that usually needs to be replaced is the silicon tubing. Using an Arduino nano to accurately control a stepper motor, this should allow us very precise control over just how much fluid can be pumped through the system. Using this method of testing, it should be easy to move, control, switch out types of liquid, and provide enough positive pressure to support an even larger testing environment. Without a properly metered pumping system, no filtration methods can be tested with quantitative results.

**Facile Synthesis of Carbon Nanotubes, Melamine, and Cu based Catalysts for Selective CO2 Reduction Reaction**

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*REU/SURE Program Name:* USRG

Conversion of $CO_2$ into fuels using electrochemical $CO_2$ reduction reaction ($CO_2RR$) is a viable pathway in reducing $CO_2$ emissions and the greenhouse effect. Electricity, a catalyst, and an electrolyte such as $KHCO_3$ are needed for the conversion into value-added fuels such as ethanol. State of the art catalysts made up of gold or silver yield high faradaic efficiency (FE) of Carbon Monoxide (CO) at feasible potentials. However, these catalysts are difficult and expensive to mass produce. Many studies have shown that catalysts made from single atomic Metal, Nitrogen, and Carbon (MNC) also yield a high FE of CO. These catalysts are cheaper and have a comparable performance to the more expensive catalysts but using these catalysts would need the further reduction of CO in order to obtain a value-added fuel. Copper, a relative cheap metal, is known for having the necessary qualities for converting $CO_2$ into value added C2+ fuels. Though recent studies have shown though that Copper lacks the stability and FE of ethanol needed to produce at industry scale. Herein, we mixed Cu and Ni based MNC to yield a high faradaic efficiency of ethanol because the MNC layer will reduce $CO_2$ to CO and the Cu will reduce CO to ethanol. This work provides insight in how Copper and MNC can be used as potential $CO_2RR$ catalysts for C2+ in an industry scale.

**Further Understanding Optical Techniques**

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*REU/SURE Program Name:* USRG

The field of optics is a truly fascinating field and stands out amongst the many other fields of Physics and Engineering. This is partly due to the fact that it deals with photons and the understanding of light, which we as people do not have a real grip on. During my summer research experience at Texas A&M University, I was lucky enough to significantly increase my understanding of optical properties while I worked on three different projects. The first of which was “HyperRaman Spectroscopy of Biomolecules”, the second was “Measurement of Germanium Power Decrease'' and the final one was “Measurement of Elasticity of Pig Larynxes” .These three projects allowed me to go through the entire process of a graduate level experiment from the planning stage all the way to the data processing phase. This experience made me become familiar with two very important optical techniques, knife edging to find a focus and two mirror alignment. These two techniques were integral in my work on the projects, even though the three projects were entirely different. I am very thankful for this opportunity to be apart of this program and learn so much. I recommend that undergraduates do this more often because they will not regret it.

**Galveston Bay Estuary Historic Trends:  Review of Species Response to Weather Events and Water Quality**

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*Research Discipline:* Interdisciplinary Research, Science (STEM)
*REU/SURE Program Name:* Independent Research Project

This report reviews compiled data from multiple facets of research across Texas in order to evaluate long-term environmental variation in Galveston Bay in relation to three invertebrate species: *Crassostrea virginica* (Virginia oyster), *Callinectes sapidus* (blue crab), and *Penaeus setiferus* (White Shrimp). The impacts of population fluctuation on higher and lower trophic levels were also considered. trace organics such as pesticides, herbicides, polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB) and other pollutants that historically posed serious risk to nearby populations. The proposed effort to improve the environmental conditions of Galveston Bay in 1993 with the intent of significant economic gain is also analyzed

alongside environmental trends noted after its implementation to determine if a significant outcome from the environmental mitigation is observable. Detailed water quality reports juxtaposed with documented weather events, anthropological and industrial impacts, and population trends in the aforementioned species across multiple decades contributes to the contextualization of these historical environmental trends within the estuaries of Galveston Bay in addition to providing a frame of reference for future environmental outreach programs.

**Ghrelin Signaling Regulates LPS-induced Activation of Autophagy and NF-κB Signaling in RAW 264.7 Macrophages**

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*REU/SURE Program Name:* Agriculture and Life Sciences Program

Activation of macrophages under LPS stimuli is essential for the host defense system while it needs to be properly controlled. Recent studies have shown that autophagy, an intracellular self-digestion process, is an important regulator of macrophage activity. Ghrelin is the only known orexigenic hormone, which is an endogenous ligand for the growth hormone secretagogue receptor (GHS-R). Recent studies have shown that ghrelin signaling also has an immunoregulatory effect. However, the underlying mechanisms on how the ghrelin signaling regulates the inflammatory and autophagic response under LPS stimulation are not fully understood. To verify the role of ghrelin signaling in LPS induced activation of autophagy and NF-κB signaling, we compared the gene expression in LPS-stimulated macrophage cell line RAW 264.7 by western blotting. To test the effect of ghrelin, RAW 264.7 cells were either pretreated with ghrelin or saline, followed by LPS stimulation. In addition, to test the effect of GHS-R, GHS-R knockout RAW 264.7 cells were compared with the wildtype. Under LPS treatment, ghrelin pretreatment suppressed the LPS induced activation of NF-κB signaling pathway and autophagy induction shown by decreased phosphorylation of NF-κB p65, IκBα and expression of p62, LC3II. Furthermore, in GHS-R KO, LPS induced activation of autophagy-related genes were suppressed compared to its WT control. Overall, these findings suggest that the ghrelin signaling pathway plays an important role in attenuation of LPS induced activation of NF-κB signaling and autophagy.

**Groundwater Pumping and Energy Usage**

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*REU/SURE Program Name:* USRG

Groundwater resources are utilized throughout the world. Being the largest accessible freshwater source, groundwater is pumped for irrigation, industry, and drinking water. Unfortunately, it is not an infinite source and overpumping causes various adverse effects attributed to declining water levels. Just like water can provide energy, obtaining water requires energy. This research examines the relationship between the depth of groundwater pumping in an aquifer and the household cost of energy. The calculation of the household cost in United States Dollars (USD) is a key part in groundwater sustainability. To investigate this connection, a system dynamics model was created using Vensim DSS. This software allowed for different variables to be changed and the effects to be evaluated to create a simulation of an aquifer with a declining groundwater volume. The model showed that as the water level of the aquifer decreased, the energy it took to pump the well in kilowatt-hours per day increased. In turn, as the energy usage increased, the cost of energy in USD increased.

**Growth Hormone Secretagogue Receptor Knockout (Ghsr KO) Protects Against Bisphenol A (BPA)-induced Colitis**

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*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Independent Research Project

The aim of this study is to determine whether the growth hormone secretagogue receptor (GHSR) genetic knockout (KO) in a mouse colitis model has a protective effect against toxicity of bisphenol A (BPA). It is known that BPA has pro-inflammatory effect and causes weight gain through enhanced adipogenesis. However, in dextran sodium sulfate (DSS)-induced colitis model, DSS leads to weight loss. In this study, we compared mouse body weights between DSS treatment group and DSS+BPA group, which include mice with wild-type (WT) Ghsr gene and Ghsr KO genotype. First, corn oil (a solvent control) or 100ug/kg BW/day BPA in corn oil was administered through gavage. Then, DSS was administered in the drinking water from day 6 to day 10. Disease activity index (DAI) was analyzed according to body weight change, texture of feces form, blood stain to assess bleeding, and anus appearances. Results showed that Ghsr KO mouse body weights were recovered faster from DSS and DSS+BPA effects. They also maintained their body weight with gradual decreases in response to DSS+BPA. More importantly, GHSR KO mice had lower DAI. These observations suggest Ghsr KO protects against the intestinal toxicity of DSS and DSS+BPA. The GHSR antagonist may potentially have a pharmacological effect to reduce inflammation and colitis.

**Identification of Genetic Variation that Contributes to PFOS Tolerance in *Arabidopsis thaliana***

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*Secondary Faculty Advisor/Principal Investigator:* Dr. Libo Shan
*Graduate Student Advisor:* Gretchen Kroh, Post Doc
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*REU/SURE Program Name:* Texas A&M Biochemistry Summer Undergraduate Research Program

Per- and polyfluoroalkyl substances (PFAS) have been known to be a risk to the environment and public health since the late 1990s; however, these chemicals have been utilized since the early 1940s to make flame retardants and chemical resistant coatings. These chemicals have properties that allow them to move downgradient in water and due to their heavy usage in the past, they have spread throughout the environment in both soil and water. Plants are known to be able to uptake PFAS from the soil. Therefore, this project aims to determine if plants can be used as a quick and cost-effective method to remove these chemicals from food and water sources to prevent any long-term damage to the health of the environment through a process called phytoremediation. The goal of this project is to use phytoremediation to rapidly remove one type of PFAS, Perfluorooctane sulfonic acid (PFOS), from the soil and decontaminate food and water sources sustained in the environment. In order to do so, 329 ecotypes of *Arabidopsis thaliana* were screened to determine which plants were the most capable of tolerating growth in PFOS. Phenotypes and root lengths were collected from these initial screenings for a Genome-Wide Association Study (GWAS). A GWAS was performed to determine which genetic markers can be attributed to PFOS tolerance. The conclusion was reached that ecotypes of this plant originating from Sweden are the most tolerant to PFOS solution. While multiple GWAS have been run, no significant genetic markers were determined; however, the project is still ongoing.

**Identifying Cyber Intrusions through Human Eye-Tracking Metrics**
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*REU/SURE Program Name:* REU Cyber Manufacturing

Analysis of eye movement has been on the rise for the past few years to explore areas of people's interest, cognitive ability, and skills. The basis of eye movement usage in these applications is the detection of its main states and events—namely, fixations and saccades, which ease and facilitate understanding of the space-time processing of a visual scene. This study presents a novel approach for the detection of eye movement events and correlating it to one of the most important elements of effective human-robot collaborations (HRCs), trust. Male and female participants were recruited to perform a collaborative assembly task with an industrial robotic arm, in which they underwent reliability conditions (reliable, unreliable). The results showed that the reliability of a robot has long been shown to manipulate trust perceptions as further validated in this investigation; however, the resulting impact of reliability on operator performance has not been thoroughly investigated. The performance of a collaborative system is influenced by the individual performances of the cobot and operator agents, in addition to the interactive/collaborative performance between the two. Consequently, further investigation is needed to make better conclusions. Nevertheless, the preliminary findings provide a strong foundation for future investigations to gain a better understanding of the relationship between eye-tracking data and trust in HRC. These promising outcomes suggest that the proposed solution may be used as a potential method for developing more diagnostic and deployable measures of trust.

**Impact of Bifenthrin-based Insecticide on DIpteran Colonization and Diversity of a Carrion**
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*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Independent Research Project

To aid in the determination of the Post-Mortem Interval (PMI), forensic entomologists must rely on the life cycles of various necrophagous Dipterans. Several prior studies have examined several factors that can influence these Dipterans' life cycles; However, no known studies have observed the potential effects of pyrethroids on dipteran colonization and diversity on a carrion. This study examined if colonization and species diversity of forensically important dipteran larvae on both buried and unburied carrion was negatively impacted by environmental contamination with a Bifenthrin-based insecticide. It was found that environmental contamination significantly decreased ($p = 0.04334$) the overall larval count across all buried carrion, and significantly decreased species diversity across all buried (p

**Implementation of Baseball Bat in OpenSim Full-Body Model**
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*REU/SURE Program Name:* BMEL UGRP

Injuries are prevalent in most sports, but especially in baseball due to the baseball players' reliance on most of the major muscle groups when batting. During the recovery process, a baseball player will go through various stages of batting training while increasing intensity to ease the player back into game-ready shape. The five stages of this batting rehabilitation are as follows: wiffle bat dry swing, a dry swing with their preferred bat, tee-assisted batting, slow toss, and ultimately batting with a pitching machine. The purpose of this study is to analyze the intensity and joint forces exerted during each stage of rehabilitation to ensure the most beneficial progression for return to sport. This analysis will occur through the modeling of motion capture data in the musculoskeletal modeling software OpenSim. To model the complex movements during the batting motion, a full-body model was modified to include both the musculoskeletal model of the body and the model of the baseball bat to allow for interactions between the player and bat to be analyzed. The bat model aided visual comprehension during analysis and we hypothesize that the model will further support the lab's findings regarding the intensity and joint forces applied by the players during their rehabilitation. In the future, the bat model will be revised to more accurately model the batting motions during these five rehabilitative stages.

**Improving Access to Higher Level Math for The Visually Impaired**

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*REU/SURE Program Name:* Independent Research Project

Mathematics is a subject that is taught with many spatial components. Spatial reasoning is often the starting point of teaching for higher level mathematics such as derivatives being associated with the slope of a graph or integrals being the area beneath a curve. Spatial logic permeates beyond graphs and into equations. The layout of an equation often includes a certain spatial logic behind it such as the placement of the lower and upper bound of an integral. Even the way we talk about equations includes spatial terms such as under a square root. Much of this spatial logic is lost when math is taught to the visually impaired as braille conversions or even speaking often fail to include all of the same information contained in the layout of an equation. In an attempt to better convey the lost spatial information to the visually impaired, we discuss the use of haptic feedback as a means to provide additional context to an equation replacing the lost information. This is accomplished through creating distinct and unique textures by implementing haptics that will then be associated with the relevant spatial information to convey association between different parts of an equation as viewing the layout would normally provide.

**Improving Cyber Security in Marine Renewable Energy Systems: Why the U.S. Military Should Care**

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*REU/SURE Program Name:* OCEANUS

Cyber attacks are a new category of threat that requires many collaborators to identify and anticipate this danger. The power sector is extremely vulnerable to cyber attacks as many communities rely on these power grids to operate. A revolutionary aspect of this sector are Marine Renewable Energy (MRE) systems that convert oceanic processes into power which is equally as defenseless to cyber attacks. MRE systems are not only renewable, they are less likely to be infiltrated and thus are attractive to defense agencies and the military. By offering improvements to the preventative measures and response rate of the cyber security framework of MRE systems, a more bipartisan approach to defense can be advised that utilizes the innovations of science. These improvements consist of the proposal of a Department of Defense agency dedicated toward assessing cybersecurity risk of MRE systems and offering preventative and active measures to cyber attacks. While there is always risk of cyber attacks and no technological system is completely foolproof, more efforts toward protecting MRE systems will ensure continuous operation of these devices especially in times of national threat. Cybersecurity architectures such as the National Institute of Standards and Technology (NIST) Cybersecurity Framework, the SPIDERS JCDT cyber security architecture for microgrids developed by Sandia National Laboratory (SNL), and the Defense Advanced Research Projects Agency (DARPA) program RADICS are considered. This study applies actions taken by other departments and analyzes previous cyber attacks in order to recommend an efficient risk management framework for MRE system protection in the U.S. Military.

**_In vitro P_ollen Tube Germination Rates Among Different Upland Cotton CS Lines & _in vitro_ Pollen Incubation and Tube Germination for _in vivo_ Fertilization of Upland Cotton Flowers**

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*REU/SURE Program Name:* Summer Undergraduate Research in Genetics and Genomics (SURGe) at Texas A&M University

Genetic and genomic research on meiotic recombination, pollen development, and function in cotton (*Gossypium hirsutum* L.) will be empowered if systems can be established for *in vitro* cotton pollen tube germination and allow for subsequent fertilization *in vivo*.
In the research component of my SURGe program, I focused on two aspects of cotton pollen tube research platform development, with the goal of better understanding the limitations and potential of a recently developed protocol for *in vitro* cotton pollen germination:
1)Are the methods sufficient to detect differences in pollen germination rates among interspecific chromosome substitution lines (CSLs)?
2)Can pollen grains incubated and/or germinated *in vitro* can be used to fertilize flowers *in vivo?*
Observed rates of pollen germination were relatively low in both wildtype controls and CSLs and too variable to discriminate statistically between them in a robust manner. *Improved germination rates and consistency would be advantageous. Future experiments would benefit from the inclusion of one or more negative (sterile) "controls", and correlative analyses of fertility/sterility, e.g., staining and/or viability assays.*
Observed rates of fruit development from control and artificially germinated pollen can fertilize *in vivo* were highly positive. *This suggests that pollen tubes could be exposed to treatments in vitro, e.g., chemical or biological mutagens, nearly immediately prior to the formation of the sperm cells and double fertilization.*

**Industry 4.0: Integrating Computerized Networks into Industrial Environments**

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This study investigates the construction of an Internet of Things network on a mechanical system, and studies how sensor data fed through an MQTT broker could be analyzed and interpreted to determine specific trends in machine behavior, as well as how to format the objectives and processes into a teachable format. A model of an integrated sensor network was created using a Raspberry Pi as a central computational device. The information from the sensors was fed through the Pi using an MQTT software called Mosquitto, and published to distinct caches of information, called topics, using a software called Node-Red. This data could then be stored and later extracted by a subscribed client based on the published topic. From this, data concerning specific aspects of the machine could be observed, collected, organized, and modeled to predict future behavior. The organization of the data can even lead to further analysis of the system by creating dashboards for proper story-telling of the industrial environment. This data visualization will help improve the existing processes that cause bottlenecks in the system, leading to higher efficiency. Additionally, the documentation of the development of this system will allow future individuals interested in IoT systems and Industry 4.0 to more easily create and improve digital networks of their own.

**Inhibition of Cysteine Proteases by Peptidomimetic Aldehydes**
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*REU/SURE Program Name:* Biochemistry Biophysics

Cysteine proteases comprise one of the four large enzyme families that catalyze the cleavage of peptides and peptide sequences in proteins. Like the serine proteases, cysteine proteases catalyze peptidolysis through double-displacement reaction mechanisms, in which the eponymous cysteine group acts as a nucleophile to attack the lytic bond, with general acid-general base assistance from a nearby histidine group. The enzyme catalysis involves the formation of a thio-ester intermediate between enzyme and substrate in an initial acylation half-reaction, which subsequently undergoes hydrolysis (de-acylation) to complete the peptidolytic reaction. Cysteine proteases are essential to metabolic processes in prokaryotes and eukaryotes, and are particularly important to human infection by parasitic protozoa (P. falciparum / falcipain /malaria; T. brucei / rhodesain/ African sleeping sickness; and T. cruzi / cruzain /Chagas's disease), and SARS coronaviruses 1 and 2 (3CL protease and papain-like protease). Aldehydes are organic compounds that are highly used as 'tool" compounds in drug discovery due to their quick inhibition reaction time. However, given their metabolic instability and high reactivities with cellular nucleophiles such as glutathione, they have limited use as potential drug candidates. By using fluorogenic peptide substrates of cruzain and human cathepsin L, the time-dependent, potent inhibition of these two enzymes by Cbz-Phe-Phe-CHO (BC-12) have been characterized, an important precursor compound for the self-masked aldehyde inhibitors of these two cysteine proteases. Monitoring enzyme reactions within a period of time to determine time-dependent inhibiton has revealed the potency and time-dependent nature of this inhibitor vs. these two important cysteine proteases.

**Injector Spray and Operating Characterization for use in a Multiphase Detonation Facility**
*Author:* Carlos Valenitn
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*Graduate Student Advisor:* Calvin J. Young
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*REU/SURE Program Name:* USRG Summer 2021

A study is conducted to characterize droplet generators for use in a new multiphase detonation facility. Interest in propulsion from rotating and pulsed detonation engines utilizing liquid hydrocarbon fuels has brought about a need to study how droplets are processed by a multiphase detonation. In order to study how droplets break-up, vaporize, and react in a detonation environment, accurate knowledge of the distribution of droplet sizes in the experiment are necessary, as well as the knowledge operating characteristics of the particle generators. In this study, several various automotive fuel injectors are investigated as possible candidates for particle generation. An experiment is constructed consisting of an injector, an optically accessible spray containment vessel, variable pressure fuel supply, and control circuitry. The setup allows for variation of selected operating parameters of the injector to determine their effects on the droplets generated. The optically accessible vessel allows for accurate particle size measurement utilizing the laboratory's new Phase Doppler Particle Anemometry system. Data on generated particles of dodecane fuel is collected and presented for a series of injectors operating at various pressures and control signals.

**Inorganic and Organic Carbon Fluxes from Tropical Andisols and Andesitic Saprolite in a Pre-Montane Rainforest**
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*REU/SURE Program Name:* Costa Rica REU

Tropical rainforests play a key role in global carbon cycling. The fate of carbon in these systems is not clear due to lack of direct measurements of transformations and fluxes. The objective of this study is to measure the fate and transport of dissolved inorganic (DIC) and organic carbon (DOC) within the major soil horizons of a first-order mountain stream in Alajuela Province, Costa Rica. Surface and subsurface DIC fluxes to stream water were previously measured in this watershed, but clear end-member chemistries were not well-defined, limiting the delineation of major sources of DIC. The main soil horizons with their conceptualized hydrologic flow pathways in parentheses are: 1) leaf litter (quick flow); 2) mineral soil (interflow); and 3) saprolite (baseflow). We hypothesize that DIC is largely produced from decomposition of organic matter during leaching of leaf litter. The leaf layer releases DOC acids, which weathers silicates within the underlying mineral soil releasing dissolved calcium (Ca). Lastly, the saprolite layer acts as a DIC sink by precipitating carbonates, which is facilitated by a rise in pH. This hypothesis was tested using duplicate sequential flow column experiments packed with the three soil horizons in columns (ID=6.3, length=20 cm). Steady-state (2.3 ml/min), storm (9.2 ml/min), and drought (0 ml/min) flow rates were simulated. The influent rainwater pH and DIC concentration was 7.6 and 3.0 mg/L, respectively. Under steady-state flow conditions downstream of the leaf litter, mineral soil, saprolite, DIC was generated at a rate of +5.7, +17.9, and -10.2 (mg/L DIC)/day, respectively, indicating saprolite acts as a DIC sink. The simulated storm enhanced kinetic rates of DIC production. The specific conductance measurements correlate to alkalinity indicating that carbon mineralization as water seeps through the rainforest floor was responsible for generating DIC and releasing other ions. Our results inform reforestation programs, such as Payment for Ecosystem Services, to evaluate effectiveness of rainforests as long-term atmospheric carbon sinks.

### Investigating the Impact of SIM2 Elimination in HC11 Mammary Epithelial Cells and their Subsequent Unfolded Protein Response (UPR)

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*REU/SURE Program Name:* Aggie Research Program

During gestation, providing nutrients for offspring demands a higher level of energy production in the mammary gland which can facilitate a stressful environment during the differentiation of epithelial cells into mammary epithelial cells. As a result of this, the endoplasmic reticulum (ER), which is responsible for protein synthesis and folding, must meet the cell's increasing demands, thereby creating endoplasmic reticulum stress (ERS). In order to combat ERS, the cell activates a network of signaling pathways that either restore the normal ER function or induce cell apoptosis; also known as the unfolded protein response (UPR). Past studies have shown that X-box-binding protein 1 spliced form (Xbp1s) and activating transcription factor 4 (ATF4), part of the network of the UPR, are necessary for mammary gland differentiation. Single-minded 2 (SIM2) is a master regulatory transcription factor from the bHLH/PAS family that is critical for development. A short spliced variant of SIM2, SIM2*s* has been established by our lab to be an essential component of mammary gland development. In order to understand the direct correlation between SIM2 elimination and the UPR, our lab utilized an in vitro model of SIM2*s* knockout in HC11 mammary epithelial tissue cells to analyze the gene expression of specific UPR genes ATF4 and Xbp1s through a qRT-PCR analysis. A question that remains is how the cell perceives the metabolic stress that occurs during mammary gland development. However, we expect that our findings would present evidence for SIM2 as a component of the homeostatic stress response.

### Investigating the Mechanisms that Bacteriophage N4 uses to Delay the Inevitable

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*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Agriculture and Life Sciences

Bacteriophages or phages are viruses that attack and kill bacterial cells by lysing them. For this reason, phages are under investigation as alternative treatments for human multidrug-resistant bacterial infections. However, understanding the regulatory pathways that lead to phage-based cell killing is critical for safe and effective application in clinical settings. Lysis is a coordinated molecular event in which phage proteins target and destroy each layer of the bacterial cell wall. Holins are a type of phage protein referred to as the "lysis clocks" because they initiate lysis by creating holes. In phage N4, an unknown mechanism prevents the holin from initiating lysis. This is known as lysis inhibition (LIN). Though lysis is delayed, N4 gains an advantage of a larger burst size when employing LIN, allowing 10-100x more virions to escape. In this study, we sought to determine the identity of the N4 signal that initiates LIN. A series of phage mutations and chemical inhibitors of specific stages in the phage replication cycle were used in a cell-based LIN assay. The results suggest the LIN signal is delivered to the infected cell from N4 virions as proteins or genomic DNA, or that it originates from the newly synthesized phage proteins encoded in early genes. Additional studies are needed to fully understand the impact that delaying lysis and a larger burst size have on overall effectiveness when N4-like phages are being considered for multi-drug resistant bacterial therapy options.

**Investigation of the Effect of Graphene Fillers in Moisture-driven Actuation of SPEEK**

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Soft-actuating, polymeric fibers have proven advantageous in applications such as artificial muscles due to their low weight and high actuation properties. Many existing studies dedicated to these microfibers detail their response to thermal stimuli despite vulnerability to temperature degradation. Consequently, other environmental stimuli are topics of interest. One such mechanism is athermal, solvent-driven actuation. The material presented in this paper evaluates the effect of humidity on sulfonated poly(ether ether ketone) (SPEEK) with various compositions of graphene fillers. SPEEK film was synthesized through treatment of poly(ether ether ketone) (PEEK) with concentrated sulfuric acid. Graphene nanoplatelet (GNP) fillers were introduced to the films with relative weights: 0%, 0.5%, and 1%. Wet-spinning served as the fabrication technique. The microfibers were characterized by ionic exchange capacity (IEC) and degree of sulfonation (DS) measurements via back titration methodology. The water uptake capacity of the fibers was also measured to characterize the fibers' water retention properties. Axial expansion and contraction of SPEEK/GNP fibers was measured using a laser sensor in an alternating, nitrogenous dry and humid environment. The data gathered indicated that the SPEEK fiber with 0.5 wt% GNP performed the best in terms of the rate and magnitude of actuation. This is likely due to graphene facilitating ion exchange. However, the 1 wt% GNP microfiber actuated the least, likely due to graphene's large Young's modulus.

***Key Words**:* Artificial muscles, Graphene nanoplatelets, Soft actuators, Solvent-driven

**Investigations of Diamond Detectors for Particle Identification**

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*REU/SURE Program Name:* Cyclotron Institute REU Program

With advancements to the chemical vapor deposition (CVD) technique, manufacturers are now able to produce single crystal diamonds with lower impurities than in the past. The diamonds made using CVD have been implemented as charged-particle detectors and have been shown to have good energy resolution, fast response time, and higher radiation hardness than silicon detectors. Because of these characteristics, diamond detectors may be used for accurate particle identification, with the potential to perform well in high energy experiments. Work presented includes data from both a diamond telescope detector and silicon telescope detector. The detectors were placed at the end of the Momentum Achromat Recoil Spectrometer (MARS) beamline at the Texas A\&M Cyclotron Institute. Using a 35 Mev/u $^{78}$Kr beam produced by the K500 superconducting cyclotron on Be and Ni targets, a direct comparison of the data from the silicon detector and the diamond detector was performed. While particle identification was possible using a ΔE - E diamond telescope, it was also observed that diamond detectors suffer from saturation and significant pulse height defects.

**Isolating Escherichia coli O157:H7 Specific Phage-Displayed Probes for Food Safety**

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*REU/SURE Program Name:* Summer Undergraduate Research Program: Texas A&M College of Dentistry

**Objective**: Development of rapid pathogen detection systems is crucial to minimize the outbreaks of foodborne pathogens. *Escherichia coli* O157:H7 is an important foodborne pathogen that infects over 63,000 people annually in the US. Ingestion of food or water contaminated with the bacterium can lead to symptoms including severe abdominal pain and bloody diarrhea. We previously developed a highly effective and user-friendly biosensor system using phage-displayed oligopeptide probes for detection of *Salmonella enterica* serovar Typhimurium. Our goal in this study was to adapt our biosensor for detection of *E. coli* O157:H7 by isolating bacterium specific phage-displayed oligopeptides. **Methods:** We used the phage display library from New England Biolabs that displays 12-oligopeptides on pIII of the bacteriophage M13 as the source of the oligopeptides. We used both exponential and stationary phase cells as targets to isolate probes that can recognize both stages of growths. To minimize strain-bias of the probes, we used four different isolates of *E. coli* O157:H7 as the target for biopanning. We also minimized cross-reactivity of probes by implementing a stringent negative biopanning procedure against other strains of non-shiga toxin producing *E. coli*, a total of 12 different serovars of *Salmonella enterica*, and 2 different species of *Shigella*. **Results:** Following 4 rounds of positive biopanning and 6 rounds of negative biopanning, we have thus far enhanced the population of phages that bind to *E. coli* O157:H7 by almost 25-fold or 0.002% of the population. Our previous results of probe isolation indicate that several more rounds of biopanning are likely to result in enhancing the desired population to approximately 10% of the population. Once isolated, the phage-displayed oligopeptide probes will be immobilized on magnetoelastic particles to form an *E. coli* O157:H7 specific biosensor for detection of the pathogen in less than five minutes.

**Isotopic Analysis of Hair as an Indicator of Growth in Bison (*Bison bison*) from the Southern and Northern Great Plains.**

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The Great Plains is vulnerable to rising temperatures and drought that affect forage for domestic and wild animals, including bison (*Bison bison*) on public and private lands. Stable isotopes of carbon ($^{13}C$) and nitrogen ($^{15}N$) track diet and environmental stressors as they are incorporated in organs and hair. We used isotopic values of female bison harvested at 2 - 3 years of age to compare growth in the northern (Saskatchewan; n=12) and southern Great Plains (Texas; n=12). Bison were similar in live mass (402.48 kg), but southern bison were smaller than northern bison when comparing the mass of the carcass (muscle and skeleton; 213.08 vs. 258.53 kg). Isotopic values of recently grown hair (1cm from base) increased with heart and liver for both $^{13}C$ and $^{15}N$. Basal hair and organs were similar in $^{15}N$ values among sites, but $^{13}C$ values were greater in southern than northern bison ( -20.11 vs. -23.19 ppt). Segments of hair were consistent in carbon concentration even though mass declined from base to 20 cm. Values for $^{13}C$ declined from the base to 20 cm in northern bison. $^{13}C$ values declined from the base to 10 cm in southern bison, while $^{13}C$ values increased in older segments. Greater variation in isotopic values of hair in southern bison is consistent with variable diets of C3 and C4 grasses in hot dry climates. Managers of public and private herds of bison could use isotopic analyses to evaluate strategies for attenuating environmental stress on bison productivity.

**Laminar Flame Speed Measurements of 1-Butyne**

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*Graduate Student Advisor:* Mattias Turner
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Jet fuel, a mixture of large hydrocarbons, is burned in a jet engine to propel aircraft. In the oxidation of jet fuel, one intermediate molecule is 1-butyne. Laminar flame speed is an important parameter of fuel that is used to characterize its combustion chemistry. Experiments were run to determine the laminar flame speed of 1-butyne. The composition of the gas mixture included 1-butyne and air. The experiment matrix for this mixture included three pressure levels (1, 2, and 3 atm), and the equivalence ratio ranged from 0.6 to 1.9 in increments of 0.1. Using a high-speed schlieren diagnostic, the spherically expanding flame was recorded, and the flame speed was extracted. The laminar flame speeds measured were significantly faster than the AramcoMech 2.0 model, around 5-6 cm/s on average. Studying the flame speed of this mixture provides valuable information for modeling the chemical kinetics of this intermediate molecule. Knowledge of the reaction rates of butyne will contribute to modeling of mixtures of large hydrocarbons such as jet fuel.

**Literature Analysis and Best Practice Recommendations for Pregnant Women Suffering from Substance Use Disorder**

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*REU/SURE Program Name:* Independent Research Project

**Background:** Stigma and prejudice have long permeated the issue of substance use disorder (SUD). These issues surrounding SUD are amplified during pregnancy. Pregnant women have difficulty finding unbiased treatment when experiencing SUD. In summer 2020, the Texas A&M College of Nursing received a grant that allows for expansion of efforts to support women, children, and families in rural areas impacted by opioids and SUD. The literature search was guided by the following question: What can be improved from the current best practices regarding pregnant women suffering from SUD? **Purpose:** Our overall project objective is to decrease stigma associated with maternal SUD and to provide prevention, treatment, and recovery resources to those suffering in the rural Golden Crescent of Texas. The aim of this presentation is to review best practices for treating SUD in pregnancy. **Results:** In a review of recent literature, 14 pieces of evidence we pulled revealed that many women appreciate a non-judgmental, supportive environment and that it can have a positive influence on the health of the mother and baby. Results of this literature search will assist in development of best practice recommendations for healthcare providers (HCPs) who may encounter pregnant women with SUD. Additionally, a pamphlet will be provided to guide women through interactions with their healthcare providers regarding SUD. **Conclusion & Recommendations:** Our goal is to help reduce stigma affiliated with maternal SUD. This can be achieved by immersing ourselves into our target region to combat circulating myths and bias among the healthcare community. We can implement programs to increase awareness of SUD during pregnancy and provide treatment options for these patients. Our recommendations for HCPs are: (1) Reduce usage of stigmatizing language in all patient interactions; (2) Propose the options of medication-assisted treatment (MAT) and alternative interventions; (3) Discharge planning should consist of screening for comorbidities and offer referrals to other services.

**Machine Learning in the Additive Manufacturing Process of Metals**

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*REU/SURE Program Name:* Cyber-manufacturing REU program

Continuously, technology has revealed to us to always be one step ahead, especially in the industry field, where different techniques have been developed to make the manufacturing process faster, as well as more promising. Such is the case of the Additive Manufacturing (AM) industrial process, which as its name implies, consists of the creation of 3D objects, through the addition of layer by layer. However, despite the great development that this process has had in such a short period of time, defects have been observed in different pieces created by it. To detect the defects that occur in the additively manufactured parts, X-ray images are taken, demonstrating more effortlessly where the defect is created in the part. Considering this, the main purpose of this research is to develop the ability to perform image processing in conjunction with the labeling of these images, in order to easily identify porosity, among other defects. Furthermore, as the main objective, a Machine Learning (ML) algorithm will be created to reach an effective result when using AM in industrial processes. It is expected that the results that will be obtained in this research will be of help for the future, as it is in infrastructure, in industry, and especially in technology.

### Machine Learning for Enhanced Reliability in Thermal Energy Storage Using Phase Change Materials

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Thermal Energy Storage (TES) platforms mitigate the paucity between peaks in consumption and supply, i.e., they absorb thermal energy during periods of excess supply and release thermal energy during periods of deficit. Phase change materials (PCMs) have attracted significant attention over recent years due to their efficacy in improving performance and reliability of TES platforms. Typically, inorganic PCMs afford higher latent heat values than organic PCMs, yet often at the detriment of compromised reliability. A crucial issue with inorganic PCMs is the higher degree of supercooling (also known as “subcooling”) required to initiated nucleation (which degrades their reliability, net energy storage capacity, and power rating of the TES platform). “Cold Finger Technique (CFT)” can be used to mitigate these issues where a small portion of the total mass of PCM in the TES platform is left in solid state (in order to facilitate the spontaneous nucleation). Therefore, reliability issues are ameliorated by using CFT but at a marginal cost to the net storage capacity while power rating of the TES remains almost unaffected. In this study, machine learning (ML) techniques were leveraged to exploit the capability of CFT more effectively. Temperature transients from PCM melting experiments are used to investigate the capability of this deep learning technique (i.e., using multi-layer perceptron model or “MLP”) in order to predict the required time to reach the designated melt fraction of the PCM. The results show that the Artificial Neural Network (ANN) model designed and implemented in this study is capable of predicting the time required to reach pre-designated value of melt fraction with outstanding accuracy (e.g., 90% melt fraction which is specified by the user). The mean error of the predictions is calculated and is expected to be less than 10 minutes, especially for an interval of 30 minutes before the TES platform reaches the desired value of the melt fraction (i.e., 90% melt-fraction) for a total time spanning 2~3 hours. However, this approach is more susceptible to the fidelity of the training data set utilized for training the ANN (MLP) algorithm.

### Manufacturing and Testing Metamaterial Arrays

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*REU/SURE Program Name:* REU

Electron Cyclotron Resonance (ECR) ion sources generate the ions accelerated at Texas A&M’s Cyclotron Institute. However, while scientists know how to use ECR to create specific ions, the properties of the plasma within the source are relatively unknown. The ultimate goal of this project is to install a microwave camera to the ECR ion source to gain a temperature gradient over the plasma. The results from this project will provide knowledge about the fundamental properties of the ECR plasma, which will give enhanced knowledge of the ECR ion source, creating stronger beams for the cyclotron. My contribution to this project included developing code for the array control system, assisting in designing manufacturing and testing procedures for metamaterial arrays, and making frequency response measurements as part of the preliminary validation of the metamaterial design. An update on the progression of the creation of the system will be shown.

**Manufacturing as a Service**

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*Research Discipline:* Science (STEM), Technology (STEM)

*REU/SURE Program Name:* Independent Research Project

Classic manufacturing techniques are outdated now that we have shifted towards virtual consumer experiences. For commercialism and business to survive, modern technology and up-to-date manufacturing methods must be implemented. The MaaS (Manufacturing as a Service) project intends to revolutionize the manufacturing workflow to fit into this upcoming industrial revolution. This project will connect stations with 3D printing technology directly to consumers wanting to order a custom part. This, in turn, will eliminate the middle man and allow for users to work directly with the manufacturers, and make parts cheaper and much more customizable. The user will be placing the order through an Uber-like platform. After the part selection process, the manufacturer will make necessary changes and send the design files in the form of G-Code instructions to the nearest printing station to the customer. The part will be printed and delivered to the user much quicker than possible when using online sites such as Amazon and Ebay. Through our 3D printing technology, the user will be able to provide us with G-Code print settings including material, quality, size, infill density, print speed, and more. Because of this, the user will be able to control the quality of their part as well as physical features. Thank you for your interest and please direct any questions to the email listed in the presentation.

**Mass Spectrometry Imaging: Revealing Molecular Pathology of Alzheimer's Disease in 5xFAD Mice**

*Author:* Bianca Aridjis-Olivos

*Primary Faculty Advisor/Principal Investigator:* Xin Yan, Ph.D.

*Graduate Student Advisor:* Dallas Freitas

*Research Discipline:* Science (STEM)

*REU/SURE Program Name:* Chemistry REU

Accounting for up to 80% of all dementia cases, Alzheimer's disease (AD) is a chronic neurodegenerative disease that affects multiple cognitive domains such as memory, language, visuospatial function, personality, and behavior. Pathological structures of AD include neurofibrillary tangles and the formation of amyloid-beta (Aβ) plaque deposits. While the exact mechanisms behind the disease are not completely understood, lipid metabolism has been reported to have a high correlation with the amyloid pathology. To shed light on the molecular pathology, this project uses the technique of mass spectrometry imaging (MSI) in conjunction with desorption electrospray ionization (DESI) to extract and study the lipid makeup and spatial distribution in brain samples of 5xFAD mice models. Several glycerophospholipids have expressed a decrease in abundance while fatty acids have increased throughout the progression of AD. Thereupon the observed lipid aberrations in the whole brain of early-onset AD pathogenesis indicate a perturbation of lipid metabolism.

**Maximum Stress vs Void Area Fraction**

*Author:* Benjamin McKeig

*Primary Faculty Advisor/Principal Investigator:* David H. Allen, Ph.D.

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*Research Discipline:* Engineering (STEM)

*REU/SURE Program Name:* USRG

This study observed the effect of voids within a material on stress intensity. This information is key to the implementation of a specific plastic composite (HDPE with glass fibers) in railroads crossties and low-cost seawalls which could prevent rail buckling and the loss of life associated with it. This composite has many holes, or voids, littered throughout it, due to the blowing process that is used in their creation. The number of voids vary as a function of location within the cross section of the composite, and it is important to determine how the strength of the material varies throughout it. One way of discovering this relationship is to figure out how the percentage of voids, void volume fraction, affects the maximum stress the material is under. Five digital, models were created and tested with one, constant, downward force to determine this relationship. Because only one force in one direction is being applied, this problem can be simplified to two dimensions without risk of inaccuracy. Each model was created with a different void area fraction between 0% and 5.79%. Two separate Python programs were used to determine the various stresses within the models to calculate the maximum, normal stress in each model. These maximum stresses were compared to their respective void area fractions and a power regression was run to solve an equation that best fits the data.

**Mechanical Fracture Development in a Biodegradable Cylindrical Bone Fixation Device After Short and Long Term Degradation**

*Author:* Andra Thurtell
*Primary Faculty Advisor/Principal Investigator:* Andrew B. Robbins, Ph.D.
*Graduate Student Advisor:* Zachary T. Lawson, B.S.
*Research Discipline:* Engineering (STEM), Health and Medicine (STEM)
*REU/SURE Program Name:* Biomechanical Environments Laboratories

Surgical reconstruction of fractures on weight-bearing long bones can have several complications; up to 20% of all fractures exhibit malunion with even more experiencing stress shielding, and requiring a follow-up surgery to remove the fixture. These risks are especially high in comminuted fractures where bone fragments are removed during reconstruction. To address these risks, a novel biodegradable shell was developed which encapsulates the fracture and degrades with the healing process to reduce stress shielding and remove the need for follow-up surgery. The present research aims to mechanically characterize these implants. Eleven shells were loaded at 200 in-lbf on a static bending setup in a degradation bath of PBS at 37ºC until failure, defined as fracture or 30º of angular displacement. If still intact, shells were removed after 7-days or 14-days. An exponential curve was fit to the time-angular displacement chart in the form $d = C_0e^{mt}$ where d is the angular displacement, $C_0$ is the initial angle, m is a time coefficient, and t is the time elapsed; $C_0$ and m were calculated across all samples. Concurrently, ten shells sat in the degradation bath unloaded, removed at 7-days (n=5) or 14-days (n=5), and tested on a custom modified four point bend test until failure. Failure encompassed four fracture types: Type 0 (no fracture), Type I (single chip fracture), Type II (single chip with cracking), or Type III (complex fracture). From the static bending setup, $C_0$ = 3.4384 (±0.5004 SD) m = 0.0105 (±0.0015 SD). From the mechanical tests, four of the five 14-day shells failed with Type 0 fracture while the 7-day shells failed with a mixture of fractures; the bone cuffs became more ductile as they degraded. The shells show promising results and likely can provide sufficient mechanical strength for 1-2 weeks until a callus is formed on the fracture site.

**Meta-analysis of Changes in Microbial Community Composition in Surface Seawater After Exposure to Oil and/or Oil and the Dispersant Corexit**

*Author:* Jean Gonzalez
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*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Observing the Ocean

The response of natural microbial communities to hydrocarbon spills is an important component of spill remediation. Recent work has focused on identifying which microorganisms bloom following spills, but this variation across time and location is poorly understood. In addition, chemical dispersants used to mitigate the effect of spills on coastal environments have disputed responses on microbial community composition and response. The objective of this research was to examine the relationship between oil and dispersant usage on microbial community composition. To do so, we analyzed data from five experiments composed of seawater sampled from the Gulf of Mexico during 2016-2019 and exposed them to oil or oil plus dispersant. We generated a database of 16S ribosomal RNA (rRNA) gene amplicon sequencing variants (ASVs) that revealed how different taxa responded under different treatments, times (summer versus fall), and sampling locations (offshore versus nearshore). Community composition was controlled most by sampling location with a secondary reliance on the experimental treatment. Certain bacterial taxa such as Alteromodaceae, Alteromonas, OM43clade, Thalassolituus, Maricurvus, Alcanivorax, Neptunibacter, Aestuariicella, Oleibacter, Marinobacter, and Cycloclasticus were shown to be oil selected. These bacteria showed different levels of relative abundance throughout the different experiments and treatments, revealing niche separation and cooperation amongst the microbial community to degrade spilled oil. This is likely because relative abundance is affected by all of the bacteria, making the entire composition more important than individual bacteria.

Overall, it seemed as if a treatment of dispersant and oil results in a larger bacterial bloom compared to control or oil treatments for most bacteria.

**Microclimate Change Across the Elevation Gradient of a Costa Rican Tropical Forest**

*Author:* Connor Owens
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*Graduate Student Advisor:* Dr. John Nielsen-Gammon
*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Texas A&M University Costa Rica Ecohydrology REU

Warming temperatures are a profound effect of climate change across the globe, and there is an increasing demand to understand the consequences of warmer temperatures. In a mountainous tropical region such as Costa Rica, air temperature and microclimates change across elevational gradients. Our study aimed to analyze the relationships between elevation and temperature. For this purpose, we analyzed raw temperature and wind data from 2017-2021 recorded at three different weather stations across an elevational gradient in the Peñas Blancas river valley in the Alajuela Province of Costa Rica and data from a meteorological tower located 1.5 km away from the valley at the Texas A&M Soltis Center in San Juan de Peñas Blancas. Over the elevational range from 470 meters at the Soltis Center to 830 meters at the Pocosol site, we determined that the linearity of the rate of air temperature decrease with elevation is nearly uniform on average during the day with a rate of -9.34 K/km at noon. However, this relationship became less linear and the lapse rate increased with altitude at night. The data from the tower were consistent with the transect data despite being from a slightly different geographic region. Additionally, the diurnal temperature range is larger at lower elevations. The wind data suggests that the scale of the climatic forces acting upon each station were different during the day and at night. During the day, winds were observed to generally be out of the Northeast, which is consistent with mean winds north of the Intertropical Convergence Zone (ITCZ), whereas the winds at night generally had a westerly component, consistent with the direction upriver, although this varied from southwest to northwest across the three transect sites based on the immediate river direction. Through this study, we concluded that there is a noticeable diurnal difference in the factors affecting the local air temperature across the elevational gradient, implying that increasing temperatures along tropical elevational gradients may be more uniform during the day, while showing less linearity at night.

**Mitigation of Uncontrolled Cooling Events via Greenhouse Gas Injection**

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*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Independent Research Project

Among known global catastrophic risks, three share the core dynamic of vast and immediate global cooling: large impact events, thermonuclear warfare, and supervolcanic eruptions. The third is the only phenomenon known to have occurred within the last hundred-thousand years. Using a simple climate model written in Python, we demonstrate the immense negative temperature anomalies generated by a modest supereruption and investigate the capabilities of various greenhouse gases (GHGs) to mitigate such cooling. For the GHGs, our model produces concentration (ppb or ppm), forcing ($W/m^2$), and temperature (°C) responses to specific emission scenarios (Mt or Gt). We assume a single 2Gt emission of SO2, with forcing data adopted from a study by Dr. Alan Robock and colleagues in 2009, to compare the expected temperature response with those of the GHG candidates, defining a viable candidate for mitigation as one which moderates post-eruption temperatures to within a [-1°C,1°C] range. GHGs tested include CO2, CH4, and F-bearing aerosols such as HFC_125a, KF, HFO_1234ze, HFC_32, and HCFC_225ca. CO2 and CH4 are found to be unviable candidates, ineffectively counteracting volcanic cooling and producing unacceptable long-term heating due to their long atmospheric lifetimes. A version of HFC_125a with the e-folding lifetime toggled to 0.5ya fits our definition of a viable candidate, while the other F-bearing compounds are discussed as possible candidates with associated uncertainties and drawbacks.

**Modeling the Production of Electron/Positron Pairs**

*Author:* Samuel Brown
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*Graduate Student Advisor:* Tommy Settlemyre
*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Cyclotron Institute REU

When studying particles with masses between 1 MeV to 100 MeV, the lack of high precision theory coupled with difficulties in experimental measurements makes studying particles with masses less than 1 MeV of significant importance. This lack of understanding promotes interesting questions in the production of these particles. Particular to this research, the study of electron-positron-pair production in the strong field has the ability to provide insight into particle production with masses less than 1 MeV. Studying electron-positron production requires kinematic modeling of collisions of non-relativistic ions such as $^{238}U$ and $^{12}C$. This research works to create dynamic kinematic models to track the motion and momentum of all atoms and leptons in the system. Due to the changing Coulomb potential between the colliding ions during electron-positron pair production, this sort of kinematic modeling is carried out numerically, employing standard integration and modeling algorithms such as Taylor expansion integrations and Monte-Carlo sampling.

**Molten FLiNaK Salt Infiltration into Graphite**

*Author:* Thomas Vandeveer
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*Graduate Student Advisor:* Randi Mazza
*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* USRG

Molten salt reactors, or MSRs, are nuclear power reactors that utilize molten salt as both the fuel mixture and coolant. MSRs are being considered for their increased safety, neutron economy, and continuous or in-batch reprocessing abilities. Nuclear grade graphite is the most abundant structural component in the cores of thermal-spectrum fluoride molten salt reactors. In MSRs graphite is utilized as the moderator to slow down neutrons produced by fission to maintain the chain reaction within the core. Graphite is inert in molten salts, even in the presence of irradiation, and shows no indication of corroding. However, salt facing graphite can interact with the salt and become impregnated due to its porous microstructure. The extent of the damage that fluoride salt intrusion can cause is still largely unexplored, as are potential mitigation strategies. By exposing selected graphite grades to FLiNaK salt, with controlled chemistry and pressure, the effect of material and salt variables can be determined. The point of this work is to find the correlation between pore size, time, temperature, and pressure on the amount of salt infiltration into various grain sizes of industrial grade graphite. This study reports on recent and future experiments aimed at identifying the optimal graphite grade for use in the molten salt research reactors and discusses the impact of the findings for fluoride based MSRs.

**Multiscale Remodeling of the Left Ventricle in Myocardial Infarction**

*Author:* Xiao Ling
*Primary Faculty Advisor/Principal Investigator:* Reza Avazmohammadi, Ph.D.
*Research Discipline:* Engineering (STEM), Health and Medicine (STEM)
*REU/SURE Program Name:* USRG REU

Myocardial infarction (MI) or heart attack is a critical condition that affects millions of people annually. MI induces significant remodeling in the left ventricular free wall (LVFW) which compromises cardiac function. In this study, the regional biomechanical properties of the LVFW post myocardial infarctions are characterized by integrated computational modeling and animal study. We have quantified animal-specific alteration of the LVFW properties and structure providing important insights into LVFW remodeling. These results could contribute towards a more detailed MI prognosis method.

**Nanomaterial Coatings to Manipulate for Heat Transfer Processes**

*Author:* Bryson Rivers
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*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* USRG

In this review, it will be discussed how heat transfer can be manipulated by the properties and wettability of a given surface. Control of a surface's wettability is an important part in surface engineering. Very thin coatings of a surface can help with controlling the wettability of a surface. Complete wetting of a surface leads to the creation of a film that engulfs the whole surface. Wetting enables the surface to have very high energy. Contact angles are the angles made when two surfaces are in contact. Contact angles measurements will help determine how the coated surface interacts with droplet. This phenomenon will help measure surface wettability. Through manipulating the roughness of a surface wettability can also be manipulated. When manipulating roughness, we can expect the samples to be super hydrophobic. Later experiments can determine if different types of coatings or more layers of coating have any effect on the wettability of a surface. This research can help with the cooling down of any heat transfer devices using adhering to the Rankine Cycle.

**Near Infrared Vibrational Circular Dichroism for Glucose Detection**

*Author:* Layan Al-Huneidi
*Primary Faculty Advisor/Principal Investigator:* Vladislav Yakovlev
*Secondary Faculty Advisor/Principal Investigator:* Georgi Petrov
*Research Discipline:* Engineering (STEM)

Absorption spectra for D-glucose, R(+)limonene, and S(-)pinene are presented. For the R(+)limonene solution, 6 different concentrations of 5%, 10%, 15%, 25%, 50%, and 75% limonene in toluene were used and their absorption spectra were found. The absorption spectra over various ranges of wavelengths including 800-110, 1100-1300, and 1450-1650 nm were recorded and analyzed. The absorption spectrum of each molecule was acquired by subtracting the background absorption spectrum of the pure solvent under identical experimental conditions. The spectra were found by averaging recurring experimental runs under identical conditions to eliminate white noise. Characteristic peaks on the absorption spectra pertaining to the different molecules were observed at a different wavelength for each molecule.

**Numerical investigation of the efficiency of a Moored WaveEnergy Converter**

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*REU/SURE Program Name:* USRG

The ocean is currently an extremely large and under-developed source of renewable energy. With increasing concerns about global warming, many countries are looking to renewable energy devices such as WEC's to decrease their carbon footprint. Recent scientific interest in environmentally-friendly energy options has led to the development of Wave Energy Converters, which gather energy from the oscillatory motion of ocean waves. When designing a WEC, the mooring system must be taken into consideration, as they are exposed to variable loads and must not interfere with the efficiency of the WEC. This paper numerically investigates the effect of the mooring system on a Point Wave Energy Converter (PWEC) by comparing the power generated from a buoy in different sea conditions. OpenFOAM, an open-source Computational Fluid Dynamics (CFD) tool, is coupled with the dynamic mooring library, Moody, to evaluate the multi-phase flow of waves around the buoy in 3-dimensional space. By integrating Moody and OpenFOAM, moored objects can be created and their reactions to wave and current motions can be evaluated. The flow is modeled using the Reynolds-Averaged Navier Stokes (RANS) equations. The results for each sea state are presented for a four-point catenary mooring configuration. The results will give insight to the effects of mooring on the energy harvesting ability of a PWEC.

**Nursing Education Regarding Firearm Safety: A Scoping Review of the Literature**

*Author:* Mary McDaniel
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*Secondary Faculty Advisor/Principal Investigator:* Cathy A. Pepper, MLIS, MPH & Sheila W. Green, MSLS
*Research Discipline:* Health and Medicine (STEM)
*REU/SURE Program Name:* Independent Research Project

The objective of this presentation is to provide a methodology for conducting a scoping review addressing firearm safety education for nursing students and nurses. This presentation will impact the nursing community by documenting the degree of research literature that has been published related to the specified topic revealing any crucial limitations of nursing education. The topic of interest is the extent of evidence related to the use of educational preparation of nursing students and professional nurses to identify risk for safety concerns with firearms across patient populations. It is anticipated that the extent of nursing education addressing the topic is few and not well documented. The research question is, "What academic preparation do nursing students and professional nurses receive in relation to firearm safety?" For the purpose of this presentation, an explanation regarding the methodology of the scoping review process will follow. The scoping review process will be guided by the Arksey and O'Malley and Joanna Briggs Institute Manual for Evidence Synthesis search frameworks. The first step included formulating a research question that was relevant to the area of research regarding firearm safety education among nurses. An aspect of the methodology was to work with the acknowledged Librarians to determine the necessary native language needed for database searches and data collection. Next, searches for articles will be conducted through the databases CINAHL, MEDLINE, Sociological Abstracts, and PsycInfo. Two team members will screen articles based on inclusion criteria and will record findings. After, the screening conflicts will be resolved followed with an extraction of the final set of articles. A synthesis of the findings from the articles will be performed and evidence will be documented in an article to submit for publication and national presentation.

***Key Words:*** Education; Intervention; Safety; Shooting; Weapon; Firearm; Gun(s); Gun violence

**Nylon-6 Electrospun Nanofibers: Influence of Solution Concentration and Applied Electric Field on Fiber Diameter and Uniformity**

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*Graduate Student Advisor:* Adwait Gaikwad
*Research Discipline:* Engineering (STEM)
*REU/SURE Program Name:* Independent Research Project

Electrospinning is an efficient technique for fabricating polymer nanofibers. Sub-micron scale fibers demonstrate several advantageous characteristics such as large surface area to volume ratio, high mechanical strength, and versatility in applications. In the present study, the influence of solution concentration and applied electric field on the diameter size and uniformity of electrospun nylon-6 nanofibers was investigated. Solution concentration was found to have the most significant effect on fiber diameter, while the strength of the applied electric field had less observable influence. Scanning electron micrographs (SEM) of the fibers showed that the average fiber diameters increased with increasing solution concentration in a quasi-power law relationship. Applied electric field (AEF) had less observable influence on PA6/FA fiber morphology and uniformity than suggested in previous reports. Optimal electrospinning conditions were those that produced fibers with minimized diameters and narrow size distribution. The optimal solution concentration was supported to be 20 wt%. Samples exhibiting the most uniformity (with consistently low standard deviation among fiber diameters) were consistently within the 100 - 200 nm range, and were predominantly made from 20 wt% PA6/FA. Optimal AEF ranges were identified for 20 and 25 wt% PA6/FA fibers. 20 wt% PA6/FA fibers spun under an AEF of 1.00-1.33 kV/cm had the most narrow size distribution among all the aforementioned samples, and offered a low average diameter of 112 nm.

**Open Source Toolbox for Determining Constitutive Material Parameters**

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*REU/SURE Program Name:* Cybermanufacturing

This research will develop an interface for determining the constitutive parameters of a material using full field information of a plastic deformation process and nonlinear optimization algorithms. The interface would enable the user to characterize a constitutive model for a given material, allowing the user to specify the choice of constitutive model, approximation algorithm, and outputs to display. A constitutive model describes a relationship between deformation-related parameters that describes material behavior at a given thermo-mechanical condition. The constitutive parameters in this model can be used to describe the plastic deformation of a specific material sample. Describing a material sample this way allows for faster and more reliable mechanical failure testing, with the additional benefit of testing on-site.

**Open-source Algorithm to Calculate the Mean Amplitude of Glycemic Excursions**

*Author:* Nathaniel Fernandes
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*Research Discipline:* Engineering (STEM), Health and Medicine (STEM)
*REU/SURE Program Name:* Independent Research Project

We need accurate, easy-to-use methods to analyze the increasing amounts of data from continuous glucose monitors, like the DexCom. The mean amplitude of glycemic excursions (MAGE) is one metric that's widely regarded as the "gold standard" for analyzing glucose variability in CGM data. However, there are two main problems in calculating MAGE. First, it is slow and error-prone to try and calculate it by hand. Secondly, all automated MAGE calculators on the market are "black boxes" and only returns the calculated value (so you can't confirm the accuracy of the calculation). In this research project, we propose an open-source MAGE calculator that is more accurate than existing calculators and provides a point-and-click GUI for physicians and researchers to explore the data and confirm the proposed calculator's accuracy.

**Optimization of the Normalizing Flow Machine Learning Method for Microscopic Calculations of the Nuclear Equation of States**

*Author:* Albany Blackburn
*Primary Faculty Advisor/Principal Investigator:* Jeremy Holt, Ph.D.
*Graduate Student Advisor:* Pengsheng Wen
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*REU/SURE Program Name:* Cyclotron Institute REU

Analyzing neutron stars, neutron star mergers, and core-collapse supernovae using a microscopic description of the nuclear equation of state offers many advantages over the dominant mean-field theory models, such as maintained connections to fundamental nuclear many-body forces, improved descriptions of thermodynamic quantities, and the ability to better track systematic uncertainty. However, introducing the higher-order, many-body corrections needed for such a microscopic description requires the evaluation of complicated, multi-dimensional integrals. We employ neural networks to learn and compute these integrals, using normalizing flows alongside Monte Carlo importance sampling. Using this framework, we investigate the effects of different pseudo-random number generators versus low discrepancy sequences and loss functions in the convergence of the normalizing flow model. Quasi-Monte Carlo (QMC) sampling methods studied include those based on the Halton sequence, the Korobov set, Lattice points, and the Sobol sequence. Models were compared directly against one another throughout training and evaluation for a variety of importance samplings methods and loss function implementations. We identify the optimal choices for the sampling methods and loss functions in evaluating perturbation theory contributions to the hot and dense matter equation of state.

**Optimizing CuO Nanostructures to Enhance Solar-Thermal Energy Conversion**

*Author:* Amanda Rasmussen
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*REU/SURE Program Name:* USRG

Solar thermal energy systems capture thermal energy from solar radiation to be used as heat or to be converted into electricity, providing renewable, sustainable energy. Such systems benefit from coatings that increase the amount of light trapped and minimize the amount of light reflected, maximizing the total energy captured by the system. Copper surfaces etched with nanostructures formed in a wet chemistry solution are excellent coatings for solar thermal systems, as the nanostructures act as selective absorbers to trap incoming radiation and suppress outgoing radiation. This study experimented with the wet chemistry solution and tested and characterized the resulting coatings to find the best recipe to form the optimum nanostructures. The coatings tested here provide a scalable, relatively inexpensive, and efficient coating for solar thermal systems in the industry, leading to more efficient solar thermal energy capture.

**Palladium Catalysts Immobilized on Silica**

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*Graduate Student Advisor:* Maxwell Kimball
*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Sustainable Chemistry REU Program

Catalysis is immensely important in academia and industry. However, most catalysts are expensive, and some require complicated syntheses. This makes it difficult to obtain the materials and resources necessary to carry out catalytic reactions. Immobilized catalysts are a potential solution to this problem by combining the high selectivity of homogeneous catalysts and the easy separation and recycling of heterogeneous catalysts to create an ideal catalytic system. These immobilized catalysts are bound to insoluble supports, such as silica. Solid-state NMR spectroscopy is a powerful tool to study these materials and is used throughout this research. Past investigations have shown that separate palladium and copper components can be immobilized on silica using bifunctional phosphine linkers to create an active and recyclable Sonogashira catalyst system. The Sonogashira reaction is a prominent cross-coupling reaction for aryl halides and acetylenes. Here, we present the palladium component of a surface-bound heterobimetallic palladium/copper complex, in which the turnover frequency (TOF) and number (TON) are expected to be higher than for previously reported systems with separate palladium and copper components. Palladium mobility on the surface in the presence of available phosphine linkers is observed using $^{31}$P High-Resolution Magic Angle Spinning (HRMAS) NMR spectroscopy. Linker degradation pathways and surface bonding modes are studied using $^{29}$Si Cross-Polarization Magic Angle Spinning (CP/MAS) and $^{31}$P HRMAS NMR spectroscopy. The immobilization of disiloxanes onto insoluble supports is also investigated. Disiloxane immobilization is more favorable than ethoxysilane immobilization because the disiloxanes are water tolerant, have higher atom economy, and result in higher surface coverage than their ethoxysilane counterparts.

**Parental Alcohol Exposure Exacerbates Spatial Memory and Craniofacial Differences**

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*Graduate Student Advisor:* Kara N. Thomas
*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* SURGe

Prenatal alcohol exposure can result in offspring born with cognitive and craniofacial abnormalities, grouped under the umbrella of Fetal Alcohol Spectrum Disorders (FASD). Craniofacial and neural development are closely tied, and changes in features of the face can often give indication that there are other underlying neurological conditions. Here, we analyzed the effects of dual parental alcohol exposure on craniofacial and neurodevelopmental differences in a mouse model. To analyze the craniofacial differences in fetal mice with prenatal alcohol exposure, we utilized the Geometrics Morphometrics and MorphoJ software in order to analyze changes in face and head shape. In this study, we focused particularly on the outer cantal width and minimal frontal width measurements, which are suggested to be malleable features that change based on alcohol exposure and could indicate other underlying complications (1). To test potential cognitive deficits in mice with prenatal alcohol exposure, we employed the novel object recognition (NOR) behavioral test because it utilizes hippocampus- and cortex-dependent spatial memory. This test relies on the innate exploratory preference of a rodent to explore a novel object over a familiar one. Through a 10-minute training phase and 10-minute testing phase 24 hours later, we were able to quantify behavioral differences of mice in adolescence and in adulthood. This study also looks specifically at mice of 9-and 12-weeks of age. Although thus far, no performance between different treatment groups was statistically significant, with an increased cohort of mice to the study, there is indication that there could be a significant difference in behavioral memory performance. Taken together, the craniofacial and behavioral assays performed on mice that have varying intensities of prenatal alcohol exposure suggests that dual-parental alcohol exposed offspring were greatly affected. This research also indicates that maternal versus paternal alcohol exposure may influence craniofacial and cognitive development differently.

**Pictures Worth A Thousand Words: Quantifying Self-Assembly Through Image Analysis Workflows**

*Author:* Tyler Corazao
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*Research Discipline:* Engineering (STEM), Science (STEM)
*REU/SURE Program Name:* UCI CCAM Materials REU

Using self-assembling soft matter, researchers can mimic biological processes like healing and growth and design devices which interface with or mimic living organisms. Microscopy is an invaluable tool to understand the properties of self-assembled materials, and the processes by which they form. However, image analysis is often limited to features immediately evident to the human eye. Using two image datasets – one static and one dynamic – I demonstrated the capabilities of more advanced image analysis software to collect quantitative information through simple, intuitive workflows. Gwyddion is a free, open-source image analysis software specialized in atomic force microscopy. I developed an efficient pipeline to perform background subtraction and collect feature height profiles on a set of peptide nanofiber images. The post-processed images provided more accurate measurements of fiber diameter. Trackpy is an open-source Python package that tracks particles in dynamic image datasets. I optimized the software on two sets of fluorescence microscopy images: one control dataset showing fluorescent beads floating freely in solution, and one experimental dataset with these beads becoming trapped by an electrically responsive gel. Using displacement data from both samples, I quantify the disruption in bead diffusion as they become embedded in gel. In both studies, intuitive and flexible pipelines extracted a wealth of data on self-assembled material systems. Augmenting a qualitative point-and-describe approach with computational image analysis can be simple and efficient. Furthermore, this quantitative approach provides new routes to understand and, eventually, control self-assembly.

**Potential $CO_2$ Removal by Enhanced Weathering of Olivine in the Tropics**

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*Secondary Faculty Advisor/Principal Investigator:* James Brumbelow
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*REU/SURE Program Name:* Costa Rica REU

To meet greenhouse gas (GHG) benchmarks set by international treaties such as the Paris Climate Accord, nations may resort to carbon dioxide removal (CDR) technologies to mitigate their emission budgets. Enhanced weathering (EW) is a promising CDR technology that involves amending soils with silicate mineral powders that interact with dissolved $CO_2$ and dissolve, forming bicarbonate ions that eventually precipitate as carbonate minerals in the ocean. In view of large-scale EW deployments, there is still considerable uncertainty in the estimation of mineral dissolution rates, which are tightly linked to the effective $CO_2$ sequestration. We investigated the potential $CO_2$ sequestration of EW in the Costa Rican highlands, where soil water content

(SWC) and temperature are ideal for mineral dissolution. We designed a field experiment across three unique land uses (native forest, tree plantation, and agricultural cropland), in which we installed 5 pairs of soil collars per site, each pair consisting of one control collar and one treated with olivine at a rate of 10 kg/$m^2$, and monitored daily SWC, temperature, and $CO_2$ flux for 7 days. Across all land uses, $CO_2$ emissions were markedly lower in collars treated with olivine and the rate of $CO_2$ removal was positively related with soil respiration, following a sigmoid function. Accordingly, we developed a parsimonious model coupling the dynamic of SWC to soil respiration that accounts for different soil structures associated with the three land uses. The model projects faster dissolution at the tree plantation, followed by the agricultural cropland and considerably slower dissolution at the native forest. The model was then used to estimate the long-term potential of $CO_2$ removal in relation to the projected shifts in rainfall regime.

**Predicting the Mechanical Properties of Carbon Fiber Reinforced Polymer Composites from Scanning Electron Microscope Images with Machine Learning**

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*REU/SURE Program Name:* Cybermanufacturing REU

The goal is to provide foundational scripts to help predict the mechanical properties of carbon fiber-reinforced polymer composites based on scanning electron microscope (SEM) images and mechanical strength data taken from labs. All SEM images are cropped and saved in four different orientations to reduce possible human errors. These images are coded into Python for an unsupervised machine learning algorithm to use. The pre-trained model is the VGG16 convolution neural network that is applied to discover patterns and group similar images using different clustering algorithms: K-Means, Density-Based Spatial Clustering of Applications with Noise, and Hierarchical Agglomerative Clustering. The result suggests that Hierarchical Agglomerative Clustering can perform better than the other two clustering algorithms. However, neither of the three can group the different orientated copies of the images in the same clusters. This hints that the VGG16 model may not be as robust as hoped. The results are fed into a supervised learning Multi-layer Perceptron Regression model to predict mechanical strengths based on SEM images and experimental data. Further work is needed to verify the training and validation errors to avoid underfitting and overfitting of the data. Additionally, it would give insights on which classification and regression models to choose from to give the best predictions.

**Preliminary Understanding of Li-Ion Battery Charging and Discharging Dynamic Behavior via a Stethoscope**

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In almost every personal electronic device such as cell phones, lithium-ion battery is the most common source of power. All batteries must be properly tested before they are distributed to consumers. Battery manufacturers have many methods for testing and diagnosing their batteries, and investigate to improve their energy capacity, safety, lifetime, and manufacturing cost. Research on batteries includes materials, cell design, and manufacturing quality. Testing of the battery is also a key category as it is a way to quantitatively assess the battery's performance and to model battery physics. One method involves using electrochemical dynamic models that include the impedance of lithium-ion mobility between the electrodes in the battery. The problem with this method is that it can take several minutes to sample low-frequency information of the lithium-ion which cuts into manufacturing time. The objective of the proposed research project aims to provide a new faster method of testing and new knowledge in lithium-ion dynamics and failure mechanisms with a digital stethoscope. When a lithium-ion battery is charging, lithium-ions move from the cathode electrode to the anode, and vice versa for discharging. This project investigates to model the lithium-ion dynamics and possible failure modes using acoustic wave analysis from the sound waves produced by the stick-slip phenomenon around the lithium-ions interfacing with the cathode, anode, separator, and electrolyte within the battery. Utilizing digital electronic stethoscopes, the lithium-ion dynamic behavior will be visualized from the sound waves by time-frequency domain analysis. The visualization will then be running through an algorithm using a machine learning approach that will be trained to classify the soundwaves produced by lithium-ions. If the expected outcome is achieved, it will shed light on lithium-ion dynamics giving manufacturers key parameters to determine battery performance in a fast, convenient, and reliable manner.

**Production or Rare Isotope Beams with MARS (Momentum Achromat Recoil Separator) Spectrometer.**

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*REU/SURE Program Name:* Cyclotron institute REU

The Cyclotron Institute at Texas A&M University is using the Momentum Achromat Recoil Separator (MARS) Spectrometer in order to produce rare isotope beams via projectile fragmentation reaction at low energy. The nuclei produced in the reactions are important to study as they contain information helpful for our understanding of origin of elements in nuclear astrophysics and some structural clues of matter for the Standard model. In the past, cyclotron personnel experimented with different elements in order to go as far from stability as possible in the nuclei chart. This work will show the results of the heaviest collision of elements ever recorded in this laboratory. Using a beam of Krypton-78 at 35 MeV/u to bombard a thin target made of natural Nickel, we got an insight to the production rates of proton-rich isotopes far for stability. The focus is set on the possibility to produce the isotopes Bromine-70 and Krypton-72 at the energies available for Cyclotron Institute. Production rates will be shown and compared to the simulation predictions in order to check the accuracy of the LISE++ model. The results of this research make investigations on experiments with rare isotope beams more feasible.

**Protein Sequence Embedding for Binary Prediction of Protein-Protein Interactions**

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Proteins are essential building blocks of biological systems, functioning through sequence-structure-function relationships. Made up of several components from protein-protein interactions (PPIs), potential PPIs are vast in living organisms. Despite the data from experimental and computational methods in determining whether protein interact, there is still a knowledge gap for 3 dimensional space interactions on how proteins interact. The discovery of such knowledge experimentally or computationally can be costly yet inefficient. Examples include principle-driven computational solutions such as protein docking, which predicts the preferred orientation of two molecules for induced fit. Aiming to achieve a conformation such that the free energy of the system is minimized, this docking process is difficult and inefficient. This research project aims to leverage available protein data and current machine learning techniques to predict and interpret potential protein-protein interactions. In utilizing several modalities of protein data including 1-dimensional sequences and 2-dimensional intra-protein residue-residue contact (RRC) matrices or maps, we aim at comparing the different representations and embeddings of proteins to compare the varying accuracies as well as to predict whether any two proteins interact as well as how they interact. We will evaluate and compare the predicted RRC geometries from proposed models and those from protein docking, in both accuracy and efficiency. Additional machine learning challenges beyond multimodal and multitask learning, such as class imbalance, will be addressed through data augmentation.

**Reconstruction of Torso in Full Body OpenSim Model for Post-Injury Batting Progression**

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*REU/SURE Program Name:* Independent Research Project

Injuries in baseball, like all sports, are a common occurrence during a 162 game season. For players, these injuries prevent a fluid swinging motion and require rehabilitation to regain their effective swing. To rehabilitate players back to peak performance, Ryan Monti published an article called "Return to Hitting", outlining a 5 staged hitting progression [1]. This hitting progression went through the following 5 sequential phases: dry swinging with a Wiffle bat, dry swinging using a bat of preference, batting off a tee, hitting soft toss, and finally hitting from a pitching machine. Theoretically, the best progression from injury would linearly distribute a player's workload during the rehabilitation process. The goal for this lab was to utilize a Motion Capture set up to help create parameters, such as torso rotation and joint moments, that depict the progression of a baseball player during the rehabilitation process. This would allow existing rehabilitation protocols to be supported with quantifiable parameters. The Motion Capture experimental setup used 12 motion capture cameras, 8 AMTI force plates, and 78 passive markers to record the movements of the subject throughout the batting process. To simulate the movement of subjects based on their passive markers' movement, we utilized a musculoskeletal simulation software called OpenSim. Unfortunately, OpenSim's most robust full-body model restricts the torso's range of motion after 30 degrees, preventing an accurate estimation of the torque produced during the swinging process. We expect that combining existing models that utilize conventional torso rotation ranges will enhance the accuracy of internal forces and will optimize the rehabilitation progressions for baseball players returning from injuries.

**Refractory High Entropy Alloy Advancements**

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NASA ESI provides funding for the advancement of additive manufacturing (AM) processing techniques with respect to high temperature refractory alloys. The Refractory High Entropy Alloy (RHEA) space appears as the most feasible space for satisfying operation at 2000°C with constraints for yield and ultimate strength. This study serves to refine the RHEA space to the most promising candidates in order to design and fabricate various aerospace components.

**Representation and Embedding of 3D Protein Structures for Predicting How Proteins Interact**

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*REU/SURE Program Name:* USRG

Protein-Protein Interactions (PPIs) are important to understand biological processes and organism function as well as to help diagnose patients and treat diseases, all from an underlying molecular perspective. In particular, understanding 3D structures of PPIs provides insights to achieve aforementioned goals. Current data-driven computational methods, especially deep learning models, are gaining popularity in the field of PPI structure prediction yet their accuracy leaves much to be improved toward the end goal. In this paper, our goal is to survey, benchmark, and assess state-of-the-art deep learning frameworks in learning 3D data for the task of representing and learning 3D structures of individual proteins as 3D point clouds, volumes, and surface manifolds as well as predicting 3D structures of interacting protein-protein pairs. Through the analyses we will gain insights into what they are and are not capable of addressing, such as rotational invariance and flexibility of protein 3D structures, in order to identify the best complementarity between interacting regions in protein

3D structures. We will also translate these insights into advanced development of new deep learning models for the task.

**Review of Deep Learning Approaches in Wave Energy Converters.**

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Wave energy converters have been developed to harness wave renewable energy, which has been researched worldwide for its high-power densities that can work as a solution for energy crisis and lower polluting fuel usage. However, the performance wave energy converters provide is yet unsatisfactory for this task because of the random waves being inconsistent in its data. Therefore, this paper reviews the different soft computing schemes that have been used and researched to predict such inconsistencies. It researches which of all these schemes is the optimal option for wave energy converter tasks. A comprehensive literature review was employed in order to list the scheme's advantages and challenges along with some suggestions and potential solutions for the following. Finally, each scheme has its own sets of pros and cons that can go well with some tasks and go bad in others, which resulted in the fact that none is a best general scheme to improve wave energy converters in all wave data inconsistencies. This research will serve as a guide allowing future researchers to make an effective decision making for which scheme will work best in the task they will be performing and motivate the use of this soft computing approach to improve the production of wave energy.

**Revisiting the Vector Dominance Model in Radiative Vector-Meson Decays**

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The application of the vector dominance model (VDM) to the Dalitz decay $\omega \to \mu^+\mu^-\pi^0$ underestimates the experimental spectra, especially when approaching the kinematic limit for the dimuon invariant mass. Recently, the discrepancy became more apparent as the NA60 experiment at the CERN-SPS re-measured the $\omega$ form factor with better precision. In the present work, we augment the baseline VDM by simulating the finite size of the $\omega\rho\pi$-vertex through a hadronic form factor, which was introduced 14 years ago in a different context. The additional momentum dependence predicted by the form factor improves the description ofthe NA60 data noticeably. In addition, we have improved the intermediate propagator by replacing its schematic width with a microscopic model for its vacuum self-energy. This leads to a further, albeit smaller, improvement in the description of the data. As another test of the form factor, we have checked the decay width of the $\rho$-meson into a gamma ray and a pion, which turns out to agree with the experimental value. We briefly look at the $\rho \to \eta\gamma$ and $\omega \to \eta\gamma$ decay widths with the same approach and used our results from these vertices to calculate the partial widths for the $\eta \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\gamma$ decays as well as the energy distribution for the $\eta \to \pi^+\pi^-\gamma$ decay. Our results thus support the use of hadronic form factors to simulate finite-size effects in hadronic interactions and improve an apparent shortcoming of the VDM.

**Sex Differences in Novel Transgenic Mice with Constitutively Upregulated b2* Neuronal Nicotinic Acetylcholine Receptors: Implications for Parkinson's Disease**

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*REU/SURE Program Name:* Texas A&M University College of Medicine Summer Research Program

Chronic tobacco use is correlated with reduced Parkinson's disease (PD) risk, and nicotine is thought to mediate this effect. However, the concentrations of nicotine in chronic tobacco users are too low to activate target neuronal nicotinic acetylcholine receptors (nAChRs), which makes this an unlikely mechanism for neuroprotection of the dopaminergic (DA) neurons lost in PD. We previously showed that nanomolar concentrations of nicotine and the nicotinic ligand, cytisine, chaperone β2-subunit-containing (β2*) nAChRs out of the endoplasmic reticulum (ER), thereby reducing the ER stress response, which results in neuroprotection. To directly test this hypothesis, we created a novel transgenic mouse line called 'β2-mutant', with enhanced ER export of β2* nAChRs. Surprisingly, β2-mutant mice demonstrated significant increases in Sec24D ER exit sites (ERES) within substantia nigra pars compacta (SNc) DA neurons of female, but not male mice. We next compared tyrosine hydroxylase (TH) expression in SNc DA neurons between midbrain sections of β2-mutant and wildtype (WT) littermates. Area of SNc TH labeling served as a measure of somatodendritic morphology, while TH intensity was used as an indirect measure of dopamine synthesis. We found that female, but not male, homozygous β2-mutant mice had significantly higher TH area and expression than WT littermates. These data support sex differences in the relationship between ERES regulation, SNc DA neuron morphology, and TH content in the mouse SNc. Future work will focus on using β2-mutant mice to elucidate mechanisms underlying sex differences in ERES biology of DA neurons, and neuroprotection in a model of PD.

**Sensor Fusion and Analysis for Smart Manufacturing**

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*REU/SURE Program Name:* Cybermanufacturing REU

In industry, factory managers must constantly monitor their machinery to prevent failures and maximize uptime. Machinery must perform within predetermined specifications to produce consistent outputs. However, manual inspections bring with them their own set of inefficiencies by lowering uptime. Sensors integrated into manufacturing machinery can provide real-time data but are difficult to interpret on their own and not available on legacy machines. Additionally, proprietary standards and products make it difficult to achieve interoperability in a mixed production line. In this project, we develop an open-source method to integrate sensors into legacy hardware. We attach off-the-shelf sensors to an Optomec hybrid manufacturing machine and use National Instruments Data Acquisition (NI-DAQ) modules to collect and stream live data. We evaluate the performance of the Smart Manufacturing Innovation Platform (SMIP), a web-based data ingestion platform part of the Clean Energy Smart Manufacturing Innovation Institute (CESMII), a U.S. Department of Energy-sponsored initiative. We demonstrate a viable implementation of Smart Manufacturing by creating a vendor-agnostic web dashboard that fuses multiple sensors to perform real-time performance analysis.

**Sequestration of Dye Contaminants from Water**

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Non-toxic, water insoluble and inexpensive poly(a-olefin)s (PAOs) can work as recyclable solvents to effectively remove trace dye contaminants from water. PAOs solutions that we used contain a phase-anchored polymer bound co-solvent that sequesters dyes through ion exchange. Polyisobutylene (PIB) with cationic end groups act as a co-solvent that we used, and we hypothesize that they can be repeatedly recycled. PIB is a nontoxic, nonvolatile, and inexpensive oligomer that will not contaminate aqueous phases during liquid-liquid extractions. Therefore, anionic dyes with carboxylate or sulfonate groups can be sequestered by these functionalized PIB cations. This solvent system has already proven effective for removing carboxylate anions from water such as 4-chlorobenzoate. Following this research, dyes with a carboxylate group were sequestered as well, such as methyl red, 4'5'-dichlorofluorescein and carmine. Similarly, dyes containing anionic groups such as sulfonates were also sequestered. This includes congo red, methyl orange, and bromocresol. PAO containing 0.025M PIB-bound pentasubstituted imidazolium group sequesters >99% of the above carboxylate and sulfonate dyes from a 0.05 mM solution. More concentrated solutions at approximately 0.2 mM had 96% of dye removed by this imidazolium cation.

**Sexual Dimorphism of Host- Pathogen Responses in Drosophila Mediated by Vitamin Homeostasis**

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*REU/SURE Program Name:* SURGe Genetics

Individuals (hosts) respond differently to pathogenic infections and pathogen-mediated diseases. This variation in responses between individuals is multifactorial and complex, and can underlie differences in environment, genotype, and gender. The Karpac lab has been using the fruit fly Drosophila melanogaster to explore the genes and signaling mechanisms that shape variation in host-pathogen responses. Drosophila provide large and genetically homogeneous populations that support functional genomic studies of inter-individual variation in host-pathogen response. Recent studies focused on the integration of pathogen-regulated innate immune responses and metabolic responses have shown that immune-metabolic control of energy substrate (lipid) allocation is central to inter-individual variation in host-pathogen responses. Specifically, detailed studies have shown that vitamin metabolism (and the sodium multi-vitamin transport [Smvt] system) can dictate host-pathogen responses by impacting energy homeostasis (lipid mobilization) to enable bacterial clearance. This finding was based solely on the analysis of female Drosophila and their response to pathogens. To this end, we also hypothesized that differential regulation of Smvt in males vs. females may underlie sexual dimorphism (gender differences) of host-pathogen responses. To test this hypothesis, we first explored sexual dimorphism of host-pathogen and immune-metabolic responses between male and female flies. To do this, neutral lipid storage (Oil Red O [ORO] staining) and survival rate of males and females were assayed after infection. Control (mock treated) populations of Drosophila were given 2.5% sucrose and infected (oral) populations of Drosophila were treated with of the insect specific pathogen Pseudomonas Entomophila (P.e.). We found that there was a difference in lipid storage between genders, with infected males displaying lipid mobilization while lipid storage was maintained in the infected female. These data also suggest that sexual dimorphism of immune-metabolic responses impacts host-pathogen responses between genders, as infected males maintained a higher survival rate, since they could defend themselves effectively, in comparison to the infected females that could not. In conclusion, these findings highlight an underlying sexual dimorphism in host-pathogen responses in Drosophila (same as seen in mammals), that correlates with immune-metabolic differences. The next step is to determine if differential regulation of Smvt underlies this sexual dimorphism of host-pathogen responses.

**Shape Fixity and Shape Recovery of Ultra High Molecular Weight Polymers**

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This study we compare the damage in shape-memory polymers in during milling and laser cutting operations. The effect of manufacturing factors, such as, feed rate, spindle speed, and depth of cut, in milling operation on the shape fixity or shape recovery of the samples are studied. Similarly, the effect of laser intensity, depth of cut and number of cuts for the laser machine on the shape recovery is studied and compared. The samples are subjected to thermal cycling to study the recovery of its original shape. Currently, recovery of the shape of the polymers were observed under thermal cycling.

**Stability of Mixed DNA**

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In addition to being genetic material, DNA can be used in the development of therapeutics and research tools. In order to overcome challenges associated with the degradation of DNA, which occurs rapidly in the human body, researchers have turned to L-DNA, the mirror-image form of the native polymer. L-DNA cannot be recognized by the enzymes that break down native D-DNA. While this property has a number of advantages, it can also lead to the toxic buildup of L-DNA in cells and/or the environment. The goal of this research was to explore strategies to make L-DNA more biodegradable. We hypothesized that incorporating D-DNA or D-RNA into the center of an L-DNA strand will help to degrade the L-DNA strand. We found that adding D-nucleotides does aid in the degradation of an L-DNA strand. The L-DNA strand containing D-DNA in the center is more stable than the L-DNA strand containing D-RNA because it takes much longer for D-DNA to break down. We also, found that adding the complementary strand to the L-DNA strand containing D-RNA makes it much more stable than the single strand containing D-RNA.

**Synthetic Testbeds for Cyber Attacks with Internet-of-Things Devices**

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*REU/SURE Program Name:* USRG

The proliferation of Internet-of-things (IoT) applications introduce new ways for malicious hackers to explore vulnerabilities in the software stack. Many researchers are investigating novel techniques to detect and mitigate IoT cyber-attacks. In this paper, we present a new, more secure, infrastructure for the emulation of IoT sensors and controllers. Using python modules that allow us to handle JSON files, manipulate CSV files, and send data from one program to another using sockets an emulator for IoT sensors was created. The emulator enables the automatic generation of adaptable workload scenarios that can be used by researchers investigating new security and efficiency techniques. The design of the proposed framework allows for the experimentation with large-scale application scenarios that would be too costly (if not unfeasible) to carry out using traditional approaches. With data gathered from the experimentation on the framework, we look to find weaknesses and address them, making the framework more secure.

**Tellurium Embrittlement Study in Inconel 617**

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*REU/SURE Program Name:* USRG

Molten salt reactors (MSRs) utilize various types of molten salts as coolants. These reactors are extremely efficient, and are also widely considered to be much safer and more environmentally friendly than a traditional nuclear reactor. However, an issue that arose through the use of MSRs is the apparent embrittlement of steel used in said reactors. Embrittlement can be defined as a decrease in ductility and mechanical strength of a material, and is mainly seen through the cracking of a material. The cracking was theorized to be a result of tellurium which is one of the biproducts of nuclear fission. J. A Hemsworth conducted research on tellurium embrittlement in 316 SS. Samples of 316 SS were tensile tested at temperatures above 800 degrees Celsius. Across two different strain rates, Hemsworth found the UTS of the samples was negatively affected by being introduced to tellurium.. Tensile tests will be conducted to determine if tellurium also causes embrittlement and impacts the mechanical properties of Inconel 617. We will be heat treating dog bone samples in a tellurium rich atmosphere which will then be tensile tested until failure. The microstructures will then be analyzed, and stress strain curves will be created to compare the mechanical properties. We will specifically observe the ultimate tensile strength and yield strength of control samples versus those in a tellurium rich atmosphere. This research will show the initial findings of whether tellurium based cracking is a degradation mode of concern in molten salt reactors.

**The Digital Citizenship Divide in Alaskan Native Political Engagement during the COVID-19 Pandemic**

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Over the last two decades, internet access has become an essential resource for communities and individuals to stay informed and engaged in socio-political issues, especially as the COVID-19 pandemic forced many into quarantine. This reliance caused a great inequality, as minority groups, those of lower socio-economic status, and rural communities continue to be underrepresented due to unreliable or no internet access. The purpose of this study is to examine how the digital divide impacted the ability of Alaskan natives to participate in public forums held by the U.S. Bureau of Land Management on the ConocoPhillips's Willow project during the pandemic. The Willow project is the most recent oil drilling project proposed for the North Slope region. This was a mixed methods study. I utilized of the National Telecommunications and Information Administration's interactive GIS map to assess the digital divide among native communities. I also virtually attended 5 public forums resulting in 9 hours of fieldwork, and I conducted a document analysis of the meeting minutes and federal and news reports. To examine the magnitude of inequality, evaluate current efforts to address it, and better assess the overall impacts on the community, fieldnotes and documents were uploaded and analyzed in QDA Miner. 24.5% of public testimonies expressing ideas of "lack of consideration", but 31.3% of reports telling of plans for "forward thinking". Preliminary results suggest that greater awareness is needed when using online platforms and that there is hope that positive change is being done to amend this divide.

**The Identification of Contaminants by Time Evolution in 99Mo Gamm-Decay Spectrum**

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*REU/SURE Program Name:* Cyclotron Institute

In efforts to differentiate emitted γ-rays with similar emission energies in the analyze of the γdecay spectra from the 99Mo production, an automated program was created. The 99Mo production is part of the novel approach to producing medical isotopes, using inverse kinematics, successfully implemented at the Cyclotron Institute, Texas A&M University[1-2]. The 99Mo was produced using an accelerated 100Mo beam impinging on a 4He gas cell-target. An 27Al catcher foil, placed after the gas cell, was used to collect the 99Mo nuclei, as well as other coproduced nuclides. After irradiation, the γ decays spectra of the foil was measured using HPGe detectors. The photopeak associated with the highest γ-ray intensity of 99Mo, located at $E\gamma = 140.5$ keV, was not resolved, due to contributions of γ decays from multiple nuclides. The total activity at $E\gamma = 140.5$ keV can be described as a combination of 99Mo ($t1/2 = 65.94$ h; $I\gamma = 89.43\%$), 99mTc ($t1/2 = 6.01$ h; $I\gamma = 89.0\%$), and 90Nb ($t1/2 = 14.60$ h; $I\gamma = 66.8\%$). The new analysis program was used to plot the activities as a function of time, for the 140.5 keV photopeak while considering the activities obtained from other photopeaks associated with 99Mo ($E\gamma = 181$ keV) and 90Nb ($E\gamma = 1129$ keV). Using the known decay constants of each produced nuclide, the contribution of each nuclide was determined. The activity as a function of time was fitted and contributions from 99mTc, 99Mo, and 90Nb were determined.
[1] G. A. Souliotis et al., A novel approach to medical radioisotope production using inverse kinematics: A successful production test of the theranostic radionuclide 67Cu, Appl. Radiat. Isotopes 149, 89 (2019).
[2] J. Mabiala et al., Enhanced production of 99Mo in inverse kinematics heavy ion reactions, HINPw6 proceedings, EPJ-woc proceedings, article 08003 (to be published).

**The Investigation of Thermo-Physical and Optical Properties of Advanced Fluids for use in Molten Salt Reactor Heat Pipes**

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*REU/SURE Program Name:* TAMU USRG

Heat pipes, which effectively transfer heat between two solid interfaces, require working fluids chosen based on specific operating temperatures. These mechanisms transport heat between the reactor core and the power conversion system for energy generation. This study investigates a working fluid used to perform thorough experimentation on heat pipes of molten salt nuclear reactors. The properties of the fluids Dowtherm A (26.5% diphenyl + 73.5% diphenyl oxide) and D-limonene (C10H16), as well as the HiTec molten salt (53% potassium nitrate + 40% sodium nitrite + 7% sodium nitrate), are investigated. The project has two related tasks: 1) the investigation of optical properties and phenomenon such as the refractive index (RI) at various temperatures and wavelengths for Dowtherm A, D-limonene, and HiTec, and 2) the exploration of optical phenomena such as fluorescence and phosphorescence of Dowtherm A and Hi-Tec mixed with various chemicals. A thorough review of Dowtherm A's and D-limonene's compositions at certain temperature ranges and physical conditions was used to validate and compare results to existing literature, as well as take measurements of data not readily available yet. The Prandtl number calculations showed important properties of the fluids such as specific heat capacity and thermal conductivity. Multiple runs of Dowtherm A and D-limonene RI measurements from 20ºC to 60ºC were performed at three different wavelengths, confirming that RI and temperature have an linear inverse relationship. The results include statistical analyses showing standard deviation, confidence intervals, data fitting methods and distributions, and error.

**The Potential Use of GSK-LSD1 to Repair Alveolar Bone Loss after Periodontal Disease**

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*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Summer Undergraduate Research Program

The gingiva, cementum, periodontal ligament, and alveolar bone are collectively known as the periodontium, which surrounds each tooth and provides support and stability. Periodontal disease (PD) is an infection in the oral cavity that causes the degradation of the periodontium. The most common treatment of periodontal disease consists of halting the disease process to stop the destruction of the periodontium. A potential alternative treatment for PD is to restore the lost periodontium. In normal periodontal ligament cells, Lysine specific demethylase 1 (LSD1) demethylates lysine side chains on histones that control the expression of genes. LSD1 function is altered during PD, potentially causing the resorption of the alveolar bone. This presentation examines the treatment of tissue damage caused by periodontal disease using the small molecule GSK-LSD1 to act on the enzyme LSD1 using a local delivery method. Human periodontal ligament (hPDL) cells were cultured and treated with varying concentration of GSK-LSD1. A collagen sponge was constructed to achieve delivery of the molecule at the intended site. The researchers found that the 50 uM solution of GSK-LSD1 induced the highest amount of osteogenic differentiation and formation of mineralization nodules out of the experimental groups used in hPDL cell culturing. The culturing of hPDL cells on a collagen sponge showed good attachment and growth on the matrix.

**The Synthesis of Dopa-Gelatin Bioadhesive and Applications to Cleft Palate**

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*REU/SURE Program Name:* SURP (Summer Undergraduate Research Program) at Texas A&M School of Dentistry

Cleft palate is a congenital craniofacial defect caused by a disruption of soft and hard tissues to fuse properly around the oral cavity and face area during embryonic development. This causes severe limitations in eating functions, speaking, breathing, and self-esteem. In clinical use, there is a need to add bioadhesive materials to accelerate the regeneration of the cleft palate. However, existing surgical adhesives have low adhesive strength in wet environments such as the oral cavity. Therefore, it is of great significance to develop new bioadhesive biomaterials that are capable of adhering to wet surface environments to enhance tissue repair and wound closure. In this study, a series of gelatin-dopamine (dopa-gel) conjugates chemically cross-linked with sodium periodate with varying levels of dopamine were fabricated. After that, the bioadhesives were assessed for adhesive and mechanical properties through lap-shear and tensile tests. The results showed that the formulation with 900 mg of dopamine had better mechanical properties compared to 450 mg of dopamine. The dopa-gel conjugate was further tested on different tissue surfaces including skin, calvarial bone, brain, gingiva, spleen, and palate to confirm their superior bioadhesive capability to natural wet tissues. In vivo study, palatal clefts were experimentally induced in mice to test the strength of the bioadhesive and its effectiveness in tissue repair and regeneration. It was concluded that the dopa-gel bioadhesive material has a potential application for the cleft palate.

**Thermochromic Nanocomposite $VO_2$ Thin Films for Fenestration Applications**

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*REU/SURE Program Name:* REU

Energy consumption within buildings around the globe has a negative impact on the environment. By taking advantage of the metal—insulator transition of $VO_2$ nanocrystals, we can design wavelength-selective window films that can modulate the transmission of electromagnetic radiation through fenestration elements. These films are capable of filtering near-infrared (NIR) section of the solar spectrum, reducing solar heat gain in warmer temperatures and enabling near complete transmission in colder temperatures. In addition, the metal—insulator transition allows for high transmission of visible light at all temperatures, thereby enabling effective daylighting of interiors.

**Thermodynamic Constraints on the Regulation of Piscine Steroidogenesis**

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*REU/SURE Program Name:* OCEANUS

An organism's metabolism is composed of chemical reactions which result in products that improve an organism's fitness, i.e. its ability to adapt to changing environments. Thermodynamics determines the feasibility of chemical reactions based on whether they are endergonic (energy required) or exergonic (energy released). Enzymology relates to the concentrations of substrates and enzymes needed to perform chemical reactions. Determining how these systems relate to each other could show how biological systems have evolved to adapt to thermodynamic constraints. In this project, I analyzed how reaction thermodynamics changes throughout piscine steroidogenesis. "Bottleneck" reactions, or reactions that have either endergonic or low exergonic forces, were expected to show higher amounts of biological regulation. Gibbs Free Energy values for the 124 reactions within piscine steroidogenesis were calculated using the eQuilibrator website. Networks analysis algorithms, Breadth-First Search (BFS) and Dijkstra, were used from Python's (v3.9)

NetworkX library to compute reaction pathways producing individual steroid hormone metabolites for the different androgens, progestogens, estrogens, and corticosteroids. The computed pathways were then run through eQuilibrator to obtain the bottleneck reactions. The results revealed that piscine steroidogenesis is overall thermodynamically favorable, and that bottleneck reactions are almost exclusively related to 3beta-hydroxysteroid dehydrogenase (3beta-HSD). 3beta-HSD is an enzyme that is regulated by more transcription factors than other enzymes within piscine steroidogenesis. This shows that organisms may have evolved to biologically regulate the slower bottleneck reactions within metabolic pathways more than the thermodynamically favorable reactions. Future laboratory studies could provide further support of this proposed hypothesis.

**Towards Functional Molecular Gyroscopes: Syntheses and Structural Dynamics of Gyroscope-like Metal Complexes Based on Dibridgehead Diarsine Cages**

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*REU/SURE Program Name:* Chemistry REU

The reaction of $BrMg(CH_2)_6CH=CH_2$ (3.0 equiv.) with $AsCl_3$ affords the trialkylarsine $As((CH_2)_6CH=CH_2)_3$ (**1**, 78%), which when reacted with (BDA)$Fe(CO)_3$ yields the diarsine complex *trans*-$Fe(CO)_3(As((CH_2)_6CH=CH_2)_3)_2$ (**2**, 87%). Subsequent three-fold intramolecular ring-closing alkene metatheses employing 1st generation Grubbs' catalyst (18 mol% in $CH_2Cl_2$, reflux) and a hydrogenation ($ClRh(PPh_3)_3$, 80°C) afford the gyroscope-like dibridgehead diarsine complex *trans*-$Fe(CO)_3(As((CH_2)_{14})_3As)$ (**4**, 75%). Nitrosylation with $NO^+BF_4^-$ yields the tetrafluoroborate salt *trans*-$[Fe(CO)_2(NO)^+(As((CH_2)_{14})_3As)]^+BF_4^-$ (**5**, 85%). Rather than afford the halogenated complexes *trans*-$Fe(CO)(NO)(X)(As((CH_2)_{14})_3As)$ (**6-X**; **X** = Cl, Br, I), treatment with *n*-$Bu_4N^+X^-$ (X = Cl, Br, I) and other halide nucleophiles results in excision of the $Fe(CO)_2(NO)^+$ moiety to afford the dibridgehead diarsine $As((CH_2)_{14})_3As$ (**7**, 75% from **5**, 21% overall). Reactions of **7** with transition metal complexes $PtCl_2$, $PdCl_2$, and $[(COD)Rh(mu\text{-}Cl)]_2$ repopulate the diarsine cage to afford the diarsine adducts *trans*-$PtCl_2(As((CH_2)_{14})_3As)$ (**10**, 55%), *trans*-$PdCl_2(As((CH_2)_{14})_3As)$ (**11**, 50%), and *trans*-$Rh(CO)(Cl)(As((CH_2)_{14})_3As)$ (**12**, 62%). Alternative routes to achieving **6-X**, including pre-metathesis nitrosylation and halogenation of the iron coordination sphere in **2**, were investigated but ultimately resulted in cleavage of the Fe–As bond.

**Towards a Low Power Low Cost MRI System for Teaching**

*Author:* Jacob Carroll
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*REU/SURE Program Name:* USRG

Largely due to the massive consumer electronics market, some electronics that have been historically expensive have become quite accessible and inexpensive. For example, the Analog Discovery 2 has two waveform generators, two oscilloscopes, 16 digital input/output pins, and other notable features. With these features, it becomes feasible to consider constructing a low-cost low-power MRI system. This project is about exploring the Analog Discovery's feature set and finding ways to create an MRI system centered around this device. Despite having a wealth of features, it still has important limitations. The Analog Discovery 2 cannot produce the train of radiofrequency pulses of different amplitudes 'out of the box'. This train is known as a 90/180 pulse sequence, used to observe the MRI signal. External hardware is needed. Using a waveform generator, DIO pin, attenuator, and a buffer allows a 90 and 180 pulse to be generated. In addition to the RF pulses, two low frequency gradient pulses must be created for spatial localization. Using the second waveform generator, the phase encoding gradient required for MRI can be generated easily. The frequency encoding gradient can be generated by two DIO pins put through an OR gate. These are all the transmitted signals required to generate a basic MR image. On the receive side, it is a little bit harder. The Analog Discovery 2 only has an 8k buffer. This limits the record time of this device. However, it can sample at a rate of about 1MHz for 5ms. This will under-sample the echo, but with proper filtering, this may be able to work. If this project is successful, the Analog Discovery 2 can replace the significantly more National Instruments equipment used in the TAMU MR Engineering course with a low-cost system that students can program in their homes.

**UAS Capability of Measuring Micrometeorological and Biogeochemical Spatial Variability**

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*Graduate Student Advisor:* Paul Fletcher
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*REU/SURE Program Name:* Costa Rica REU

This project explores the ability of an uncrewed aerial system (UAS) to detect spatial variability of micrometeorological and biogeochemical variables. Instantaneous concentrations of carbon dioxide [$CO_2$] and water vapor [$H_2O$] below the UAS were recorded as the UAS flew along programmed horizontal plots. These flights occurred over three sites with unique land uses in the Alajuela Province of Costa Rica: a relatively undisturbed rainforest, a replanted forest that previously participated in Costa Rica's Payment for Environmental Services program, and an agricultural field growing cassava. Initial findings suggest a lower average but greater range of [$CO_2$] at the replanted forest compared to the rainforest during both the morning and afternoon. [$CO_2$] also decreases at both sites in the afternoon with the greater decrease occurring at the replanted forest. These data support the hypothesis that the rapidly growing replanted forest would have the lower daytime [$CO_2$] accompanied by the greatest difference between morning [$CO_2$] driven by soil respiration and afternoon [$CO_2$] driven by photosynthesis. At each site, regions with higher [$CO_2$] coincide with regions with lower [$H_2O$]. This phenomenon could be explained by the relationship between transpiration and photosynthesis, suggesting the UAS detected differences driven by vegetation activity. Given the agreement between conceptual expectations and UAS measurements, our study demonstrates UAS climatic and biogeochemical monitoring capabilities and encourages a deeper exploration of this monitoring method.

**UAS Measured Profiles of Micrometeorological Conditions above Contrasting Land-use Types in Costa Rica**

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*REU/SURE Program Name:* Costa Rica REU

Uncrewed aerial systems (UAS) provide users the access to collect atmospheric data in remote areas with precise geolocations. The objective of the study was to observe temporal variations in carbon dioxide concentrations, water vapor saturation, and temperature in the airspace above each site. This study observed the micrometeorological conditions in vertical profiles over three different land-use types. The field tests were conducted in central Costa Rica at the Texas A&M Soltis Center, specifically over a cassava field, a payment for ecosystem services (PES) tree planation, and a mountainous area of the tropical rainforest. A UAS, equipped with a high-precision infrared gas analyzer, was used to collect the data. Levels of carbon dioxide are shown to be highest in the early morning before photosynthesis begins, and the distribution of the data points show an explicit flow of trace gases and heat between the lower boundary layer and the canopy of the study sites during mid-morning and afternoon flights. Amongst the test sites, the tree plantation generally had the lower carbon dioxide levels throughout the day with a proportional increase to altitude showing the potential of carbon intake by the plantation. This study contributes to prior knowledge of the relationship between the atmospheric boundary layer and earth's surface, as well as the conversation around using UAS in carbon flux monitoring across the globe.

**Using Single Cell RNA Sequencing Data Analysis to Construct a Score to Predict T Cell Exhaustion**

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*REU/SURE Program Name:* Summer Undergraduate Research in Genetics and Genomics (SURGe)

T cell exhaustion is characterized by the loss of normal function of T cells that can eventually cause death of T cells. The exhausted T cells are no longer able to fight off infection. There was no way to score T cell exhaustion for each cell in a sample previously. Using single cell RNA data analysis a T cell exhaustion score was constructed to predict how exhausted each T cell was in a sample. The score was based on 11 positive marker genes and their expression in each of the T cells. The T cells with a higher expression of the marker genes had a higher score for T cell exhaustion. Using the score constructed, data sets were examined to determine the validity of the score. One particular data set examined contained two groups of mice with chronic lymphocytic choriomeningitis virus (LCMV). One group was the control group of mice and the other was mice with Ptpn2 knock out. From the score it was determined that the knockout Ptpn2 group of mice had more highly exhausted T cells than the control group. This result was expected because Ptpn2 prevents T cell exhaustion, so knocking it out should increase the exhaustion in the T cells. The data set examined provided support that the T cell exhaustion score constructed was accurate.

**Using Time-Domain Electromagnetics to Classify the Composition of Subsurface Media with a Focus on Bedrock Contribution to Streamflow**

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A better understanding of water-supply dynamics and sources of streamflow is needed to address human needs in a changing climate. Contrary to previous perceptions, recent studies suggest that fractured bedrock can be a groundwater reservoir and play a major role in streamflow generation. Thus, we investigated the role of bedrock in streamflow generation in a tropical montane rainforest in Costa Rica, hypothesizing that fractured volcanic bedrock is a preferential conduit for subsurface flow. Time-domain electromagnetic (TDEM) geophysical mapping deployed along forest trails measured the electrical conductivity of the subsurface, which acted as a proxy for the presence of water. Four recurring signal types comprised a majority of the data. Based on the electrical conductivity of dry and wet earth materials, we proposed that the four signal types represent four subsurface media: A) dry bedrock, B.) saturated (and fractured) bedrock, C.) saturated soil/saprolite, and D.) indeterminate. This signal classification method formed the basis of our interpretation, leading to interesting conclusions about a 100 m transect on a mountainside trail running N-S. The southern half of the transect displayed Type A signals, while the northern half displayed Type B and C signals. Furthermore, an outcrop of exposed fractured bedrock in the northern half exhibited a multitude of water seeps. The evidence suggested that subsurface water from uphill was following a flow-path downhill through *connected* fractures in the bedrock, exfiltrating at the outcrop fractures. Subsurface water exfiltrating through rock fractures, then, appeared to be the cause of the Type B and C signals in the northern half of the transect. Future studies before and after rain events will reveal the degree of connectivity between rock fractures throughout the transect. Our study confirmed that fractured volcanic bedrock in Costa Rica acts as conduits for subsurface water. We also concluded that TDEM mapping is well-suited to elucidate the role of fractured bedrock in streamflow generation in tropical montane rainforests.

**Utilizing Imaging to Evaluate Immune Cells to Determine the Efficacy of Immunotherapy in Skin Cancer**

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*REU/SURE Program Name:* URSG

Immunotherapy is an important modality currently used clinically to treat cancers. It is well established that immune cells can respond to the tumor antigens; however, many tumors promote an immune-suppressive environment that inhibits immune cell activities. Immunotherapies are designed to enhance the anti-tumor activities of immune cells, either through mediating immune cell–cancer cell interactions or through bio-manufactured immune cells, such as CAR T cells. Despite the promise of immunotherapies, the response rate to treatment often does not exceed 15%. Therefore, there is a critical need for technologies that can evaluate immune cell activities to monitor immunotherapy efficacy. We will use fluorescence lifetime imaging microscopy of NADH and FAD to quantify the metabolism of immune cells and cancer cells. Macrophages will be imaged with microscopy before and after the immunotherapy treatment to evaluate the effects of immunotherapy on macrophage metabolism and function. SPCImage and Rstudio will be employed to analyze the imaging data at the cellular level. We expect to see the macrophages switch from a pro-tumor phenotype to an antitumor phenotype after the immunotherapy treatment. If differences within the macrophage population are found due to immunotherapy treatment, these imaging technologies can be used to evaluate the immunotherapy response of patients.

**Various Stages in a Graduate Level Optics Experiment**

*Author*: Jason Pipal
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*REU/SURE Program Name:* USRG

During the Texas USRG at A&M University, I learned a lot about the process that a graduate optic experiment goes through. I learned the basic concepts of setting up an experiment with a few techniques including two beam alignment and knife edging. I got to use these techniques firsthand when setting up a Germanium experiment with PhD student Chris Marble and a fellow USRG student Ethan Keene. On one hand I got to see the difficult and time-consuming nature of starting an optics project, while on the other I got to see reward of gathering the data after an experiment has been successfully built. I got to see this side more with PhD student Vsevolod Cheburkanov and Ethan Keene, and Vsev's Pig Larynx Experiment. During this stage of the project. I got to see the reward of capturing data. In addition, I also worked with Vsev on processing the data from his experiment through the use of python. Getting to see multiple stages of a real-life project, as well as getting to apply concepts from classes such as python and physics has made this an invaluable experience to me. This has helped me solidify my passion for the field of optics and my desire to attend A&M Graduate school.

**Vertical Habitat Use of a Scalloped Hammerhead and Bigeye Thresher Shark**

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*REU/SURE Program Name:* REU OCEANUS

Information on the diving behavior of Scalloped Hammerhead (*Sphyrna lewini)* and Bigeye Thresher *(Alopias superciliosus)* sharks is complicated due to the difficulty in studying these large pelagic sharks. Both species are endangered and caught as bycatch from longline fisheries, thus vulnerability of their populations is high. Declining shark populations can cause trophic cascades, affecting other marine organisms negatively. Analyzing the shark's behaviors can help assess the overlap between fisheries and habitat use. The purpose of the study was to examine the vertical habitat use of a Scalloped Hammerhead and a Bigeye Thresher shark in the Gulf of Mexico (GOM). A single male Scalloped Hammerhead and Bigeye Thresher shark was caught and tagged with an archival satellite tag, while the Scalloped Hammerhead was additionally tagged with a SPLASH tag. Time at depth was deeper during the daytime for the Bigeye Thresher, while Scalloped Hammerhead had deeper time at depth at night. The Scalloped Hammerhead habitat use was restricted to the Texas continental shelf and tracks were consistent using both tag types. Bigeye Thresher horizontal location data was not available due to the deep diving behavior and tag limitations. Differences in the vertical habitat use between these two species can be attributed to predator-prey interactions and thermoregulation, which can ultimately be coupled with fishery catch data to adjust management practices of vulnerable species populations.

**Voxel Bio-Printing**

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*Research Discipline:* Engineering (STEM), Health and Medicine (STEM)
*REU/SURE Program Name:* Cyber-Manufacturing

3D printing has the ability to dramatically explode the manufacturing and distribution markets in the U.S. and abroad. Computed axial lithography (CAL) 3D printing methods, when used in conjunction with infrared light crosslinking, provides numerous benefits to the additive manufacturing market, with an emphasis in the biomedical engineering sphere. The main advantages of CAL printing are the ability to have instantaneous printing time, allow for over-printing, and the ability to work with previously unusable unique biomaterials. Infrared light, instead of the visible light spectrum, gives advantages such as being able to penetrate objects more deeply and not harming live cells from its wavelengths. The group performs their experiments by voxelating STL files of CT scans to be projected through a DLP projector onto a rotating vat of resin. The team created the CAL printer by using the base of an existing 3D printer as a stage and rotating platform. The group then used a laser in a DLP projector through an optical setup to project an image into the vat of resin. The vat of resin was engineered by using a GELma recipe with carbon nanotubes to provide additional strength and scaffolding purposes. This allows the group to 3D print objects on demand by healthcare professionals. The team is working towards using all of these strategies to print a heart valve from a CT scan on a public domain website.

**Waste Not, Want Not: A Comparison of Reuse Wastewater Systems**

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*REU/SURE Program Name:* Reuse Water Quality Research and Extension Experience for Undergraduates (RWQ-REEU)

Contaminated wastewater is a major public safety and health concern, especially when the wastewater has a chance of reentering drinking water sources. At the Texas A&M University System RELLIS campus' Reuse Water facility, four onsite wastewater treatment trains remove organic, nutrient, microbial, and chemical contaminants to achieve direct or indirect reuse water quality. This study explores the overall treatment level (OTL) of each train, and whether the water produced at the end meets the Texas Commission on Environmental Quality's (TCEQ's) secondary and reuse water quality standards. In addition, previous analysis of RELLIS campus water conducted by students showed an overabundance of some contaminants in the drinking water; therefore, this study further evaluates levels of those contaminants to determine if they meet the Safe Drinking Water Act (SDWA) requirements. For the four treatment trains, samples from eighteen sites were tested for water contamination parameters in the field and the lab. The samples' averaged parameter levels were compared to other samples to find the OTL of each treatment train and to the TCEQ's standards to determine if the wastewater trains are properly working. For the RELLIS campus drinking water, fifteen samples were taken at various points of the drinking water pipeline or from commercially bottled water. From each sample location, samples were tested at multiple labs for twelve different heavy metals. The average of each sample's heavy metal levels is compared to the SDWA requirements to determine if the water at RELLIS campus is safe for drinking.

**Well-Being in Nurses Seeking Sexual Assault Nurse Examiner (SANE) Education**

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*REU/SURE Program Name:* Independent Research Project

***Introduction.*** Sexual assault nurse examiners (SANEs) are registered nurses who provide care to patients who have recently experienced sexual assault. SANEs are exposed to secondary traumatization, making them at risk for burnout. The objective of this study was to describe well-being, stress, self-efficacy, resilience and burnout in a sample of nurses training to become SANEs. ***Methods.*** Nurses seeking SANE education in the Texas A&M Center of Excellence in Forensic Nursing were invited to participate in this study. Seventy nurses completed an initial SANE Well-Being survey. The survey consisted of 92 questions: Nurse Well-Being Self-Assessment (NWSAT), Perceived Stress Scale (PSS), Connor-Davidson Resilience Scale (CD-RISC), General Self-Efficacy Scale (GSE) and Maslach Burnout Inventory (MBI). Participants had already completed a survey providing their demographic information. ***Results.*** Seventy nurses completed the baseline survey (97.06% female). Mean age was 41. Average number of SANE exams completed was 2.90. Education level included: 36.76% Associate's, 44.12% Bachelor's, 17.65% Master's, 1.46% Doctorate. Race and ethnicity included 61.76% White, 22.06% Hispanic, 11.76% Black, 4.42% other. Approximately 1/3 were ER nurses (33.85%), 23.08% were women's health nurses, and 43.08% worked in other settings. Most nurses worked full-time (82.09%). The majority worked in non-rural hospitals (61.43%). Mean scores on the NWSAT: Bio=5.55, Rela=5.30, Emo=4.99, Spir=7.63. Mean for other scales were: PSS=20.47, GSE=33.74, CD-RISC=33.34, MBI Emotional Exhaustion=1.54, MBI Depersonalization=0.78, MBI Personal Accomplishment=5.13. ***Discussion.*** Nurses in our sample had slightly lower NWSAT scores than a national sample of nurses on all subscales except the religio-spiritual scale. Resilience and self-efficacy scores were similar to those in general samples. PSS scores were moderately higher than those in a sample of trauma nurses, although burnout scores were much lower than in a U.S. nursing sample. It is important to note that about 1/3 of nurses completed the survey during the pandemic. **Conclusion.** SANE nursing has a high potential for burnout. Results of our study suggest nurses who pursue SANE education have lower burnout risk than nurses generally. Therefore, they may be more resilient even when stress levels are high, and higher religio-spiritual well-being may be protective against burnout.

**miRNA Differentiation Between Two Tick Species**

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*Graduate Student Advisor:* Brenda Leal
*Research Discipline:* Science (STEM)
*REU/SURE Program Name:* Independent Research Project

As both ticks are economically and medically important around the world, the control of vectors is an essential method to limiting human and animal suffering. A further understanding of miRNA roles during tick feeding could be used towards developing novel acaricidal control methods. The focus of this study was to determine the miRNA profiles and their roles in a one-host, *Ixodes scapularis* and three-host tick, *Rhophisuphilis microplus*. In order to accomplish this, the following must be achieved: establish a protocol for miRNA extractions from salivary glands and extracellular vesicles; isolate miRNAs using a Qiagen miRNeasy micro kit, and perform Real-time polymerase chain reaction (PCR) to view miRNA expression at 1, 3, 5, and 7 days of feeding between both ticks. During this phase of the project, protocol establishment was a priority to create a baseline for future work. Samples were characterized by sex, salivary gland vesicles and salivary gland organs. All samples used were from *Ixodes scapularis.* After isolation of miRNAs the quantity of vesicles and miRNA present was determined and finally an analysis of the quality of the miRNA. During this phase of the project miRNA degradation was the largest hindrance to continued experimentation. In further experimentation, more caution must be used to prevent the degradation of miRNA.

**γ-ray Reconstruction from Nuclear Decay**

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*REU/SURE Program Name:* Cyclotron Institute REU Program

Measuring γ-rays from nuclear decay is important for distinguishing different models describing the photon strength function. Because γ-rays often scatter from one detector into another within an array, one must reconstruct the actual energy of the initial γ-ray from the energies deposited in multiple detectors. Current γ-ray emission data is reconstructed using modern day addback-clustering algorithms, however due to scattering and cross-talk in detectors, the algorithms can only reconstruct a fraction of the events accurately. This research investigates the potential use of neural networks to reconstruct gamma energy and multiplicity using simulated detector data originating from DICEBOX. These results are then compared to the performance of the current clustering algorithms. If the neural network outperforms the clustering algorithms and is able to identify previously unknown patterns in the data, then it may replace the clustering algorithms to reconstruct γ-ray emissions. Excited states of 58Fe made in DICEBOX in conjunction with GEANT4 to create simulated events were used to train and test various different networks.

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