

Presentation Number: 100

Presentation Title: Nanogels for Oncological Drug Delivery Produced from Thermophile-derived Biopolymers

Student Name: Nathaniel Strickland
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Biomedical Engineering

Advisor: Dipayan Samanta
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Abstract: Nanogels utilizing a core-shell structure with a thermophile-derived biopolymer corona were studied for successful synthesis. A simple, green synthesis involving biocompatible polymers was utilized, resulting in a two-step synthesis with large up-scaling potential. Biopolymers derived from thermophilic bacteria grown within a minimal salt media with corn stover or soy hull as a carbon source. Casein micelle structures were stabilized with calcium crosslinking before incorporation of EPS was introduced through accumulation. Core Shell nanogels were characterized with SEM, AFM-IR, and DLS; while additional encapsulation, release and swell studies were carried out with curcumin as a model drug. The hydrophobic inner domains of the casein micelles and hydrophilic core-shell interface presents potential for a high drug loading environment, while the hydrophilic shell aids in stabilization within a physiological environment. These core-shell nanogels serve potential in the field of oncology as modifiable vehicles for targeted and responsive release.

Poster Presentation
Undergraduate Student

Presentation Number: 101

Presentation Title: Effect of Ablation Angle from Laser Ablation for Space Debris Removal

Student Name: Hannah Duncan

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Advisor: Dr. Prasoon Diwakar

Mechanical Engineering

Abstract: Space-based laser ablation is an efficient active removal method for space debris in low Earth orbit. Plasma generated from the process of laser ablation can be used to initiate the transfer of debris into the Earth's atmosphere for termination. This presentation will explore the use of nanosecond-pulsed laser ablation to change the trajectory of space debris through momentum transfer. This presentation will focus on how the ablation angle affects the amount of momentum that can be transferred in a single pulse for various energies.

Poster Presentation

Undergraduate Student

Presentation Number: 102

Presentation Title: Comparison of the performance of Soil Moisture Sensors

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Abstract: Accurate soil moisture data are essential for developing a Decision Support Tool (DST) to support crop and livestock management and machine learning–based forage estimation under climate variability. This study compares three soil moisture measurement methods, Hobo sensors, Hydrosense probes, and the oven-drying gravimetric method, to evaluate their accuracy, reliability, and suitability for real-time applications. The Hobo sensors were set up and tested. Measurements were benchmarked against oven-dried samples, and performance was assessed using statistical indicators of agreement. While oven drying provided the highest accuracy, it was labor-intensive and unsuitable for continuous monitoring or real-time data transmission. Hydrosense sensors require manual operation, limiting their efficiency for large-scale deployment. In contrast, Hobo sensors enabled continuous, spatially distributed monitoring and demonstrated strong correlation with gravimetric measurements. Results indicate that calibrated wireless sensors are well-suited for integration into machine learning models, real-time modeling, and operational decision support tools for sustainable crop and livestock management

Poster Presentation

Undergraduate Student

Presentation Number: 103

Presentation Title: Effects of Design Variables on Viscous Rayleigh-Taylor Growth to Study Plasma Viscosity

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Dr. Sonya Dick

Leslie A. Rose Department of Mechanical Engineering

Abstract: In attempts to make Inertial Fusion Energy (IFE) a more practical solution to the fusion energy concept, studying the growth of hydrodynamic instabilities in high-energy-density (HED) plasmas at extreme conditions during laser compression can provide information about the transport properties, such as viscosity, of IFE-relevant materials. In this work an analytical model for viscous linear Rayleigh-Taylor growth is employed to study the behavior of hydrodynamic instability growth of viscous of HED plasmas under high temperature and pressure. Through this model, a parameterization study can be conducted to find ideal values of amplitude, wavelength, material densities, and laser acceleration for experimental design.

The growth of hydrodynamic instabilities in HED plasmas can be modelled using the Rayleigh-Taylor Instability (RTI) equation, which is dependent on the viscosity and density of various materials. In this work, an in-house MATLAB code that solves the viscous RTI equation was used to find the ideal materials and values of governing variables, that leads to the largest sensitivity between different material kinematic viscosities for experimental design. The primary challenge associated with this approach is establishing reasonable bounds of each variable given experimental limitations of laser facilities, such as the National Ignition Facility. These limitations include diagnostic resolutions, small experimental timescales, and laser power limitations.

Poster Presentation

Undergraduate Student

Presentation Number: 104

Presentation Title: Devising a Tunable Stiffness Hydrogel Material to Overcome Ineffective Wound Closure in Simulated Microgravity Environments

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Advisor: Dr. Tugba Ozdemir

Nanoscience and Biomedical Engineering

Abstract: Introduction

Effective wound healing is significantly impaired in microgravity, leading to an increased risk of complications during spaceflights. Human dermal fibroblasts (HDFs) are critical for the healing process, as they are responsible for the cell contractility and collagen deposition necessary for new tissue formation. In simulated microgravity (SMG) environments, these processes are diminished. However, research suggests that mechanical signals from substrate stiffness can be used to change fibroblast behavior. In this study we proposed using the tunable stiffness of polydimethylsiloxane (PDMS) to match the mechanical properties in SMG. Through tracking the displacement of embedded fluorescent beads into the PDMS, we propose to measure force vectors that re exerted to the underlying substrate from HDF using traction force microscopy (TFM). We will tune the cell generated forces through altering stiffness of our future wound dressing materials.

Methods

To make the polydimethylsiloxane (PDMS) substrates, a silicone elastomer and curing agent were mixed in a 1:10 ratio, and spin-coated onto glass disks at 500 RPM for 30 seconds. The disks were cured at 80°C then treated with a 5% APTES solution to facilitate bead conjugation. A 0.05% carboxylate fluorescent nanobead solution was sonicated at 50Hz, filtered through a 0.45-micron filter, and incubated on the PDMS surface. After a Tris solution added on the disks, the substrates were coated with collagen to support cell adhesion and sterilized with 1% Pluronic. Final substrates were washed with 1xPBS and stored at 4°C before cell culture.

Results

The nanobead coverage on the disk is homogenous across the PDMS surface with a average density of 34,000 beads per image of disk at 20x magnification. Initial cell studies confirm that adult human dermal fibroblast (AHDF) cells are capable of proliferation and adhesion to the disks. TFM procedure is still being optimized and adjusted to ensure correct quantification.

Poster Presentation

Undergraduate Student

Presentation Number: 105

Presentation Title: Characterization of Flavone synthase II (FNS2) in *Citrus sinensis*

Student Name: Taylee Schramm

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CBHS

Advisor: Daniel Owens

CBHS

Abstract: Flavone synthase II (FNS2) is a membrane-bound cytochrome p450 that is involved in the flavonoid metabolic pathway. FNS2 synthesizes flavones from flavanones by catalyzing a double bond between C2 and C3 in the C-ring heterocyclic skeleton, this includes liquiritigenin to 7,4'-dehydroxyflavone, naringenin to apigenin, and eriodyctiol to luteolin. The *Citrus sinensis* FNS2 gene was isolated from leaf mRNA and converted to cDNA by RT-PCR. Cloned into the Gateway system, with the entry vector pENTR D-TOPO, recombination into the expression vector pET-DEST42, and the transformation into the expression platform BL21. The synthesis of a co-polymer to be used in the solubilization of discrete lipid-based discoidal particles will allow for detergent free elution and purification of FNS2. The co-polymer will be synthesized with a standard reflux reaction of styrene and maleic anhydride to produce the styrene maleic acid (SMA) co-polymer, that will then be applied to membrane fraction following enzyme expression and cell homogenization to produce SMA lipid particles (SMALP). Following this, purification of enzymes will be done by way of metal affinity chromatography. Finally, enzyme characterization of FNS2 will be conducted with several assays: relative activity, thermostability, pH, temperature, co-factor concentration and enzyme kinetics. Quantitative analysis will be done by way of high-pressure liquid chromatography (HPLC).

Poster Presentation

Undergraduate Student

Presentation Number: 106

Presentation Title: Investigation Into Analytic Solutions of Corrugated Shock-Wave Oscillations

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Advisor: Dr. Sonya Dick

Mechanical Engineering

Abstract: Shock waves are a necessary component in most IFE designs. Shock waves can evolve from being axisymmetric to developing a corrugation in the shock front when interacting with target defects. Recent work has also shown the development of a shock front traveling through printed foam geometries proposed for future IFE target designs. However, the behavior of these shock fronts, especially in viscous fluids, have not been well characterized. Specifically, comparisons between theory, simulation, and experiments are lacking in the high-energy-density regime.

In a paper titled “Shock-wave viscosity measurement,” an analytic model is proposed for the oscillatory decay of a corrugated shock wave’s amplitude in a viscous fluid. (1) This model has potential to be used for experiment design and analysis in high energy density regimes. Unfortunately, the equation of interest and associated plots presented in (1) do not match. Through use of a plot digitizer to extract data from the published plots and MATLAB code that implements the equation of interest, we can show the discrepancy quantitatively.

Additionally, through continued effort to implement the full eigenvector solution that Miller and Ahrens present, we hope to present a thorough review of this model. This continued effort of validating the variety of models presented in Miller and Ahrens will provide confidence in a theoretical tool to predict shockwave amplitude decay in a viscous fluid. Doing so has far reaching implications, from designing experiments to measure the viscosity of high energy-density materials, to better predicting the behavior of corrugated shockwaves generated in structured foam targets.

*This work is supported by the South Dakota Mines Nelson Research Grant.

[1] Gregory H. Miller and Thomas J. Ahrens, “Shock-wave viscosity measurement,” *Reviews of Modern Physics*, Vol. 63, 919 (1991).

Poster Presentation

Undergraduate Student

Presentation Number: 107

Presentation Title: Evaluation of grape pomace pretreatment methods to improve fermentable sugars and nitrogen values for *L. plantarum* (ATCC 8014) fermentation

Student Name: Anika Main
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CBE

Advisor: Dr. Salmeron
CBE

Abstract: Grape pomace, consisting primarily of grape seeds and skins, is the major solid waste generated from the wine industry, accounting for 25% of the total grape weight. Lactic acid bacteria, which form the monomer that makes up polylactic acid, are widely used in industry for the design of biopolymers. The feedstocks research can be 40-70% of production costs, thus the demand for cost-effective alternatives. This study aims to characterize the profiles of reducing sugars and nitrogen of grape pomace and quantify the changes in their levels during lactic acid production. The lactic acid strain used in the grape pomace media was *L. plantarum* (ATCC 8014). Media was developed through different pretreatment methods to increase sugar and nitrogen values. The grape pomace was acidified and heat-treated to determine the most effective way of liberating sugars. The thermal hydrolysis was at 60°C for 1-h, and for the acid pretreatment, 0.5% sulfuric acid was used. Additionally, a green strategy involving supercritical CO₂ pretreatment was employed. Fermentation trials monitored the growth of the lactic acid strain in comparable media by measuring pH values, cell growth, total reducing sugars, and free amino nitrogen levels over a 48-h period. Preliminary findings indicate that thermal hydrolysis optimizes the media, yielding the highest levels of sugars (10 g/L) and free amino nitrogen (287 mg/L) while supporting similar cell growth (3×10^8 CFU/mL) among pretreatments. Available sugars, cell growth, sugar consumption, and lactic acid production will be evaluated to assess the most effective pretreatment method to achieve higher lactic acid yields.

Poster Presentation
Undergraduate Student

Presentation Number: 108

Presentation Title: Implementation of a deep eutectic solvent system for sustainable lignin extraction from corn stover using AI and Machine Learning

Student Name: Joel Tettey

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Nano and Biomedical Engineering

Advisor: Salmeron Ivan Ochoa

Chemical and Biological Engineering

Abstract: Joel Tettey, Daniel Tobias-Soria, Kazi Khoda, Ivan Salmerón

Lignocellulosic biomass such as corn stover represents a promising renewable feedstock for sustainable materials and green chemicals. This work presents an integrated experimental data-driven framework for optimizing lignin extraction and cellulose preservation using deep eutectic solvents (DESs). DES systems based on choline chloride combined with formic acid, lactic acid, and 1,4-butanediol were synthesized and applied to corn stover under controlled pretreatment conditions (80–120 °C, 2 h, 1:20 w/v). Lignin was recovered via antisolvent precipitation, and cellulose-rich solids were characterized using FTIR and SEM to assess structural and morphological changes. Experimental data were curated into a structured dataset linking DES composition, molar ratio, temperature, and process variables to lignin extraction efficiency and cellulose retention. Supervised machine learning models were developed to construct nonlinear surrogate relationships between solvent chemistry, operating conditions, and extraction performance. Model benchmarking and feature importance analysis identified temperature, DES acidity, and solvent-to-biomass ratio as dominant factors governing lignin solubilization and selectivity. The predictive models enabled data-driven optimization of DES formulations and operating windows, providing experimentally consistent guidance for maximizing lignin recovery while preserving cellulose integrity. By coupling systematic experimentation with interpretable machine learning, this study establishes a scalable methodology for intelligent solvent and process design in lignocellulosic biorefineries, advancing sustainable and circular biomass valorization strategies.

Poster Presentation

Undergraduate Student

Presentation Number: 109

Presentation Title: Prehistoric Films and Science: A Blurring of Fact and Fiction

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Humanities

Abstract: This poster presentation explores the historical and psychological relationship between paleontology and its representation in film, specifically focusing on the blurring of scientific fact and fictional narrative. While movies serve as significant learning tools, the speculative nature of paleontology allows filmmakers to make creative choices that often deviate from established scientific knowledge. By tracing the evolution of dinosaur portrayals, from early "movie monsters" to the "animalized" creatures of the dinosaur renaissance, this analysis highlights the profound cultural impact of the "Jurassic Park Effect." It also utilizes psychological and philosophical frameworks to examine how fictional narratives possess a persuasive power that can alter public beliefs and attitudes more easily than factual stories, arguing that the popularity of franchises like Jurassic Park has created false narratives and unrealistic expectations regarding both the appearance of prehistoric life and the reality of paleontological work. These fictional narratives have been further exacerbated by poor communication within the scientific community and the speculative tendencies of modern "documentaries." Ultimately, the presentation advocates a new media approach that balances creative fiction with scientific factuality to better align with contemporary discoveries and enhance public understanding of science.

Poster Presentation
Undergraduate Student

Presentation Number: 110

Presentation Title: Optimizing Time-Zero in Germanium Detectors of LEGEND-200

Student Name: Ryan Cantz

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Physics

Advisor: Cabot-Ann Christofferson

Chemistry

Abstract: LEGEND-200 is searching for neutrinoless double-beta decay (0 ν BB) in germanium-76 using high-purity germanium detectors (GeDs) submerged in an active liquid argon veto system. The discovery of 0 ν BB would prove that the neutrino is a majorana particle (i.e., its own antiparticle) and provide a possible explanation for the imbalance of matter and antimatter in the universe. Accurate signal start time (t_0) determination in GeDs is crucial for precise data analysis of events in LEGEND-200. The current t_0 in GeDs is subject to uncertainties arising from signal propagation effects and electronic noise, among other factors. To improve timing accuracy, the t_0 provided by the silicon photomultipliers (SiPMs), which exhibits superior timing resolution compared to the GeDs, will be utilized. By comparing the GeDs t_0 to the SiPMs t_0 , the error in the GeDs t_0 measurement can be directly determined. Additionally, other parameters are investigated that affect t_0 in GeDs, including pulse shape, energy, and drift time. Correlating these relationships through statistical analysis can, in later work, improve the precision of LEGEND's analysis parameters used to separate signals from backgrounds.

Poster Presentation

Undergraduate Student

Presentation Number: 111

Presentation Title: Analysis of Radon Emanation from Titanium to Enable Future Dark Matter Searches

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Advisor: Richard W Schnee
Physics

Abstract: The components of the dark matter research experiment LUX-ZEPLIN (LZ) require minimal radioactivity. Radioactive signals can mimic those of dark matter events, leading to potential misinterpretations in the experiment. The Titanium used in the LZ cryostat chamber is susceptible to radium contamination, making it a significant source of background radiation we have observed. This necessitates developing a specific surface treatment method, such as acid etching, to reduce radium concentration in the Titanium.

The experiment analyzed radon emanation from titanium samples to assess the radium background in the material prior to any treatment. As radium 226 in the titanium decays, it releases atoms of radon 222. Those radon 222 nuclei get transferred to our detection chamber. We measure the amount of radon daughters, polonium 218 and 214, by observing their alpha decays.

The baseline for our titanium contamination is approximately 0.85 mBq. Moreover, conducting measurements at low pressure shows that at least half of the radium is at the surface of the sample titanium. Further experiments will determine the effectiveness of acid etching in reducing radium levels in our samples. An effective surface treatment would allow for future dark matter experiments with better sensitivity.

Poster Presentation
Undergraduate Student

Presentation Number: 112

Presentation Title: Communicating Climate

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AES & STS

Advisor: Dr. Kayla Pritchard

STS

Abstract: Since the Industrial Revolution, people have been producing more greenhouse gases than ever before. This has caused expedited changes within our environment and atmosphere. As a result, we are seeing more detrimental impacts on our society. Though the Earth has dealt with natural fluctuations before, these changes are vastly different and have a much bigger impact. The issue is very large, and should it be addressed, it will require collaboration from people of all walks of life. There are three parts to this research that need to be answered: how do we communicate the impacts of climate issues effectively, how can we as scientists educate and provide people with actionable items about these issues, and how do we as scientists communicate uncertainty? This project will explore those ideas. There are many current obstacles to overcome, such as political partisanship, cost-effective solutions, and fair distribution of justice and burdens. It will be up to us as scientists to learn how to effectively communicate the urgency and importance of these issues. Understanding where people have knowledge gaps, and learning as scientists how we can best fill in those gaps, will be of utmost importance in the coming decades, as climate issues will only worsen. While there is no perfect solution, and there is no one specific area that solely needs to be addressed, this issue will require large-scale, pragmatic, and holistic solutions that address these issues as best as they can while promoting the well-being of everyone, as everyone will be impacted by climate issues in one way or another.

Poster Presentation

Undergraduate Student

Presentation Number: 113

Presentation Title: Assessing the effects of differing acid digestion methods on bulk carbonate trace element analyses

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Advisor: Sarah W. Keenan(1), Scott R. Beeler(2)
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Abstract: The major and trace element compositions of carbonate rocks (limestone and dolomite) provide critical archives of past environments as proxies for past temperatures, biological productivity, and water provenance and mixing. One frequent method of analysis employed is acid digestion, allowing ion release into solution, paired with inductively coupled plasma mass spectrometry (ICP-MS). Despite the extensive utilization of this approach, carbonate digestion methodology varies widely between studies. Common variables include acid type and concentration, digestion temperature and duration, sample mass, stepwise digestion, and sample pre-treatment. The digestion methodology variation causes issues to arise, as the methodology selection may result in the digestion of detrital minerals, notably silicates, whose geochemistry is not controlled by climatic or paleoenvironmental conditions. This outside input can impact the resulting geochemical signature measured by the ICP-MS, potentially misleading paleoclimatic and paleoenvironmental interpretations. In this study, we quantitatively compared multiple digestion methods to evaluate how they affect the resulting ICP-MS analyses to determine the most appropriate methodology for examining the major and trace element composition of carbonate rocks. Five differing carbonates ranging from nearly pure calcite to diagenetic carbonates were examined using six differing digestion methods. We determined that digestion methodology affects measured elemental compositions, however, the degree of difference varies depending on sample mineralogy and the element of interest. One example being nitric acid or a digestive microwave use can result in the liberation of elements from clay minerals or potential secondary reactions, which are not representative of the carbonate-bound elements. Our results demonstrate the need for a standardized methodology within the carbonate geochemistry community to ensure the reliable use of geochemical proxies.

Poster Presentation
Undergraduate Student

Presentation Number: 114

Presentation Title: Computational Image Analysis of Cellulose Synthase Complexes

Student Name: Claire Foster

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Biomedical Engineering & Nanoscience

Advisor: Steve Smith

Biomedical Engineering & Nanoscience

Abstract: Title: Computational Image Analysis of Cellulose Synthase Complexes

Student: Claire Foster: Department of Biomedical Engineering and & Nanoscience

Mentors: Steve Smith: Department of Biomedical Engineering and & Nanoscience; Shi-You Ding, Department of Plant Biology, Michigan State University

This research investigates the function and motility of cellulose synthase complexes (CSCs). These synthase complexes are responsible for building the primary structural component of plants, cellulose nanofibrils, thus they are vital in maintaining plant structure and integrity. These complexes move through via microtubules, hollow tubes composed of proteins, key in intracellular transport. CSCs take the shape of a rosette with 6 lobes, with each lobe being composed of 3 cellulose synthase proteins. Fluorescent fusion CSCs are studied through single molecule localization microscopy (SMLM) live cell imaging and tracking of CSCs formed in root tissue obtained from *Arabidopsis thaliana*. These images were taken in our lab and at Michigan State University in collaboration with Dr. Shi You Ding. The images were collected after genetically tagging the complexes with fluorescent proteins and imaged in our SMLM microscope. Computational analysis in ImageJ/Fiji of single molecule trajectories comparing complexes C3, C5, and C6 fluorescent fusion CSCs, where different component enzymes were fused with either green fluorescent protein (GFP) or yellow fluorescent protein (YFP), show differences in motility between complexes, including differences in speed, distance travelled, and confinement ratio (linearity/straightness).

Poster Presentation

Undergraduate Student

Presentation Number: 115

Presentation Title: Survey of Ord's Kangaroo Rat (*Dipodomys ordii*) in Buffalo Gap National Grassland

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Advisor: Kelsey Gilcrease
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Abstract: Kangaroo rats (*Dipodomys*) are arid-specialists and burrowing rodents that inhabit the arid and semi-arid regions of North America. Ord's kangaroo rat (*Dipodomys ordii*) ranges from the Desert West into the Great Plains and is the only kangaroo rat species found within South Dakota. Their presence at specific sites within the state is not well documented, and the species is not locally monitored. This project surveyed their presence within a location at Buffalo Gap National Grassland (BGNG). An additional objective was to correlate South Dakota kangaroo rat presence to soil type as soil composition is essential to the viability of their burrow construction. From September to December 2025, five trail cameras were used to capture video for presence identification. Camera locations were changed approximately every week and placed within USDA soil codes upon sparsely vegetated locations favorable to kangaroo rat movement. Kangaroo rats were detected at three different camera locations on the CuD (Conata-Hisle complex, 6 to 25 percent slopes) and Bb (Badland) soil codes. No kangaroo rat sightings were found in the camera placed within the MyE (Midway silty clay loam, 9 to 35 percent slopes) soil code. This survey successfully confirmed and documented the presence of Ord's kangaroo rat in BGNG. However, while a correlation between sighting and soil type was present, more data and potentially other survey methods are needed to draw conclusions with confidence. Many other species were also identified and captured on video, which allows this project's data to serve as a basic inventory of wildlife within the area.

Poster Presentation
Undergraduate Student

Presentation Number: 116

Presentation Title: Effect of Ablation Energy on Momentum Transfer in Laser-Based Space Debris Removal

Student Name: Krista Burkman
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Mechanical Engineering

Advisor: Dr. Diwakar
Mechanical Engineering

Abstract: Space-based laser ablation is an efficient active removal method for space debris in low Earth orbit. Plasma generated from the process of laser ablation can be used to initiate the transfer of debris into the Earth's atmosphere for termination. This presentation will explore the use of nanosecond-pulsed laser ablation to change the trajectory of space debris through momentum transfer. This presentation will focus on how the ablation energy affects the amount of momentum that can be transferred in a single pulse for various energies.

Poster Presentation
Undergraduate Student

Presentation Number: 117

Presentation Title: Investigating Alterations in Extracellular Matrix Deposition of Diabetic Fibroblasts using Silk Fibroin Films

Student Name: Isabella Holmbo
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Advisor: Tugba Ozdemir
Nanoscience and Biomedical Engineering

Abstract: Introduction:

Diabetes mellitus is a chronic disease in which the pancreas cannot produce sufficient insulin, which is a vital hormone in glucose metabolism. Excessive glucose remaining in the bloodstream causes abnormal cell activity, notably in the extracellular matrix. Cells cannot function properly and their wound healing properties are decreased or stop completely.

Silk has been highlighted as an optimal biomaterial for use in wound healing because of its versatility. Silk wound dressings have been shown to increase cell proliferation in the extracellular matrix and silk proteins exhibit antibacterial properties. It can be modified to promote healing in different wound types by tuning properties. The goal of this study is to develop an environment in which diabetic fibroblasts exhibit healthy properties.

Methods/Materials:

Silk preparation: Silk cocoons were minced and cooked in a sodium carbonate solution and solubilized with lithium bromide salt. The salt was removed from the solution using dialysis and the final silk fibroin solution was analyzed to determine concentration. A mold was made using a 3-D printer and sterilized. The silk fibroin solution was poured into the mold and left to dehydrate into a film within a sterile environment. The film was cut into discs and were kept in a sterile container until ready to use.

Cell preparation and integration: Adult healthy human dermal fibroblasts and diabetic human dermal fibroblasts were thawed and incubated at 37 degrees Celsius. They were allowed to grow and were monitored for signs of contamination. The cells were cultured on the film discs and monitored for signs of growth.

Results:

We optimized our methodology to fabricate silk films with consistent mechanical properties. Ongoing experiments are focusing on culturing normal and diabetic fibroblasts and extracellular matrix deposition.

Poster Presentation
Undergraduate Student

Presentation Number: 118

Presentation Title: Tensor based Time Series Forecasting

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Advisor: Kyle Caudle

Mathematics

Abstract: This research investigates time series forecasting for tensor-valued data, where observations consist of multidimensional arrays evolving over time. The project focuses on comparing predictive performance across forecasting models and examining how different data representations influence prediction accuracy. Tensor-based forecasting methods allow multiple related variables to be predicted simultaneously, with applications including temperature forecasting, financial data analysis, and other high-dimensional time-dependent systems. Forecast accuracy is evaluated by computing the Frobenius norm between predicted and observed tensors at each time step, providing a quantitative measure of overall prediction error.

Poster Presentation

Undergraduate Student

Presentation Number: 119

Presentation Title: IMPROVING MASS TRANSFER IN METHANOTROPHIC BIOREACTORS USING NANOBUBBLE TECHNOLOGY

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Department of Chemical and Biological Engineering

Advisor: Dr. Rajesh Sani

Department of Chemical and Biological Engineering

Abstract: Products from cultivating methanotrophs are of interest to the biomedical field due to their environmental stability and wide range of utilities. This project focuses on designing a reactor for more efficient processing of methane using methanotrophs and nanobubble technology. Previously, bioprocessing research has shown mass-transfer is particularly inefficient. A limitation is the C-H bond in methane is relatively unreactive and requires a high activation energy to break. This makes the process energy-intensive and more costly. More effective methane processing is needed due to its slow growth rates hindering large-scale bioprocessing. Using nanobubble technology may assist in distributing methane to methanotrophs for more efficient breakdown. They are stable in media for a much longer period of time due to their size and stronger internal pressure. Nanobubbles possess several properties, including high Laplace pressure, high surface area to volume ratios, low buoyancy for suspension time, and negative surface charge for sustainability. Combined, this increases the volumetric mass transfer coefficient through their effect on the concentration of gas near the surface and high internal pressure. Residence is extended through near continuous gas transfer into media, and the boundary layer is reduced due to quickening of gas diffusion. Finding a way to utilize nanobubbles within larger-scale bioreactors efficiently is limited. Nanobubbles possess several properties that improve mass-transfer; however, further research is needed to understand how to more efficiently utilize nanobubbles in a larger-scale bioreactor. There are various difficulties in applying nanobubbles: stability compromise due to organic matter and salts, energy consumed to generate the bubbles, and detecting the bubbles in solution.

Poster Presentation

Undergraduate Student

Presentation Number: 120

Presentation Title: Simulation of Radon Mitigation with Silver Zeolite

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Physics

Advisor: Dr. Schnee

Physics

Abstract: The decay of radon causes one of the largest backgrounds in rare-event particle physics experiments such as neutrinoless double beta decay and dark matter detection. The current standard for removing radon from the air is activated carbon swing systems. A swing system has two columns, flowing forwards through one at a time, and uses some of the clean air to push the radon out of the other column. Recently, it has been found that silver zeolite is around 500 times better at adsorbing radon than activated carbon, potentially enabling the design and creation of much more effective and less expensive radon-reduction systems. I have edited a preexisting simulation for carbon-based radon mitigation to help design a physical system to measure silver zeolite radon adsorption under different temperatures. For different zeolite masses and air flow rates, the simulation predicts the time it takes radon to break through the zeolite column as well as its measurement uncertainty. As expected, larger masses of silver zeolite and slower flows of air lead to longer breakthrough times as well as lower errors associated with the parameters. For a flow rate of 0.25 standard cubic feet per minute and a mass of 500 grams, the simulation yields a breakthrough time of around 17.5 hours; this is an ideal time for testing many temperatures efficiently in a physical system. Preliminary results from the simulation indicate the precision of the breakthrough time may be as good as 0.4% fractional uncertainty, providing the same fractional uncertainty on the zeolite adsorption coefficient. This simulation should allow for precise and efficient measurements of the properties of zeolite. These better defined parameters will allow the design of a less expensive, much more efficient radon-reduction swing system.

Poster Presentation

Undergraduate Student

Presentation Number: 121

Presentation Title: Evaluation of Remediation Pathways for a Bentonite Mine Site using Remote Sensing

Student Name: Grace Belcher
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Advisor: Dr. Lisa Kunza
Chemistry, Biology, and Health Sciences

Abstract: Within the mining sector, reclamation practices are often completed during active mining operations, as required by law. However, sites mined prior to the passing of the Surface Mining Control and Reclamation Act of 1977 were often left unremediated. The bentonite mining site, also called the "Moonscape", is an area northwest of Belle Fourche, South Dakota, managed by the Bureau of Land Management (BLM). The BLM has investigated various remediation approaches on the site since the late 1970s. Our research project focused on applying remote sensing and geospatial information systems (GIS) using ArcGIS Pro to identify flow paths that will allow the formation of catchments for fine sediments, organic matter, and water to help soil development and instigate remediation. To assess potential catchment locations, we applied a support vector machine approach classifying National Agriculture Imagery Program (NAIP) near-infrared imagery. We classified vegetative area as 53%, water bodies as 3%, and bare ground as 44% of the total area. Then we used identified locations from the classification to assess flow lines and drainage areas via a deterministic flow direction methodology. We plan to visit the study area to validate our findings. Additionally, we will create a cost-benefit analysis for identified historical remediation approaches. Our goal is to create a cost-effective reclamation approach based on the utilization of natural processes. Future research will utilize this data to characterize sites that will allow soil development and eventual vegetation growth. Overall, the research provides information that will help to define a more efficient, cost-effective approach in which ecosystems can be jump-started to remediate themselves.

Poster Presentation
Undergraduate Student

Presentation Number: 122

Withdrawn

Presentation Number: 123
Withdrawn

Presentation Number: 124

Presentation Title: Underground Neutron Background Measurements at Sanford Lab

Student Name: Dakota McNutt

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Physics

Advisor: Dr. Juergen Reichenbacher

Physics

Abstract: Experiments on the leading edge of particle physics are being conducted almost a mile underground at the Sanford Underground Research Facility (SURF). The particle physics research being conducted at SURF requires the detection of elusive particles, whose signal can be drowned out by the cosmic radiation bombarding Earth's surface. To eliminate this background noise, particle detectors are built underground to shield from cosmic rays. These experiments are the LUX ZEPLIN Dark Matter experiment (LZ), the Deep Underground Neutrino Experiment (DUNE), and the Compact Accelerator System for Performing Astrophysical Research (CASPAR).

Building these detectors underground eliminates the cosmic ray background. However, there is still a substantial radioactive background due to traces of radioactive material in the massive rock and shotcrete. Particularly, neutrons comprise a significant component of SURF's radioactive background for these experiments, looking for elusive neutrinos, dark matter particles, or nuclear fusion reactions, as they could easily mimic such particles or reactions. Despite the underground neutron flux being well over a thousand times smaller than on the surface, the detectors can still see a critically large rate of neutrons. Our underground measurement setup uses helium-3 proportional tubes to measure the neutrons emitted from the cavern walls and shotcrete. Given the size of the 13" long helium-3 gas-filled tubes, the neutron-induced signals are expected to cause a very low rate of about 0.1 mHz. The challenge then becomes reducing internal tube backgrounds from noise and intrinsic radio-contaminants in the tube materials to measure this small cavern neutron rate. Results from the first underground neutron background and neutron calibration source measurements will be presented. Furthermore, the concept of a dedicated signal waveform analysis for pulse shape discrimination of real neutrons from internal background noise is being outlined.

Poster Presentation

Undergraduate Student

Presentation Number: 125

Presentation Title: Linking Speckle Pattern Method to Spatial Resolution in Digital Image Correlation

Student Name: Andrew Lindgren

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Dr. Cassandra Birrenkott

Leslie A. Rose Department of Mechanical Engineering

Abstract: Digital Image Correlation (DIC) is a non-contact optical technique used to measure full-field surface displacement and calculate strain. Accurate DIC measurements require high contrast, random speckle pattern on the surface of interest. While DIC is a widely used strain measurement tool, the relationship between speckle pattern generation strategies and achievable spatial resolution can be time consuming – often determined through trial-and-error processes - yet is incredibly useful for future work with specific equipment. The objective of this project is to identify a speckle patterning method that provides the highest spatial resolution using the 3D DIC system available in the JMP Lab at South Dakota Mines.

For many material characterization applications, strain fields around small structural features (e.g. fibers in a composite or voids in a casting) are of interest. Thus, understanding how spatial resolution depends on pattern characteristics is critical for DIC experiment design. Developing a better understanding of this relationship allows DIC users to intentionally select a patterning method based on the scale of measurement.

To evaluate spatial resolution for the JMP Lab system, two factors were investigated: pattern quality and equipment noise. Pattern quality was quantified using grayscale histograms, estimated mean speckle size, and mean intensity gradient. Equipment noise was assessed through a rigid-body translation experiment, in which a patterned sample was displaced in-plane by a known amount and compared to the displacement measured by DIC. Combining these analyses establishes a relationship between speckle patterning method and spatial resolution. This relationship will be validated using ESC 105, a thermoplastic matrix composite reinforced with discontinuous glass fibers. The outcomes of this work provide practical guidelines for optimizing speckle patterns and improving strain measurement accuracy for microscale material characterization.

Poster Presentation

Undergraduate Student

Presentation Number: 126

Presentation Title: High-Fidelity LES Simulation of Supersonic Retropropulsion for Planetary Entry

Student Name: Liam Hoefler

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Mechanical Engineering

Advisor: Dr. Thalakkottor

Mechanical Engineering

Abstract: Supersonic retropropulsion (SRP) is a method used to decelerate spacecraft during entry, descent, and landing (EDL) in thin atmospheres such as Mars. Under these conditions, aerodynamic drag alone cannot provide sufficient braking for a controlled descent of higher mass payloads at higher altitudes. This study implements a high-fidelity wall modeled large eddy simulation (LES) approach with adaptive mesh refinement. Both 2D and 3D domains are analyzed to examine the supersonic flow around the Mars Science Laboratory (MSL-2012) entry capsule in regimes relevant to powered descent and angled entry. The simulations capture transitional flow behavior, shock interactions, and recirculation within the capsule's wake. Flow visualization shows how these structures develop and interact as the flow approaches a steady state. The results improve understanding of the flow physics that govern SRP and capsule aerodynamics, supporting more accurate modeling of future planetary EDL systems.

Poster Presentation

Undergraduate Student

Presentation Number: 200

Presentation Title: Molecular Modeling and Simulation of 3-Hydroxybutyric Acid in Aqueous, Ionic Liquid, and Deep Eutectic Solutions

Student Name: Emily Randolph
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Chemical and biological engineering

Advisor: Dr. Ken Benjamin
Chemical and biological engineering

Abstract: 3-Hydroxybutyric acid (3HBA) is an important biosynthetic intermediate and biopolymer precursor. Although prior modeling has focused on biomedical derivatives, its behavior in biopolymer and bioprocessing contexts remains unexplored.

This work combines molecular dynamics and quantum chemical methods to investigate the liquid-phase thermodynamic and structural behavior of 3HBA in water, synthetic ionic liquids, and deep eutectic solvents. In aqueous systems, 3HBA is modeled with the CHARMM36 force field and water with TIP3P. Electrostatic point charges for 3HBA were derived using the CHELPG method at the CBS-Q3 level of theory. All-atom simulations were performed to analyze mixture properties and intermolecular interactions, including 3HBA–3HBA, 3HBA–water, and water–water aggregation.

COSMO-based quantum chemical calculations using COSMOtherm were also conducted to determine infinite dilution activity coefficients of 3HBA in water and alternative solvents. These results inform the selection of greener solvents for 3HBA extraction in bioprocessing applications.

Oral Presentation
Undergraduate Student

Presentation Number: 201

Presentation Title: Physical Separation and Characterization of Micrometeorites from Belle Fourche Shale

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Materials and Metallurgical Engineering

Advisor: Dr. Jon Kellar
Materials and Metallurgical Engineering

Abstract: The Earth is continually showered with micrometeorites (MMs). In this study MMs were collected in fossilized form from Belle Fourche Shale (BFS). BFS was comminuted (hammer mill) to liberate individual particles, slurried, and separated into magnetic/non-magnetic fractions using wet high intensity magnetic separation (WHIMS). The magnetic particles were classified by size, and a stereomicroscope was used to identify (based upon sphericity) potential MMs. This physical separation resulted in a flux of 40 MM prospects in 26.4 kg of BFS. Potential MMs were next analyzed with a scanning electron microscope (SEM). The SEM allowed high resolution and imaging as well as energy dispersive x-ray spectroscopy (EDS). Further characterization of potential MMs was performed using a focused ion beam (FIB) and a transmission electron microscope (TEM). EDS revealed that many of the MM prospects were composed of iron oxides (magnetite (Fe_3O_4) and wustite (FeO)) as well as iron silicates like olivine ($(\text{Mg}, \text{Fe})_2\text{SiO}_4$). Tungsten and tantalum-nickel based particles were also found, however further analysis of these prospects is needed to confirm their origin (anthropogenic or not).

Oral Presentation
Undergraduate Student

Presentation Number: 202

Presentation Title: MPS Microenvironment Characterization For Further Study Of Ovarian Cancer

Student Name: Drake Van Steenwyk

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Department of Nanoscience & Biomedical Engineering

Advisor: Dr. Travis W. Walker

Karen M. Swindler Department of Chemical and Biological Engineering

Abstract: Ovarian cancer is the 5th-leading cause of death among women in developed countries, with a 5-year survival rate of only 15%. Nearly 80% of cases develop chemotherapeutic resistance, yet 95% of novel chemotherapeutics fail in clinical trials. These failures are largely due to inadequate preclinical models. Current approaches rely on simplistic 2D cell culture, microfluidics, and animal models, which fail to sufficiently recapitulate human physiology. Micro-physiological systems (MPS) represent a promising next generation of advanced in vitro models that are capable of better mimicking a tumor microenvironment. This project aims to characterize the microenvironment for an MPS that is designed for the further study of ovarian cancer. Central to developing a representative MPS is matching the mechanical properties of the native ovarian microenvironment. Stiffness is a critical regulator of cell differentiation, motility, and adaptability. To this end, we quantify the stiffness of collagen hydrogels across varying construction parameters, including collagen concentration and crosslinking conditions. A combination of compressional and shear rheology is employed to establish the relationship between these parameters and the resulting mechanical properties.

Oral Presentation

Undergraduate Student

Presentation Number: 203

Presentation Title: Simulation Study for Improving Current X-Ray Medical Diagnostics with New Gamma-Ray High-Purity Germanium Detectors

Student Name: Shane Garcia
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Physics

Advisor: Juergen Reichenbacher
Physics

Abstract: In collaboration under Germanium-based Science and Technology Advancement Research (Ge-STAR) one of the goals is to explore the use of High Purity Germanium (HPGe) Detectors for medical applications. One such application is the use of HPGe Detectors as an alternative for tumor screening using Compton Scattering to distinguish between tumor and healthy tissue in addition to pinpointing the location of a tumor inside healthy tissue. This presentation is an exploration of the magnitude of effects regarding chemical composition and density on detection rates with a HPGe Detector to understand the limitations and inform the design of a device. In order to observe the detection rates for the gamma-ray interactions in matter of Compton Scattering and Photoelectric Absorption we use GEANT4 nuclear physics simulations of our detector, source, and screening sample. Additionally, these effects are observed over a range of gamma-ray energies from 55 keV to 1460 keV on varying density and chemical compositions for healthy and tumorous tissue. This analysis helps build an understanding for what metrics a screening device needs to meet its goals to improve current X-ray diagnostics with new gamma-ray HPGe detectors.

Oral Presentation
Undergraduate Student

Presentation Number: 204

Presentation Title: Developing an Accurate Microphysiological System for Studying Vasculature

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Nanoscience & Biomedical Engineering

Advisor: Dr. Travis Walker

Karen M. Swindler Department of Chemical and Biological Engineering

Abstract: Animal clinical trials are a crucial element of the modern pharmaceutical industry, but recent initiatives have cast doubt on their accuracy and relevance to human patients. These studies are extremely expensive and often result in the drug failing to move on to a human trial. Additionally, these early animal studies can fail to catch adverse side effects, which in turn can put human subjects at risk. For these reasons, the medical industry has been pushing for less reliance on animal models and more accurate and cost-effective testing methodologies. Microphysiological systems (MPSs) are one such device that can fit this need. MPSs are in vitro models that seek to accurately mimic a targeted human tissue or organ.

While MPSs are currently being developed as a supplement to animal testing, many such devices have yet to comprehensively account for chemical and physical forces innate to native tissue, which have been shown to impact the behavior of cultured cells. As such, research is needed to develop MPS systems that strive to accurately mimic the forces at play within the body.

These forces come into special consideration when developing MPSs to model human blood vessels. By utilizing microfluidics, these devices can mimic human vasculature. Lithography is traditionally used to carve out channels in a PDMS mold. PDMS lithography severely limits the channel layouts, resulting in flat, rectangular channels. This subjects the cells and the fluid in the channels to different mechanical signals than the cells in cylindrical, human blood vessels. In response to this, this research group has been developing a model that addresses these design flaws.

Our design process has resulted in development of MPSs with physiologically relevant length scales and cylindrical channels. However, these designs still require further improvement. Further work is currently underway to improve the usability, sterility, and data collection from these devices.

Oral Presentation

Undergraduate Student

Presentation Number: 205

Presentation Title: Dust Deposition on Radiopure Titanium

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Physics

Advisor: Dr. Richard Schnee
Physics

Abstract: Minimizing radium contamination is essential for experiments such as the LUX-ZEPLIN (LZ) dark matter detector at the Sanford Underground Research Facility. Although LZ uses the purest titanium ever made, radium impurities in the titanium are believed to be the main source of background interactions. To determine the best way to remove radium from titanium in future experiments, we plan to measure radon emanation from titanium both before and after acid etching. Because dust particles emanate radon, sample surfaces must be cleaned to a level of less than one microgram of dust per square centimeter to ensure dust contribution is negligible when performing a radon emanation test of the titanium.

This project evaluates specialized cleaning techniques for preparing ultrapure titanium samples for low background measurements. Because dust particles fluoresce under UV light, I was able to determine how much dust was on the surface by taking magnified images lit by blacklight. Images taken of the titanium samples after initially using an ultrasonic cleaner showed that dust contamination was $21\mu\text{g}/\text{cm}^2$, over 20x too high. Powerwashing was performed because titanium is not soft enough to be deformed by a normal powerwasher, but most material adhering to the surface would be washed away. Though mineral deposits and other contaminants from the water being left behind were a concern, the amount of material left behind after powerwashing was found to be under $1\mu\text{g}/\text{cm}^2$. The next steps in this experiment are to perform a radon emanation run of the world's purest titanium in the Dakota Building cleanroom.

Oral Presentation
Undergraduate Student

Presentation Number: 206

Presentation Title: Optimization of Silk Extraction and Characterization of Dip-Coated Tubes for Tissue-Engineered Vascular Grafts

Student Name: Alexis Backhaus

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Nanoscience and Biomedical Engineering

Advisor: Travis Walker

Karen M. Swindler Chemical Biological Engineering Department

Abstract: Heart disease remains the leading cause of death in the United States, accounting for about one in five deaths. Vascular grafts are commonly used in coronary artery bypass grafting (CABG) to treat cardiovascular disease, but reliable options for small-diameter grafts are limited. The development of a functional small-diameter vascular graft requires specific material selection, consistent processing methods, and thorough characterization to ensure reproducible mechanical and biological function. Silk fibroin (SF) was selected as a biomaterial due to its favorable biocompatibility and mechanical properties. Because native SF must be extracted and solubilized to form regenerated silk fibroin (rSF) before fabrication, the protocol plays an important role in determining the final material properties. In this study, a modified extraction and solubilization protocol was developed to improve consistency. Dip coating was used to create silk tubes with a similar diameter to vascular grafts. The products of each processing step were characterized, and the properties of the rSF solution were related to the starting material and final tube performance. Mechanical evaluation of the dip-coated tubes, including burst pressure and compliance was conducted. This work emphasizes the importance of protocol consistency and material characterization in the development of reliable silk-based small-diameter vascular grafts.

Oral Presentation

Undergraduate Student

Presentation Number: 207

Presentation Title: Stellar Body Evolutions and Analysis of Carbon Burning in MESA

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Physics

Advisor: Frank Strieder

Physics

Abstract: Stellar nucleosynthesis is the process carried out by stars throughout the universe. A well-known method of nucleosynthesis is nuclear fusion. This fusion allows a star to resist gravitational collapse and continue to evolve while producing the elements that make up our universe. Studying this process grants a deeper understanding of the mechanisms that drive the lifecycles of star. Some stars will experience distinct stages of nucleosynthesis in which they can burn heavier elements depending on the mass and the amount of energy being produced by the current burning phase. Stars in the mass range of around 8 solar masses can reach the carbon burning phase in which the star begins using carbon as its primary fuel source. This has profound implications for the end-of-life result for the star as if the star has enough energy in can lead to a supernova explosion, releasing the material out into to space. The primary goal of the research is to determine the mass range for stable carbon burning in massive stars by measuring the effects of varying the nuclear cross-section of Carbon-12 Carbon-12 reactions. For this project, the open-source computational software known as Modules for Experiments in Stellar Astrophysics (MESA) is utilized. MESA simulates stellar evolution by taking in several adjustable parameters given by the user, such as the mass of the star, composition, and more. In MESA we can produce plots of important characteristics of the star like temperature vs density, or of particular interest to us abundance of material inside the star. The program allows us to save the results numerically and graphically at set intervals. My current task is to study the mass range of carbon burning. Doing this changes energy requirement for the star to reach higher levels of burning and by extension the requirement for the star to go supernovae. As it stands now, we have preliminary results that stand by our current estimated ranges, and we will continue to gather more data.

Oral Presentation

Undergraduate Student

Presentation Number: 208

Presentation Title: Preliminary Exploration of The Equitent Problem for Soap Films with Non-Convex Interiors

Student Name: Connor McCollar
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Physics & Mathematics

Advisor: Dr. Neil Steinburg
Mathematics

Abstract: Equitent problems (where “equitent” refers to both “equal content” and “equal extent”) are a type of geometric optimization problem that seek to find an area minimizing, m -dimensional hypersurface under two joint constraints: (1) the hypersurface encloses a given $m+1$ -dimensional volume; and (2) it spans a given boundary in \mathbb{R}^n , where $n \geq m+1$. The goal of this project is to find solutions to the equitent problem for hypersurfaces with non-convex interiors. Although we consider the equitent problem in any dimension, we put greater emphasis on 2 and 3 dimensional hypersurfaces, since these constitute the possible physically realizable soap-films. We consider a soap film to be physically realizable if it is possible to obtain the appropriate soap-film surface on a wire frame dipped in a soap solution. We develop a general construction for hypersurfaces beginning from regular polytopes (n -dimensional analogs to regular polygons) with circumradii greater than their edge lengths. Included in this construction are all the regular polygons with more than 6 vertices in 2 dimensions, and the dodecahedron in 3 dimensions. We limit the potential starting figures to regular polytopes with circumradii greater than their edge length, since these will always bring about non-convex interior regions through our construction. We attempt to prove that our conjectured hypersurfaces are in fact area-minimizing within their homotopy class using competitor surfaces and the method of metacalibration. We address the advantages and challenges of using the Knothe-Rosenblatt (KR) rearrangement on non-convex interior regions within the proof. This work is motivated almost entirely by earlier research findings in equitent problems from the group of researchers at BYU who originally coined the term “equitent”.

Oral Presentation
Undergraduate Student

Presentation Number: 209

Presentation Title: Fabrication of 2D van der Waals Heterostructure Devices via Dry Transfer Method

Student Name: Hannah Lias
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Advisor: Khimananda Acharya, Tula R. Paudel
Physics

Abstract: Two-dimensional (2D) materials have emerged as a versatile platform for next-generation electronic devices due to their atomically thin nature and the ability to form van der Waals interfaces without lattice-matching constraints. In this work, we assembled a 2D heterostructure and investigated its rectifying behavior. Individual flakes were obtained via mechanical exfoliation and identified by optical microscopy before assembly. We used a pre-defined gold electrode for the fabrication of the device. The heterostructure was constructed using a polymer-assisted dry transfer method, which minimizes contamination and interlayer damage. Electrical transport was characterized using current-voltage (I-V) measurements, which reveal clear diode-like rectification. Overall, we demonstrated a 2D heterostructure device with clear rectifying behavior, showing the potential of van der Waals junctions for electronic applications.

Oral Presentation
Undergraduate Student

Presentation Number: 300

Presentation Title: Inhibiting Migration of Endothelial-Derived Mesenchymal Cells Using a Nanoparticle-Based Photothermal Treatment Impedes Atherosclerosis and Cancer Progression

Student Name: Xin Luo
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Biomedical Engineering

Advisor: Dr. Congzhou Wang
Nanoscience and Biomedical Engineering

Abstract: The migration and invasion of endothelial-derived mesenchymal cells (EMCs) play a crucial role in both atherosclerotic plaque formation and cancer metastasis. However, current strategies aimed at suppressing EMC formation often suffer from poor specificity and undesirable side effects, and few efforts have directly targeted the migratory and invasive behavior of EMCs. In this study, we present a nanoparticle-based strategy to specifically inhibit EMC migration and invasion using cadherin-2 targeted melanin nanoparticles in combination with mild photothermal treatment. Cell migration and invasion assays demonstrate that the synergistic effect of nanoparticle uptake and photothermal treatment effectively impedes EMC motility. Atomic force and super resolution microscopy indicate that this inhibition is associated with disruption of the actin cytoskeleton and consequent morphological alterations. Furthermore, Western blot analyses elucidate the underlying molecular mechanism, showing that cadherin-2 dependent RhoA activation is downregulated by the combined nanoparticle and photothermal treatment, leading to cytoskeletal disorganization. Overall, these in vitro findings serve as a proof-of-concept study for a potential alternative or complementary strategy to attenuate atherosclerotic plaque development and cancer metastasis by targeting the migration and invasion of EMCs from a novel mechanistic perspective.

Poster Presentation
Graduate Student

Presentation Number: 301

Presentation Title: Comparative Analysis of Enzyme Interactions in the Flavonoid Biosynthetic Pathway of Blonde and Blood Oranges

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Chemical and Biological Sciences

Advisor: Dr. Daniel Owens

Chemical and Biological Sciences

Abstract: Flavonoids are the major secondary metabolites in citrus fruits and play fundamental roles in pigmentation, antioxidant activity, and stress responses. Differences between Blonde and Blood oranges depend mainly on differences in the flavonoid biosynthesis pathway and the network of interactions among key enzymes that channel substrates toward colored or non-colored end products. This work focuses on structural and functional differences in the flavonoid biosynthetic pathway of Blonde and Blood oranges, highlighting enzyme–enzyme interactions that are important regulators of metabolic flux. RNA isolation and cDNA synthesis were carried out from the leaf tissues of both Blonde and Blood orange, followed by PCR amplification for major biosynthetic genes, namely CHS, CHI, F3H, FLS, DFR, and ANS. Protein–protein interaction analysis by Y2H assays has been used to assess whether enzymes form metabolons or substrate-channeling complexes impacting flavonoid accumulation patterns. Preliminary results from amplification indicate successful expression of key pathway genes in both varieties, though interaction screening points toward differences in the pairing of downstream enzymes such as DFR and ANS enzymes strongly associated with anthocyanin formation in Blood oranges. Our findings point out that in Blonde and Blood oranges, the variation in the flavonoid profiles may not rely on gene presence alone but rather on dynamic interactions among enzymes that regulate substrate flow toward flavonols or anthocyanins. Understanding these interactions gives insight into the metabolic regulation in citrus and supports future work on improving fruit nutritional quality, pigmentation, and stress tolerance through metabolic engineering.

Poster Presentation

Graduate Student

Presentation Number: 302

Presentation Title: PAN/UiO-66-Amidoxime Composite Sponge for Gallium Recovery

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Department of Chemistry, Biology & Health Sciences

Advisor: Dr. Fan Zheng

Department of Chemistry, Biology & Health Sciences

Abstract: An ultraporous composite membrane was developed by integrating electrospun polyacrylonitrile (PAN) nanofibrous mats with UiO-66-AO, an amidoxime functionalized metal-organic framework (MOF), for high-efficiency gallium recovery.

The electrospun PAN nanofibers provide a macroporous and mechanically robust support, while UiO-66-AO enhances performance through (1) amidoxime groups that selectively bind gallium ions and (2) a high surface area from microporous architecture that improves adsorption capacity and kinetics. A three-dimensional spongy membrane was achieved via freeze-drying after crosslinking of polyvinyl alcohol (PVA) with PAN nanofibrous fragments. Structural and compositional characterization was performed using Fourier Transform Infrared Spectroscopy (FTIR), optical microscopy, scanning electron microscopy (SEM), and X-ray diffraction (XRD). Future work will assess mechanical properties, gallium adsorption efficiency (capacity, selectivity, and kinetics), membrane stability under operational conditions, and regeneration performance over multiple adsorption-desorption cycles.

Poster Presentation

Graduate Student

Presentation Number: 303

Presentation Title: Biomanufacturing Ultra-High Molecular Weight Protein Biomaterial in yeast via Split-intein polymerization

Student Name: Swati Srivastava
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Civil and Environmental Engineering

Advisor: Dr. Saurabh Sudha Dhiman
CBHS/CEE

Abstract: Biomanufacturing of ultra-high molecular weight (UHMW) protein-derived biomaterial remains a defining bottleneck in bio-inspired materials engineering, as conventional prokaryotic systems lack the post-translational modification (PTM) machinery required. While lower eukaryotic systems possess the PTM components, it often fails to assemble monomeric protein chains of various lengths. To overcome these existing challenges in biomanufacturing, we developed a transformative cell expression strategy by deploying split-intein-mediated polymerization into an engineered yeast, i.e., *Pichia sp.* Leveraging *Pichia sp.* inherent PTM machinery and extracellular secretion pathways, we designed a pioneering plasmid construct encoding the UHMW monomeric subunit flanked by de novo designed split-intein pairs. The plasmid construct was computationally validated for its stability and subsequently transformed into the *Pichia sp.* Electrophoresis and Mass Spectrometry approaches have confirmed the expression of the monomeric UHMW protein. Follow-up harvesting of the heterologously expressed UHMW protein has validated ~6-fold increase in its molecular weight, validating at least 6-fold polymerization of the monomeric subunit. The designed research establishes a sustainable Living-Cell Factory leveraging the broad substrate specificity, inherent PTM machinery, and extracellular secretory features of a lower eukaryotic host. The modularity of the designed split-intein framework enables authoritative and tailored polymerization of UHMW biomaterials, positioning it as a highly versatile production paradigm, with direct implications in tissue engineering and self-healing structural bio-composites.

Poster Presentation
Graduate Student

Presentation Number: 304

Presentation Title: PILLAR RECOVERY SCHEDULING WITH BACKFILL CONSTRAINTS FOR VALUE MAXIMIZATION

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Mining Engineering & Management

Advisor: Dr. Andrea Brickey

Mining Engineering & Management Department

Abstract: Underground pillars are commonly left in place due to safety, sequencing, or economic constraints. However, changes in market conditions and backfill practices may create opportunities for their recovery. Traditional production schedules often exclude pillar extraction and do not explicitly account for backfill timing constraints, potentially underestimating the overall economic value of the deposit.

This study evaluates the integration of pillar recovery into underground mine scheduling using an optimization framework that incorporates tonnage, grade/NSR, backfill volume requirements, precedence relationships, and operational constraints. An OPP solver is used to generate production schedules that maximize discounted cash flow while maintaining feasibility under backfill limitations.

The expected outcome is an optimized extraction sequence that identifies economically viable pillars and improves net present value (NPV) compared to conventional scheduling approaches. By explicitly modeling backfill constraints, this research provides a more realistic and value-focused framework for underground production planning.

Poster Presentation

Graduate Student

Presentation Number: 305

Presentation Title: Open-pit production scheduling with autonomous haulage systems: Short to medium-term planning

Student Name: Katekani Maswanganyi
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Mining Engineering and Management

Advisor: Dr. Andrea Brickey
Mining Engineering and Management

Abstract: In an effort to improve occupational safety and efficiency in the mining industry, mining operations are adopting autonomous haulage systems (AHS). This research develops an optimization framework that incorporates long-term production planning with detailed short-term scheduling for AHS in open-pit mines. While long-term planning establishes production targets and fleet capacity, short-term scheduling determines daily truck-shovel assignments under operational constraints. The proposed model incorporates multiple time horizons and time fidelity to evaluate the alignment between shift level scheduling decisions and long-term production objectives. A case study of an open-pit gold mine will be used to test and validate the model. The research aims to assess the impact of integrated multi-horizon scheduling on equipment utilization, production throughput, and project net present value (NPV), thereby contributing to improved decision making in open-pit AHS.

Poster Presentation
Graduate Student

Presentation Number: 306

Presentation Title: Data-Driven Modeling for Power Demand Behavior at Residential Level

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Electrical Engineering and Computer Science

Advisor: Long Zhao

Electrical Engineering and Computer Science

Abstract: In the U.S., residential consumers account for approximately 40% of total electricity consumption, making the residential sector the largest electricity-consuming sector compared to industrial and commercial sectors. This substantial share highlights the critical role households play in shaping overall load patterns.

One of the most significant drivers of residential electricity demand is temperature. Electricity consumption in homes is highly sensitive to temperature variations, primarily due to heating, ventilation, and air-conditioning (HVAC) systems. It is estimated that nearly one-third of residential electricity consumption is attributable to temperature-dependent equipment. As climate variability intensifies and extreme weather events become more frequent, this temperature sensitivity is expected to become even more pronounced.

In this context, our research focuses on developing a data-driven model to characterize household-level electricity demand using advanced data mining and machine learning techniques. The central objective is to model residential power demand as a function of time and temperature—two of the most influential determinants of electricity usage. To accurately capture these dynamics, we are developing a Temperature-Time-Day (TTD) model that quantifies and integrates the combined effects of temporal and meteorological variables on residential electricity demand. As part of this framework, we first constructed a model to quantify the impact of temperature on household consumption.

Building upon these findings, we apply clustering techniques to group residential consumers based on their temperature responsiveness and usage patterns. The goal of clustering is to identify segments of consumers with similar characteristics—for example, households that exhibit strong winter heating loads or those highly sensitive to summer cooling demand. By distinguishing these behavioral patterns, the model enables more targeted and insightful analysis.

Poster Presentation

Graduate Student

Presentation Number: 307

Presentation Title: Sustainable Management and Treatment of Mine Wastewater: A Review of Water Sources and Applications

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Advisor: Dr. Andrea Brickey
Mining Engineering and Management

Abstract: Water is a necessary resource for humans, ecosystems, and industrial operations, e.g., mining. In the mining sector, water plays a pivotal role and influences every phase of a mine's operation, from exploration to reclamation, requiring a focus on water quality and environmental sustainability. With the growing need for water globally, focus has been placed on adopting more sustainable mining practices that emphasize effective water management, treatment, and reuse of mine wastewater. This research evaluates conventional and advanced treatment technologies, demonstrating that the selection of an effective treatment method is based on understanding mine water sources, flows, chemistry, and usage. This paper also reviews global case studies of mines that faced severe water-related challenges and discusses lessons learned. Based on this review, a framework is developed that provides guidance to engineers regarding best practices for unique situations related to mine site hydrology. Furthermore, this framework will provide an early-stage evaluation to minimize future financial and environmental risks.

Poster Presentation
Graduate Student

Presentation Number: 308

Withdrawn

Presentation Number: 309

Presentation Title: A Microfluidics Device for Labelling and Washing Cells

Student Name: Samuel Clark Van Osdel

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Biomedical Engineering

Advisor: Dr. Brandon Scott

Biomedical Engineering

Abstract: Microfluidic devices use microscale channel geometries to manipulate fluids and suspended particles. Our lab is developing a spiral microfluidic device for on-chip cell sorting designed to autonomously label and wash cells, reducing preparation time from hours to minutes and increasing throughput.

Spiral microchannels generate three primary forces on suspended cells: Dean drag, shear lift, and wall lift. The balance of these forces drives cells from an initially random distribution into focused bands at specific cross-sectional positions. Band location and width depend on channel dimensions, flow rate, and cell diameter. Adjusting these parameters alters the force balance, enabling size-based separation as differently sized particles focus at distinct positions.

This size-dependent focusing phenomenon is well documented and forms the foundation of our approach. Because microfluidic systems operate in the laminar flow regime, streamlines do not mix. By combining inertial focusing with laminar flow, our objective is to transfer cells between streamlines within the device to enable washing and labeling on-chip.

This presentation will outline the design methodology of our current device iteration, including the geometric rationale supported by literature, and describe our development pipeline: modeling, simulation, and experimental validation. I will also discuss the custom fluid control system we developed, along with current progress and future directions.

Poster Presentation

Graduate Student

Presentation Number: 310

Presentation Title: Temporal Dynamics of PI3P During Macropinosome Formation in Fetal Liver Macrophages

Student Name: Peng Yin
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Advisor: Brandon Scott (PhD)
NANO & BME

Abstract: Macropinocytosis is a crucial endocytic process by which macrophages internalize large volumes of extracellular fluid. Phosphatidylinositol 3-phosphate (PI3P) is known to regulate macropinosome fusion with early endocytic organelles and accumulate on mature macropinosome. However, the precise temporal recruitment of PI3P during the early stages of macropinosome formation, specifically during cup formation, remains unclear. Using oblique plane microscopy (OPM) to achieve high spatiotemporal resolution, we investigated whether PI3P, visualized with the 2xFYVE-mScarlet fluorescent probe, is present during cup formation before macropinosome closure in fetal liver macrophages. Fetal liver macrophages represent an important developmental macrophage population that performs constitutive macropinocytosis. Our preliminary time-lapse imaging of the initial cohort of cells revealed that mScarlet signal was absent during the membrane ruffling and cup formation stages in the macropinocytosis events observed thus far. These initial findings suggest the possibility that PI3P recruitment may occur post-closure as part of macropinosome maturation rather than during the initial cup formation phase. However, these results represent early observations from a limited sample set. To establish statistical significance and confirm this temporal pattern, we are continuing to image additional fetal liver macrophages to expand our dataset. Further analysis of a larger cell population will be necessary to definitively determine whether PI3P is consistently absent during cup formation or whether temporal variations exist across different macropinocytosis events and individual cells. This ongoing work aims to provide comprehensive insights into the spatiotemporal coordination of lipid signaling during macropinocytosis in developmentally relevant macrophage populations.

Poster Presentation
Graduate Student

Presentation Number: 311

Presentation Title: Exploration of Magnesium Diboride Pyrotechnic Formulations for the Decomposition of Chemical Warfare Agents

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CBE

Advisor: Dr. Lori Groven
CBE

Abstract: The decomposition of chemical warfare agents (CWAs) remains a critical challenge. Diisopropyl methyl phosphite (DIMP) is widely used as a non-toxic surrogate to model the behavior and degradation pathways of organophosphonate nerve agents. Magnesium oxide (MgO) has demonstrated strong efficacy in decomposing both vapor and liquid phase DIMP and exhibits high adsorption for a variety of CWA stimulants. However, conventional MgO synthesis routes are often energy intensive, time consuming or limited in scalability. This study explores an alternative production pathway for reactive MgO via the combustion of magnesium diboride pyrotechnic formulations. Oxidizer systems were systematically varied to evaluate their effects on combustion behavior, oxide yield, and product characteristics. Formulations were optimized to promote complete combustion and the formation of high-surface-area, nanoscale MgO. The resulting materials were characterized to assess phase composition and catalytic performance toward DIMP degradation.

Poster Presentation
Graduate Student

Presentation Number: 312

Presentation Title: Thermophilic Nitrogen-Fixing Cyanobacteria from Yellowstone National Park as a Platform for Sustainable Biohydrogen Production

Student Name: Ishika Garg

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Chemical and Biological Engineering

Advisor: Dr. Rajesh Sani

Chemical and Biological Engineering

Abstract: Modern agriculture depends on nitrogen, yet producing over 180 million metric tons of synthetic fertilizer each year is energy-intensive and a significant source of greenhouse gas emissions. Biological nitrogen fixation offers a sustainable alternative that generates hydrogen as a natural byproduct, but thermophilic systems and thermostable cyanobacterial nitrogenases remain largely unexplored. This study focuses on isolating thermophilic nitrogen-fixing cyanobacteria from geothermal environments in Yellowstone National Park. We hypothesize that cyanobacteria adapted to elevated temperatures (60-73°C) exhibit enhanced nitrogenase stability and sustained metabolic activity, enabling efficient nitrogen fixation coupled with hydrogen evolution under thermophilic conditions. Enrichment and isolation were conducted at 60°C, 65°C, and 73°C to target high-temperature adapted strains. Sustained growth was established at elevated temperatures, and isolates were verified for purity using light microscopy. Media composition was refined using geochemical modeling with MINTEQ to better simulate thermal spring chemistry and support thermophilic growth. Inductively Coupled Plasma Mass Spectrometry (ICPMS) characterized trace metals relevant to nitrogenase cofactors. In parallel, metagenomic sequencing of Yellowstone samples was performed to assess microbial community composition and identify potential nitrogen-fixing cyanobacteria; these data are currently under analysis. These findings establish progress toward thermophilic biological nitrogen fixation linked to biohydrogen production. Future work will include nif gene analysis, functional validation of nitrogen fixation and hydrogen evolution, optimization of nitrogenase activity, and characterization of thermostable systems. We are also developing CyanoVault, a curated repository to catalog and preserve thermophilic cyanobacterial isolates for the extremophile research community.

Poster Presentation

Graduate Student

Presentation Number: 313

Presentation Title: Expanding the Culture Inventory of Thermophilic Diazotrophic Cyanobacteria from Yellowstone Geothermal Springs

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Advisor: Dr. Tanvi Govil
Chemical and Biological Engineering Department

Abstract: Biological nitrogen fixation sustains global nutrient cycling, yet its operation under sustained thermal stress remains poorly understood. Nitrogenase is an oxygen-sensitive, energy-intensive enzyme that converts atmospheric nitrogen into biologically usable forms. While mesophilic diazotrophs are well studied, thermophilic nitrogen-fixing cyanobacteria are rarely cultured, limiting insight into nitrogen fixation at high temperatures. Understanding this metabolism at elevated temperatures is increasingly important as engineered biological systems move toward more robust, high-temperature operation to improve stability, kinetics, and contamination resistance. To address this limitation, we investigated cyanobacterial communities from four geochemically distinct geothermal springs in Yellowstone National Park: Mushroom Pool, Five Sisters, White Creek, and Octopus Spring. Site characterization using ion chromatography, inductively coupled plasma mass spectrometry, and total organic/inorganic carbon analysis defined physicochemical conditions associated with thermophilic phototrophic growth. Guided by these profiles, selective nitrogen-depleted enrichments were established at 45°C and 55°C to suppress mesophilic competitors and promote thermophilic diazotrophs. This approach recovered stable thermophilic phototrophic consortia and filamentous, heterocyst-forming isolates consistent with aerobic nitrogen fixation. Distinct morphotypes from different springs indicate site-specific adaptation and underexplored thermophilic diversity. Ongoing 16S rRNA gene sequencing and physiological characterization will link isolate identity to geochemical origin and evaluate nitrogen-fixing capability. By converting geothermal microbial diversity into laboratory-stable strains, this work establishes a reproducible framework for studying nitrogen fixation under thermal stress and expands the resource base for high-temperature biological systems research.

Poster Presentation
Graduate Student

Presentation Number: 314

Presentation Title: Sub-Layer Engineering of Multifunctional Composites for Superior Impact and Ballistic Performance

Student Name: Palash Kumar Saha

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Nanoscience and Biomedical Engineering Department

Advisor: Dr David R Salem

Nanoscience and Biomedical Engineering Department

Abstract: The provision of lightweight building materials with significant thermal insulation performance, structural load bearing properties, and protective shielding of occupants from high energy impacts is a prerequisite to sustain critical defense facilities in remote, cold regions. Composite materials, particularly multi-layered composites combined with syntactic foam, offer a promising solution to address these multifunctional needs. Based on an impact/blast tuning concept, Adewole, a former researcher in our group, developed a multilayer composite, later refined by Olowonigba in our group, that efficiently absorbs 1000 J energy impacts (using a 2-inch hemispherical projectile) and provides good thermal insulation properties. While this impact performance is impressive for a low density ($< 1\text{g/cm}^3$) material, there is strong interest in increasing the impact resistance of these multilayer composites (Structural Thermal Insulation and Impact Resistant Composite (STIIRC) panels) still further, since at impact energies higher than 1000 J, they have been shown to be susceptible to delamination at a critical interface. To mitigate this limitation, the present study introduces sublayer engineering, especially involving the incorporation and systematic reconfiguration of ballistic fabrics in the structural panels. The effects of these different layup configurations on the impact response of the panels at different impact energy levels was investigated. The impact results show a promising reduction in delamination and back-face deflection when the layer sequence is optimized, substantially enhancing the impact and ballistic resistance of the panels. This study reports on the fabrication of these structurally engineered composites and demonstrates the elimination of delamination and other failure at impact energies up to at least 1400 J using a 2-inch diameter hemispherical impactor head and up to 1300 J using a $\frac{1}{2}$ inch diameter hemispherical impactor head.

Poster Presentation

Graduate Student

Presentation Number: 315

Presentation Title: A Comparative Analysis of ECOSTRESS Daily Evapotranspiration Estimates and AmeriFlux Eddy Covariance Tower Measurements

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Advisor: Dr. Edson Costa Filho
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Abstract: Evapotranspiration (ET) is a key component in water resource management which helps quantify land-atmosphere energy and water interactions. Remote sensing-based ET products provide spatially continuous coverage but need validation to assess their accuracy at the site scale. This study aims to analyze the accuracy of NASA's ECOSTRESS (ECOSystem Spaceborne Thermal Radiometer Experiment on Space Station) daily satellite ET predictions against AmeriFlux ET measurements in forested ecosystems from 2019-2024. Data analysis included four AmeriFlux sites with different vegetation types and environmental constraints. Data availability varied due to the daytime available data. The application of a 2D footprint model provided spatially averaged values of ECOSTRESS ET to compare to the AmeriFlux daily ET from energy flux towers that use the Eddy Covariance (EC) approach to indirectly measure ET. Turbulent heat flux data measurements did not have any adjustment for energy balance closure. Preliminary results indicate that ECOSTRESS daily ET products ranged by -0.30 ± 1.09 mm d⁻¹ (MBE \pm RMSE), a clear underestimation of ET by approximately 22% when assessing the combined data from all sites. Site US_xRM provided the lowest normalized RMSE (± 18 %), whereas site US_xWR provided the highest RMSE (± 110 %). Overall, this satellite-based ET prediction showed an acceptable agreement with the flux tower-measured ET over forested ecosystems.

Poster Presentation
Graduate Student

Presentation Number: 316

Presentation Title: Generation and Characterization of a Radially Polarized Beam

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Nanoscience and Nanoengineering

Advisor: Dr Steve Smith

Nanoscience and Nanoengineering

Abstract: Radially polarized vector beams generate a strong longitudinal electric-field component under tight focusing, which can enhance surface-sensitive nonlinear signals such as second-harmonic generation (SHG). This makes them promising for tip-enhanced SHG and femtosecond scanning-probe microscopy. We generate and characterize a radially polarized femtosecond beam from a Ti:Sapphire laser operating near 810 nm. Following established liquid-crystal q-plate approaches for vector-beam generation, a linearly polarized Gaussian beam is converted to circular polarization and then passed through a q-plate adjusted to operate near half-wave retardance at the laser wavelength. The resulting output is expected to display an annular (donut-like) intensity distribution consistent with a first-order cylindrical vector mode. To verify the radial polarization state, an analyzer-angle-resolved beam imaging system using a rotating linear polarizer results in a two-lobe pattern. From this rotating-polarizer image series, we quantify (i) the polarizer-angle-dependent transmitted power modulation and (ii) the dark-bar visibility between the lobes as the analyzer rotates, and compare these metrics to the ideal versus imperfect radial polarization in Ma and Wu's model. The resulting radially polarized excitation will serve as a validated input for subsequent femtosecond scanning probe experiments, where ultrafast excitation is localized by a nanoscale probe to access sub-diffraction spatial information. Such an approach is broadly relevant for mapping nanoscale optical nonlinearities and local symmetry breaking in 2D materials, hotspot-driven responses in metamaterials, and label-free contrast mechanisms in bioimaging.

Poster Presentation

Graduate Student

Presentation Number: 317

Presentation Title: Spectrally-resolved Polarization-resolved Multiphoton Luminescence and Second Harmonic Imaging in Low-dimensional Materials

Student Name: Arik Ahmed

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Nanoscience and Biomedical Engineering

Advisor: Steve Smith

Nanoscience and Biomedical Engineering

Abstract: Quantum entanglement is a phenomenon where multiple particles possess features (e.g. position, momentum, polarization, etc.) that remain correlated even across large distances. Entangled photon pairs can be used in applications such as quantum cryptography and quantum computing. Second-order nonlinear susceptibility is an important materials property for the generation of entangled photon pairs, which can be notably enhanced in low-dimensional materials. A spectrally-resolved multi-photon induced luminescence (MPL) and second harmonic generation (SHG) imaging system, based on a closed loop piezoelectric stage, a transmission grating and an EMCCD is used to examine the nonlinear optical properties of low-dimensional materials. We visualize the spectrally-resolved MPL (luminescence) and SHG in the two-dimensional (2D) material WSe₂ along with angularly resolved SHG spectroscopy. We also perform similar measurements for In₂Se₃, CuCrP₂S₆, and heterostructures of WSe₂/hBN.

Poster Presentation

Graduate Student

Presentation Number: 318

Presentation Title: BTNN: Bayesian Temporal Neural Network

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Advisor: Dr. Randy Hoover

Computer Science

Abstract: Many real-world time series problems encounter change in the incoming data, whether that be degrading sensors or changes in the data being collected. The work in this poster attempts to solve the case where this change in incoming data happens at a constant and continuous rate. Simulated data was created in the form of binary classification in order to test the capabilities of the Bayesian Temporal Neural Network (BTNN). The BTNN enforces a Gaussian Process on a set of neural network parameters over time, allowing for smooth updates. To reduce memory and time complexity, two techniques were enforced and tested: A transportation matrix to transport a smaller network to the original larger network architecture, Linear Interpolation across time of the model parameters. Each method was tested with respect to accuracy and computation time, providing a solid foundation to expand to more complicated model architectures and data sets.

Poster Presentation

Graduate Student

Presentation Number: 319

Presentation Title: Emerging Trends in Optical Borehole Imaging: 3D Visualization, AI Integration, and Future Directions

Student Name: Millicent Oppong
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Mining Engineering

Advisor: Rudrajit Mitra
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Abstract: Borehole imaging helps visualize underground conditions and geological features that affect the strength and safety of underground excavations. Recent technological advancements have significantly improved camera resolution, borehole coverage, and data interpretability. This study discusses the ability of modern optical imaging systems to generate detailed three-dimensional representations of borehole walls and how the integration of artificial intelligence for feature extraction has enhanced conventional optical borehole imaging devices. Emphasis is placed on new developments such as improvements in key components of the imaging tool, automatic feature detection, and multi-source data integration which collectively enhances predictive capabilities and decision making. Challenges such as identifying geologic rock types that play an important role in fracture development are examined alongside future research directions.

Poster Presentation
Graduate Student

Presentation Number: 320

Presentation Title: Novel Actinomycetes from Pine Ridge: Functional Insights for Sustainable Agriculture and Biotechnology

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Advisor: Dr. Ram Nageena Singh[1], Dr. Rajesh K. Sani [1,2]
1. CBE, 2. CBHS

Abstract: Soil is a rich source of microbial diversity, hosting a diverse group of bacteria, fungi, and actinomycetes that play critical roles in nutrient cycling and ecosystem functioning. Actinomycetes are a very important microbial group in the soil and contribute to soil nutrition, helping plants to combat pathogens. They are filamentous Gram-positive bacteria known for producing bioactive secondary metabolites and extracellular enzymes with applications in agriculture, industry, and medicine. To date, no published studies have specifically reported the isolation and characterization of actinomycetes from soils of the Pine Ridge Reservation, highlighting the untapped potential of this region as a source of novel microbial diversity and bioactive metabolites. This study aims to isolate, identify, and characterize bacteria and actinomycetes from Hemp rhizosphere soil samples to explore their potential for agricultural and biotechnological use. Soil dilution and spread plate techniques were applied to isolate the microbes. A total of 38 distinct microbial isolates were obtained by culturing on Nutrient Agar and Actinomycetes Agar and purified through re-streaking. Their morphological characteristics exhibited notable variation. Out of 38 isolates, 23 were creamy, 8 yellow, 5 white, 1 blue, and 1 pink, indicating diverse pigmented bacterial communities. These isolates have diverse colony sizes, including 9 large, 14 medium, 11 small, and 6 tiny colonies, indicating significant morphological diversity. Isolates are currently being identified using 16S rRNA gene sequencing and NCBI BLASTn analysis. The study characterizes these bacteria, specifically actinomycetes, for agricultural traits such as enzymatic activity, siderophore biosynthesis, and antibiotic sensitivity. By exploring these functional traits, the research aims to identify strains with high potential for enhancing soil health, agricultural productivity, and biotechnological innovation.

Poster Presentation
Graduate Student

Presentation Number: 321

Presentation Title: Ejector Effect-Induced Flow Dynamic Characterization within Semi-Enclosed Jet Engine Testing Cells

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Mechanical Engineering

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Abstract: A computational study with analytical validations was conducted to analyze flow relations surrounding the process of the ejector effect. The ejector effect is a phenomenon where a high velocity core mass flow exhausts from a nozzle into an exhaust duct or mixing chamber, entraining surrounding ambient fluid. Four main flow cases are presented to be investigated within the computational study, each of which systematically increases in complexity. The cases all have the same domain, with a colinear nozzle and exhaust duct. To increase complexity, boundary conditions are changed. Starting from a fully freestream condition, then changing the vertical boundaries to no-slip walls and finally changing the wall aft the exhaust duct to form the semi-enclosed testing cell. The intermediate tests are currently ongoing. Through computational analysis and analytical relation of the nozzle plumes, it is observed that the half-value width (vertical location of the plume where the velocity is half of the axial velocity) is an important parameter, as if the exhaust duct is set to be between the half width diameter and twice the half width diameter, the nozzle exhaust will be effectively ventilated from the testing cell.

Poster Presentation
Graduate Student

Presentation Number: 322

Presentation Title: Non-Destructive Thickness Mapping of 2D Nanosheets Using Optical Microscopy

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Advisor: Dr. Steve Smith

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Abstract: Identification of thickness (layer number) in two-dimensional (2D) materials is essential for understanding their thickness-dependent optical and electronic properties. In this work, we demonstrate a rapid and non-destructive method for determining nanosheet (few atomic layers) thickness using conventional optical microscopy. Optical transmittance value of the thin films containing assorted nanostructures of MoS₂ (revealed by SEM studies) was obtained from optical microscope images taken under white light and laser illumination. The relationship between the reflected light intensity from the substrate and the pixel intensities of the flake images are exploited to establish an approximate correspondence between average pixel intensity and the optical transmittance of the material. We establish a quantitative correlation between optical intensity variation and the layer number of mechanically exfoliated WSe₂ nanosheets. The statistical analysis of regional intensity distribution offers a reliable and rapid identification of mono, few and multi layered 2D materials in future.

Key words: 2D materials, TMDs, Optical transmittance.

Poster Presentation

Graduate Student

Presentation Number: 323

Presentation Title: Integrating Two-Dimensional Materials with Optical Metasurfaces for Nanoscale Control of Quantum Light

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Advisor: Steve Smith
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Abstract: Scaling quantum photonic technologies requires compact, efficient light sources capable of producing single or correlated photons on demand. While quantum dots and color centers demonstrate strong performance, they often require cryogenic operation and complex fabrication that limits scalability. Two-dimensional materials offer an alternative platform, hosting optically active defect centers capable of stable single-photon emission at room temperature. Hexagonal boron nitride has emerged as a promising host due to its robust defect-based emitters and compatibility with layered heterostructures [1,2].

Metasurfaces are planar arrays of subwavelength resonators that engineer light–matter interactions by tailoring local electromagnetic fields, phase response, and emission directionality [3]. Integrating two-dimensional quantum emitters with resonant metasurface geometries provides a pathway to enhance spontaneous emission rates, improve photon extraction efficiency, and enable compact on-chip quantum light sources [4].

This work investigates hybrid platforms combining layered two-dimensional materials with lithographically defined gold metasurface structures. Finite-difference time-domain simulations model dipole–resonator interactions and optimize asymmetric rectangular geometries for enhanced Purcell factors and directional emission. In parallel, thermal scanning probe lithography using a NanoFrazor system fabricates subwavelength gold asymmetric rectangles on dielectric substrates, enabling rapid prototyping without conventional electron-beam lithography.

These metasurfaces serve as a testbed for studying how engineered resonances modify the local photonic density of states and emission behavior of nearby quantum emitters. By combining electromagnetic modeling with accessible nanofabrication workflows, this project aims to establish scalable design principles for room-temperature quantum light sources integrated within planar nanophotonic systems.

Poster Presentation
Graduate Student

Presentation Number: 324

Presentation Title: Integrating Physics-Based Simulation and Machine Learning for Germanium Detectors in Medical Imaging

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Advisor: Dr. Matthias Plum
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Abstract: High-purity germanium (HPGe) detectors provide superior energy resolution compared to conventional scintillation detectors, offering strong potential for high-precision gamma-ray medical imaging. This project investigates the integration of machine learning techniques with physics-based detector modeling to improve event reconstruction and interaction localization in germanium-based imaging systems.

Synthetic datasets are generated using detailed simulations of gamma-ray interactions and charge transport within the detector volume. Supervised neural network architectures are being developed to perform event reconstruction. Model performance will be evaluated using simulated cancer phantoms representing heterogeneous tumor geometries embedded in tissue-equivalent media.

This ongoing work aims to establish a framework that combines advanced detector physics with synthetic data-driven algorithms to enhance tumor detectability and quantitative imaging accuracy in next-generation gamma-ray imaging systems.

Poster Presentation
Graduate Student

Presentation Number: 325

Presentation Title: Quantitative Comparison of Phagocytosis and Trogocytosis Using Undifferentiated and Differentiated HL60 Targets

Student Name: Oleksandra Rachynska
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Biomedical Engineering (BME)

Advisor: Brandon Scott
Biomedical Engineering (BME)

Abstract: Phagocytosis is the process by which a cell engulfs an external target into an intracellular phagosome. Macrophages are professional phagocytes that use this pathway to capture and clear targets, but their interactions do not always lead to full engulfment. In some cases, macrophages nibble membrane from a target without internalizing the entire cell, a process known as trogocytosis. Trogocytosis leaves the target only partially removed, allowing continued survival and representing incomplete clearance rather than full elimination.

Our hypothesis is that target-cell behavior, particularly actin-dependent motility, shifts macrophage–target interactions toward trogocytosis instead of complete engulfment. We used HL60 cells as a target model and examined macrophage interactions with undifferentiated and DMSO-differentiated HL60s across multiple differentiation stages. Target cells were labeled using a biotin/antibiotin strategy to enable standardized recognition and visualization.

To regulate actin-dependent behavior, we used cytoskeleton-targeting drugs: a three-drug JLY cocktail (Jasplakinolide, Latrunculin B, and Y-27632) or Latrunculin B alone. We performed the assay in a multi-well format by adding labeled targets to plated macrophages and imaging interactions using automated time-lapse microscopy on an ImageXpress system. From the movies, we quantified target motility and classified macrophage–target interactions as complete engulfment versus trogocytosis using event-based criteria.

We also used Lattice Light-Sheet Microscopy (LLSM) to acquire high-resolution 3D time-lapse movies of macrophage–HL60 interactions, capturing both full engulfment and trogocytosis across HL60 differentiation stages. Using this combined workflow, we evaluated HL60 uptake outcomes across differentiation and cytoskeleton drug conditions and tested whether more motile targets are more likely to undergo trogocytosis rather than full engulfment.

Poster Presentation
Graduate Student

Presentation Number: 326

Presentation Title: Ferroelectric Control of Spin Filtering in a Multiferroic CuCrP2S6 Tunnel Junction

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Advisor: Tula R. Paudel
Physics

Abstract: CuCrP2S6 (CCPS), a van der Waals multiferroic material, offers a promising platform for electrically controlled spin-filter tunnel junctions by combining switchable electric polarization and layered magnetism within a single barrier. Here, using density functional theory combined with nonequilibrium Green's-function calculations, we investigate spin-dependent transport in an Au/CCPS/Au junction and demonstrate non-volatile electric control of spin-dependent tunneling via polarization-induced modulation of the tunneling barrier. The antiferroelectric phase of CCPS supports highly efficient spin filtering, yielding nearly 100% spin polarization and a giant tunneling magnetoresistance (TMR) of approximately 3100%. In contrast, in the ferroelectric phase, polarization-driven interfacial charge transfer reduces the spin asymmetry of the barrier, lowering the spin polarization to ~67% and suppressing the TMR to ~48%. Momentum-resolved transmission and complex-band analyses reveal that this reduction originates from competing spin-dependent evanescent states across the two-dimensional Brillouin zone. Calculated current-voltage characteristics exhibit distinct, experimentally accessible signatures of polarization-controlled spin filtering, establishing CCPS as a compelling platform for electrically tunable spintronic devices.

Poster Presentation
Graduate Student

Presentation Number: 327

Presentation Title: The Mechanobiology of Diabetic Fibropathy: Regulation of Fibroblast Force Generation by Matrix Stiffness

Student Name: Amelia Huffer
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Advisor: Dr. Brandon Scott
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Abstract: Cellular function and morphology are heavily influenced by the mechanical properties of the extracellular matrix (ECM). Fibroblasts typically adopt an activated myofibroblast phenotype characterized by increased contractility and stress fiber formation on stiffer substrates. This mechanosensitive behavior is often dysregulated in diabetic fibroblasts, contributing to impaired wound healing. We hypothesize that substrate stiffness directly modulates fibroblast contractile forces, and that softening the substrate may restore normal contractility in diabetic cells. To test this, we will quantify traction forces in healthy and diabetic fibroblasts cultured on hyaluronic acid (HA)-coated polydimethylsiloxane (PDMS) surfaces of varying stiffnesses. To enable high-resolution imaging on an oblique plane microscope, the PDMS substrates will be spin-coated to a thickness of approximately 10 μm . Fluorescent beads embedded within the substrate will be used to track deformation fields and calculate traction stress via Traction Force Microscopy (TFM). We anticipate that diabetic fibroblasts will exhibit altered contractile profiles compared to healthy controls on stiff substrates. Furthermore, we expect that reducing substrate stiffness will decrease excessive contractile forces in diabetic fibroblasts, suggesting a potential therapeutic strategy to improve wound contraction and closure in diabetic patients.

Poster Presentation
Graduate Student

Presentation Number: 328

Presentation Title: Sustainable EPS Production from Corn Stover Using Thermophilic Bacterium Integrating Lignocellulose Bioconversion with Applications

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Department of Chemical and Biological Health Sciences

Advisor: Dr. Rajesh Sani

Chemical and Biological Engineering

Abstract: Microbial exopolysaccharides (EPS) hold significant promise as precursors for nanogel-based biomaterials; however, metabolic bottlenecks and the high cost associated with lignocellulosic biomass pretreatment continue to limit their industrial-scale production. This study evaluates the capacity of a thermophilic bacterium to produce EPS directly from untreated corn stover (0.5% w/v) as a renewable lignocellulosic substrate, bypassing conventional pretreatment requirements. Bioprocess scale-up was conducted in a 30 L bioreactor at Dakota BioWorx to establish scalable production conditions. Growth kinetics were monitored through quantification of total sugar, reducing sugar, and protein concentrations to track carbon release and its metabolic redistribution towards EPS biosynthesis. Structural characterization of the extracted EPS was performed using atomic force microscopy (AFM), Fourier-transform infrared spectroscopy (FTIR), and Brunauer–Emmett–Teller (BET) analysis. A further investigation was conducted to establish the link between substrate depolymerization and polymer biosynthesis through daily assessment of lignocellulosic degradation efficiency at bench-scale reactors. Collectively, these findings establish an initial framework supporting the development of a scalable waste-to-biopolymer such as nanogel-based biomaterials, platform by positively connecting the EPS biosynthesis with both lignocellulosic depolymerization and metabolic flux dynamics.

Poster Presentation

Graduate Student

Presentation Number: 329

Presentation Title: Palladium Tetrahedral Nanoparticles' Synthesis

Student Name: Junming Yue

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NANO&BME

Advisor: Dr. Shan Zhou

NANO&BME

Abstract: The controlled synthesis of nanoparticles remains a critical area in materials science and nanotechnology. Here, I am presenting our recent effort focusing on the precision synthesis of palladium (Pd) nanoparticles with tailored size, shape, and high structural uniformity, aimed at their potential use as building blocks for assembling long-range ordered structures with promising catalytic applications. To achieve this, we systematically investigate and optimize synthetic parameters critical to producing nanoparticles with the desired size and shape uniformity. Comprehensive characterization, including Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM), is employed to elucidate their morphological and structural properties. By uncovering the mechanisms that drive nanoparticle synthesis and self-assembly, this work aims to advance the rational design and scalable development of next-generation functional nanomaterials.

Poster Presentation

Graduate Student

Presentation Number: 330

Presentation Title: Numerical Analysis of Long-Term Stability of Planned New Excavations at SURF

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Advisor: Dr. Zhi Ye
Geology and Geological Engineering

Abstract: The Sanford Underground Research Facility (SURF) plans the construction of new underground excavations at the 4,850-ft level to expand research capacity. This study presents a three-dimensional numerical investigation of the planned tunnel system using a hybrid Discrete Fracture Network–Finite Element Method (DFN-FEM) modeling framework. The primary objective is to evaluate the mechanical influence of explicitly represented fracture networks on excavation response. A conventional continuum FEM model is developed and compared directly with a DFN-FEM model incorporating stochastically generated fracture sets within the rock mass. Displacement magnitudes and distributions at critical tunnel locations, including the roof and sidewalls, are quantified to assess differences in deformation behavior. In addition, excavation interaction effects are examined by comparing single-tunnel and twin-tunnel configurations under identical in-situ stress conditions. Results demonstrate that explicit fracture representation modifies local stress redistribution and displacement concentrations in the surrounding rock mass. The study establishes a structured numerical workflow for integrating DFN concepts into large-scale FEM analyses of deep underground excavations.

Poster Presentation
Graduate Student

Presentation Number: 331

Presentation Title: Evaluating and Refining Hands-On Systems Thinking and Systems Engineering Activities in Mechanical Engineering Courses

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Dr. Micah Lande, Dr. Cassandra Birrenkott

Leslie A. Rose Department of Mechanical Engineering

Abstract: Engineering programs often emphasize technical analysis in early coursework, while systems thinking (ST) and systems engineering (SE) are introduced later. As a result, students have limited opportunities to develop systems-oriented reasoning when first encountering authentic engineering problems. To address this gap, this multi-institutional project integrates and evaluates hands-on activities that introduce ST and SE principles in first-year mechanical engineering courses across three universities.

The instructional model follows a flipped approach in which students complete online modules before class and engage in structured, collaborative activities during class. This paper focuses on the refinement and evaluation of several one-hour activities designed to reinforce core ST/SE concepts through analysis, stakeholder reasoning, teamwork, iteration, and design trade-offs. A fourth activity is under development to extend these objectives through rapid prototyping and mission-driven, solution-neutral design.

Recent refinements account for differences in classroom settings and resources across institutions. Updated materials include clearer prompts, standardized assessments, and embedded reflection questions to better align hands-on experiences with targeted ST/SE learning outcomes. Effectiveness is evaluated using a mixed-methods approach, analyzing student surveys, open-ended feedback, instructor reflections, and assessment artifacts from Fall 2024 through Fall 2025 implementations.

Results indicate that students consistently perceive the activities as engaging and valuable for learning systems concepts. Instructor feedback highlights the importance of facilitation, pacing, and scaffolding to support abstraction and systems-level reasoning. These findings inform ongoing refinement and provide practical guidance for integrating ST and SE concepts into early engineering coursework.

Poster Presentation

Graduate Student

Presentation Number: 332

Withdrawn

Presentation Number: 333

Presentation Title: Simulation Studies of a High-Purity Germanium-Based Gamma Imaging Detector (GeGI) for Nuclear and Medical Applications

Student Name: Noomen Belmechri
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Physics

Advisor: Juergen Reichenbacher
Physics

Abstract: High-purity germanium (HPGe) detectors provide excellent gamma-spectroscopic energy resolution and are promising candidates for advanced gamma-ray imaging systems. As part of the Germanium-based Science and Technology Advancement Research (Ge-STAR) initiative, the GeGI detector has recently been acquired at SD Mines to investigate its potential as a Compton imaging detector. In this work, Geant4 simulations are being developed to model the GeGI detector geometry and study gamma-ray interactions within the system. These simulations allow investigation of separate interaction mechanisms such as Compton scattering and photoelectric absorption and thus can provide insight into expected multistrip detector response, energy deposition spectra, and imaging capabilities for gamma-radiation and medical samples. The simulation framework will inform future experimental measurements using the GeGI detector. Ultimately, these studies guide the long-term goal of the Ge-STAR collaboration to design and optimize next-generation germanium strip detectors for gamma-ray imaging and nuclear radiation detection and medical applications.

Poster Presentation
Graduate Student

Presentation Number: 334

Presentation Title: Electromagnetic Characterization of a Novel Metal Tetrahedral Nanostructure: Insights into Chiroptical Properties and Polarization Sensitivity

Student Name: Md Kausar Hamid Miji

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Nanoscience & Nanoengineering

Advisor: Dr. Robert Anderson

Nanoscience and Biomedical Engineering

Abstract: The plasmonic behavior of nanoparticles (NPs) has been studied extensively and adopted widely across diverse fields, including physics, engineering, and biotechnology. Current research increasingly focuses on the design of sophisticated 0D to 3D plasmonic building blocks to unlock novel material properties. This work investigates the electromagnetic properties of tetrahedral bipyramidal noble metal nanoparticles using the Finite Difference Time-Domain (FDTD) technique to simulate their response. These geometrically distinct materials hold significant potential for advancing quantum information processing and quantum sensing. Future work will include characterization of the chiral response and polarization sensitivity of engineered layers comprising these bipyramidal novel 2D materials and experimental validation against physical samples of fabricated plasmonic materials.

Poster Presentation

Graduate Student

Presentation Number: 335

Presentation Title: Promising Equation of State Models for High-Pressure High-Temperature Wells

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Advisor: Dr. Rajesh Shende

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Abstract: This study analyzed and compared promising Equation of State models for High-Pressure High-Temperature (HPHT) well applications. The study examined four fluid phase behavior Equation of State (EOS) models namely, (Peng-Robinson (PR), Cubic-Plus-Association (CPA), Perturbed-Chain Statistical Associating Fluid Theory (PC-SAFT) and Peng-RobinsonBabalola-Susu (PRBS). Their strengths, weaknesses, and computational efficiencies in calculating molar volumes with pressure change were rigorously analyzed using the Python program for five reservoir fluid systems: WELL 1, WELL 2, WELL 3, WELL 4 and WELL 5. PRBS, PC-SAFT, and CPA showed accurate predictions at specific high-pressure ranges between 90 and 160 MPa on the average, PRBS exhibited the lowest percentage Absolute Average Deviation (%AAD) of 21.0, followed by PC-SAFT with 28.0, followed closely by CPA with 31.8 while PR was shown to be totally unapplicable to high pressure reservoir systems as it had a %AAD of 125.4.

Artificial Intelligence (AI)/Machine Learning (ML) modelling is currently being investigated to understand the role of surfactants in high-temperature, high-pressure aqueous-phase liquefaction

of agriculture & forest residue.

Poster Presentation

Graduate Student

Presentation Number: 336

Presentation Title: Upscaling injection-induced fracture slip from core-scale experiments to large-area direct shear tests

Student Name: Khomchan Promneewat
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Geology and Geological Engineering

Advisor: Dr. Zhi Ye
Geology and Geological Engineering

Abstract: During subsurface fluid injection, increasing pore pressure can reduce the effective normal stress acting on faults or fractures, which may decrease fracture/fault shear strength and trigger injection-induced seismicity. This process is associated with several subsurface engineering applications, including carbon storage injection, geothermal energy production, and wastewater disposal. Previous laboratory studies commonly investigate this mechanism using pre-existing fractures in rock cores with inclined shear planes, producing a typical shear area of approximately 4.5 in², which enables effective control of pore-pressure distribution during fluid injection due to the small surface area. However, when considering upscaling to practical subsurface applications, larger fracture surfaces should be examined because injection pressure distribution along the fracture is an important factor influencing slip behavior. Direct shear experiments provide a simple framework for studying fracture slip by shearing two blocks under controlled normal and shear stresses, but the larger shear surface makes fluid pressure distribution more difficult to control. This study presents a simple approach to regulate pressure distribution by applying an O-ring seal along the shear plane to simulate an undrained condition. Results from the continuous injection approach show that the O-ring configuration produces similar mechanical behavior while maintaining an undrained condition over a larger shear surface of approximately 25 in², which is about 5.6 times larger than the shear area commonly used in compression shearing experiments. This approach provides a useful framework for investigating pressure distribution and slip behavior over larger fracture surfaces relevant to subsurface injection applications at relatively low cost.

Poster Presentation
Graduate Student

Presentation Number: 337

Presentation Title: Confining Pressure Effects on Elastic Modulus, Failure Envelope, and Crack Localization in Lakota Sandstone

Student Name: Ajita Bhandari
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Advisor: Zhi Ye
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Abstract: Microcrack evolution governs the mechanical response of deep subsurface rock under confining pressure. In this study, we conducted multistage triaxial tests on Lakota sandstone to determine its strength, elastic parameters, and Mohr–Coulomb failure parameters (e.g., friction angle, cohesion). We then use the Particle Flow Code (PFC) under the same loading conditions to benchmark the experimental results.

The sandstone core specimen was subjected to four successive confining pressures ranging from 1000 psi to 3000 psi, with 3,000 psi representing the maximum confinement level prior to failure. At 1000 psi, the measured Young's modulus and Poisson's ratio were 33.02 GPa and 0.16, respectively. As confining pressure increased (simulating greater depth), the Young's modulus slightly decreased to 31.79 GPa, while Poisson's ratio increased to 0.20, suggesting the accumulated damage caused during the multistage loading. The derived Mohr–Coulomb shear strength parameters of the sandstone are cohesion of 33.88 MPa, an internal friction angle of 39.96° , and a friction coefficient of 0.83.

The sandstone was also modeled in PFC under similar conditions. The simulation reproduced crack initiation, propagation, and failure (tensile or shear mode) localization. Crack density increased with confining pressure, and failure localized along a dominant shear plane controlled by the applied stress state. The results indicate that the PFC simulation and experimental data are in good agreement. Overall, these findings constrain the elastic and shear strength parameters of sandstone under triaxial loading and support geomechanically modeling of deep rock formations.

Poster Presentation
Graduate Student

Presentation Number: 338

Presentation Title: Hyaluronic Acid (HA) Binding Peptide Functionalized PLGA/PCL Core-Shell Nanofibers for Endogenous HA-enriched Regenerative Wound Dressings

Student Name: Whitney Ponwith

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Biomedical Engineering

Advisor: Tugba Ozdemir

Nanoscience & Biomedical Engineering

Abstract: Wound healing in adults often leads to fibrotic scarring due to excessive extracellular matrix (ECM) deposition and myofibroblast activation, marked by elevated alpha-SMA expression. In contrast, neonatal wound healing is regenerative and associated with elevated high molecular weight hyaluronic acid (HA) and diminished α -SMA expression. Hyaluronic acid binding peptides (HABPs) can retain endogenous HA and influence ECM remodeling. Preliminary work showed a 10-fold increase in HA on HABP treated surfaces compared to non-coated surfaces. In this study, we developed degradable scaffolds by coaxial electrospinning PLGA/PCL core-shell nanofibers functionalized with HABP to retain endogenous HA and cue fibroblasts toward a regenerative phenotype.

Fabrication and Characterization: PLGA (shell) and PCL (core) fibers were formed through coaxial electrospinning using a design of experiments (DoE) approach. Morphology was characterized by SEM and core-shell structure confirmed by TEM. NaOH etching selectively degraded the shell, leaving the PCL core exposed. **Surface Functionalization:** The shell was functionalized with HABP (GAHWQFNALTVR), confirmed by Alcian Blue staining and water contact angle. **Cellular Studies:** Adult and neonatal primary human dermal fibroblasts will be comparatively studied. Immunostaining for α -SMA and collagen expression will evaluate fibroblast phenotype and HA synthase activity.

TEM confirmed the formation of core-shell PLGA/PCL nanofibers with distinct contrast between the PCL core and PLGA shell. SEM after NaOH treatment revealed controlled PLGA shell degradation, exposing the PCL core, confirmed by FTIR spectra of the carbonyl region (1765-1710 cm^{-1}) showing a shift from PLGA to PCL.

This work confirms core-shell formation of coaxial PLGA/PCL nanofibers with controllable degradation functionalized with HABP. By influencing HA retention and fibroblast behavior, we may be able to promote regenerative versus fibrotic wound healing outcomes.

Poster Presentation

Graduate Student

Presentation Number: 400

Presentation Title: Reversing fibroblast-to-myofibroblast transition using surface-engineered nanoparticles to potentially ameliorate fibrotic diseases

Student Name: Xiao Yu

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Nano&BME

Advisor: Dr. Congzhou Wang

Nano&BME

Abstract: Fibroblast-to-myofibroblast transition (FMT) is a cellular transformation process driving the pathogenesis of fibrotic disorders such as pulmonary fibrosis and scleroderma. Despite advances in anti-fibrotic therapies, existing treatments primarily slow disease progression rather than directly targeting extracellular matrix (ECM)-secreting myofibroblasts, and cannot reverse established fibrosis. In this work, a nanoparticle-enabled, anti-fibrotic approach is demonstrated to reverse the FMT in myofibroblasts via targeting cadherin-2 (CDH2), a cell-surface marker of myofibroblasts, using melanin nanoparticles with surface-engineered CDH2 antibody (CDH2-MeINPs). Treatment with CDH2-MeINPs promotes myofibroblast-to-fibroblast transition (MFT, reversed FMT), significantly suppressing ECM deposition, proliferation, migration, and invasive behavior of myofibroblasts, while concurrently mitigating tissue contractility and stiffness, the hallmarks of fibrosis. Mechanistic studies reveal that this nanoparticle-driven MFT is regulated by the inhibition of the Rho signaling, a critical regulator of FMT. Overall, these findings propose an alternative therapeutic avenue to potentially halt or reverse a broad spectrum of fibrotic diseases. The manipulation of fibroblast/myofibroblast phenotype using nanoparticles may also serve as a promising tool in tissue engineering, enabling precise control over tissue remodeling.

Oral Presentation

Graduate Student

Presentation Number: 401

Presentation Title: Level Ancestors and Tree Accumulations: Simplification and Parallelization

Student Name: Luke Videckis

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Computer Science

Advisor: Dr. Christer Karlsson

Computer Science

Abstract: Preprocess a rooted tree then answer queries requesting the ancestor of a specified node on a specified level. We present the second ever $O(n)$ preprocessing, $O(1)$ query algorithm which does not use Method of Four Russians; the first ever was given by Hagerup [1]. We describe how to parallelize both our and Hagerup's [1] preprocessing algorithm to run in $O(n/P)$ time on P , $P \leq n/\log(n)$, processors on a CREW PRAM. We give ideas for calculating parallel tree accumulations over one binary operator which does not rely on tree contraction.

[1] Hagerup, Torben. "Still simpler static level ancestors." arXiv preprint arXiv:2005.11188 (2020).

Oral Presentation

Graduate Student

Presentation Number: 402

Presentation Title: The Influence of Beaver Dammed Reaches on Stream Temperature, Specific Conductance, and Algal Communities in the Black Hills of Western South Dakota

Student Name: Eli Huot

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Chemistry, Biology, and Health Science

Advisor: Dr. Racz-Brunner

Chemistry, Biology, and Health Science

Abstract: Beaver dams are increasingly recognized as ecosystem engineering structures capable of modifying stream hydrology, water chemistry, and downstream biological conditions. In Black Hills freshwater systems, stream temperature and specific conductance (SPC, $\mu\text{S}/\text{cm}$) are important drivers of algal productivity and may influence the prevalence of nuisance and potentially toxin-producing taxa. While prior research suggests beaver dams can reduce stream temperatures and influence water quality, the extent to which beaver-driven physicochemical changes correspond with shifts in algal communities remains under-characterized. This study evaluates whether naturally maintained, bank-to-bank beaver dammed reaches in the Black Hills are associated with changes in stream temperature and SPC, and how these shifts may influence algal community structure.

Field sites were selected based on dam morphology, with sampling stations established upstream, within, and downstream of each dammed reach. Water chemistry was measured in situ using a calibrated YSI multiparameter probe. Algal communities were sampled upstream within the beaver pond and downstream of each dammed reach for laboratory identification and enumeration. Across sites and sampling visits to date, downstream patterns indicate consistent decreases in stream temperature and SPC, consistent with prior work that beaver dams can influence thermal regimes and ionic conditions in running waters. Algal enumeration will illuminate whether these downstream physicochemical shifts correspond with changes in algal biovolume and taxa composition, including potentially harmful or nuisance-associated groups. By linking beaver-induced changes in water chemistry with algal community responses, this research addresses a key knowledge gap relevant to stream restoration, conservation planning, and water quality management in the Black Hills under shifting hydrologic and climatic conditions.

Oral Presentation

Graduate Student

Presentation Number: 403

Presentation Title: Probing the energy and mass dependence of cosmic-ray anisotropy with deep neural networks in IceCube

Student Name: Ian Reistroffer

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Physics

Advisor: Matthias Plum

Physics

Abstract: Cosmic rays are energetic particles thought to originate from explosive astrophysical events like supernovae and quasars. Upon their collision with Earth's atmosphere, a cascade of secondary particles is created and is measurable by instruments like the IceCube Neutrino Observatory, a large ground-based detector array located at the geographic South Pole. The collected data for a given cascade helps reconstruct the incident energy, arrival direction, and mass of the cosmic ray. Recently, an energy-dependent anisotropy in cosmic-ray arrival directions across the Southern Hemisphere has suggested an influence of features in the local interstellar medium on cosmic-ray flux in the TeV-PeV range. Leveraging modern machine learning techniques, we now additionally seek to probe the mass dependence of the arrival direction distribution. Using a convolutional neural network-based reconstruction framework, we expect to increase our understanding of the phenomenology responsible for past anisotropic observations. Jointly, the mass dependence of the arrival directions will shed light on the role of turbulent interstellar magnetic fields in shaping cosmic-ray propagation within our local galactic environment.

Oral Presentation

Graduate Student

Presentation Number: 404

Presentation Title: Dual Substitution in Cationic and Anionic Sublattices of Lithium Indium Chloride for High-Performance Solid-State Lithium Metal Batteries

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Materials Science & Engineering program

Advisor: Dr. Alevtina Smirnova

Department of Chemistry, Biology, and Health Sciences

Abstract: Solid-state electrolytes play a crucial role in advancing high-energy-density lithium-metal batteries by providing enhanced safety, electrochemical stability, and environmental sustainability compared to conventional liquid electrolytes. Among these, metal-based lithium chlorides, particularly Li_3InCl_6 , have emerged as promising superionic conductors. However, their practical application remains constrained by factors such as low room-temperature ionic conductivity, interfacial instability with lithium metal, and sensitivity to moisture. This study introduces a dual-doping strategy to overcome these limitations by simultaneously modifying its cationic and anionic sublattices. The singly doped $\text{Li}_3\text{In}_{1-x}\text{Zr}_x\text{Cl}_6$ ($0 \leq x \leq 0.5$) electrolytes exhibit enhanced ionic conductivity, while fluorine-substituted $\text{Li}_3\text{InCl}_{6-y}\text{F}_y$ ($0 \leq y \leq 0.5$) electrolytes demonstrated improved oxidation stability at the electrolyte-lithium metal interfaces. The synergistic effect of dual substitution results in an optimized $\text{Li}_{2.6}\text{In}_{0.6}\text{Zr}_{0.4}\text{Cl}_{5.9}\text{F}_{0.1}$ electrolyte with superior electrochemical performance compared to both undoped and singly doped counterparts. This novel electrolyte demonstrated several favorable properties, such as high ionic conductivity (1.7 mS cm^{-1}), broad electrochemical stability window, enhanced moisture tolerance. Additionally, it facilitates the formation of an artificial protective layer of LiF, resulting in stable lithium stripping/plating performance. Solid-state electrochemical cells incorporating this electrolyte and NMC811 cathode achieve a high specific capacity of 216 mAh g^{-1} at 0.1C . The dual-doping strategy enhances the properties of inorganic solid-state electrolytes, provides critical insights into lithium-ion transport at interfaces, and reveals key transformations in structure-property relationships with progressing from undoped to singly doped, and further to dual-doped superionic conductors for next-generation energy storage systems.

Oral Presentation

Graduate Student

Presentation Number: 405

Presentation Title: Laser Ablation for Efficient Space Debris Removal

Student Name: Jaden Dougal

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Dr. Prasoon Diwakar

Leslie A. Rose Department of Mechanical Engineering

Abstract: Laser ablation is a promising solution to the growing space debris removal problem. Laser-induced plasma can be used to adjust debris trajectory in order to push the debris into Earth's atmosphere for termination or send the debris into a graveyard orbit. This presentation will explore the use of nanosecond-pulsed laser ablation to change the trajectory of space debris through momentum transfer. It will focus on the firing angle and material sensitivity to move the debris to a lower altitude, thereby expediting natural deorbit.

Oral Presentation

Graduate Student

Presentation Number: 406

Presentation Title: Photon Detection System Calibration for DUNE

Student Name: Denis Torres

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Physics

Advisor: David Martinez

David Martinez

Abstract: The Deep Underground Neutrino Experiment (DUNE) relies on a precise Photon Detection System (PDS) to provide accurate timing information, enhance sensitivity to low-energy and non-beam events, and support detector performance studies in liquid argon time projection chambers. Achieving these goals requires a well-understood and stable optical calibration strategy that operates reliably under cryogenic conditions.

In this talk, I will present Photon Detection System calibration studies performed in ProtoDUNE, focusing on the characterization of the ultraviolet (UV) light calibration system and key optical components in the light-delivery chain. I will discuss measurements of optical fiber transmission, SMA-to-SMA connector and feedthrough interface losses, and diffuser assemblies, emphasizing wavelength dependence, attenuation, and performance under cryogenic thermal cycling and stability tests.

These studies provide quantitative inputs for understanding light transport, uniformity, and long-term reliability of the PDS in large-scale liquid argon detectors, and they directly inform calibration strategies for the DUNE Far Detector.

Oral Presentation

Graduate Student

Presentation Number: 407

Presentation Title: SuperCDMS Radon Purge System

Student Name: Nevena Cail

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Physics

Advisor: Richard Schnee

Physics

Abstract: SuperCDMS is a direct dark matter detection experiment at SNOLAB in Canada set to start taking data this year. As a rare-event search, the experiment requires background sources and signals to be well understood and mitigated to reach the experiment's design sensitivity. One significant background arises from radon progeny originating from ambient radon in the underground cavern. Without mitigation, gamma decays from radon daughters near the detectors would dominate the signal region. Our group has designed and begun installing the Radon Purge System to address this challenge. This system operates by flowing low-Radon nitrogen gas into the shield volume surrounding the detector cryostat, with an adjustable rate that responds to cavern pressure variations. Pressure differentials resulting from these variations are large enough to damage the shield materials if not compensated for by the adjustable gas flow. Our approach regulates shield pressure, suppresses radon accumulation near the detectors, and provides continuous monitoring of radon concentration within the shield volume to inform data quality in real time. This presentation will describe the design, testing, and installation of the SuperCDMS Radon Purge System.

Oral Presentation

Graduate Student

Presentation Number: 408

Presentation Title: An experimental calibration between dual carbonate clumped isotope ($\Delta 47$ and $\Delta 48$) in dolomite and temperature

Student Name: Isaac Bondzie-Selby
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Advisor: Dr. Chelsea Pederson
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Abstract: The dual carbonate clumped isotope proxies ($\Delta 47$ and $\Delta 48$) have emerged as powerful tools to reconstruct palaeotemperature, investigate diagenetic processes, and equilibrium in Modern and ancient carbonates. While it is currently believed that the relationship between temperature and $\Delta 47$ is similar for calcite and dolomite, there is still some skepticism that could lead to significant uncertainty in the reconstruction of dolomitisation temperatures – and, by extension, the oxygen-isotopic composition of the diagenetic fluid ($\delta^{18}\text{O}_{\text{FLUID}}$) – in ancient carbonate rocks. Such uncertainty extends to $\Delta 48$ values, on which there has been significantly less research. In this study, we dolomitised aragonite between 150–250 °C and produced a suite of dolomite reaction products with variable $\Delta 47$ and $\Delta 48$ values, and mineralogical properties. Only samples with >99% dolomite were analysed for dual clumped isotope ($\Delta 47$ and $\Delta 48$) analysis. Results suggest that the $\Delta 47$ and $\Delta 48$ values may be sensitive to mineralogical properties such as dolomite stoichiometry, cation ordering, and unit cell volume. Further investigation is needed to identify relationships. This study demonstrates the importance of the dual clumped isotope approach for dolomite research and provides an empirical calibration between $\Delta 47$, $\Delta 48$, and temperature. The relationship further provides a framework for using $\Delta 48$ to validate $\Delta 47$ -based temperature reconstructions. The approach enables the identification of mineralogical artifacts and controls, thereby improving confidence in temperature reconstructions.

Oral Presentation
Graduate Student

Presentation Number: 409

Presentation Title: Enhanced Magnetization in Metastable Disordered Fe-Ga Nanocomposites

Student Name: Paul White

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Physics

Advisor: Tula Paudel

Physics

Abstract: Recent research has focused on developing soft magnetic materials with superior magnetic properties for next-generation inductor cores in electrified vehicles. We explored an alternative alloy to the traditional Fe-Nb-Cu-Si-B alloy using Ga substitution for Si. The novel Fe-Nb-Cu-Ga-B alloys were found to have a ~35% larger magnetization from VSM measurements. Structural characterization performed with XRD and SAED determined the crystal structure and microstructure. The diffraction patterns show a competition between the stable ordered Fe₃Ga (sp. gr. 225) phase and metastable disordered Fe-Ga (sp. gr. 229) phase. From the complex microstructure, we were able to determine that the Fe-Ga phase formed as an intermediate step as the Fe₃Ga phase was crystallizing due to the rapid cooling rate ~10⁶ K/s. First principles calculations found that the Fe magnetic moment increased by 35% in the disordered Fe-Ga phase compared to the ordered Fe₃Ga phase, correlating with the experimentally measured increase in magnetization. Our findings show a significant increase in magnetization due to the presence of metastable disordered nanocrystalline phases, which may be the future of soft magnetic materials.

Oral Presentation

Graduate Student

Presentation Number: 410

Presentation Title: In-situ Calibration of the 61-Pixel IceAct Camera Using Single-Muon Signals

Student Name: Fathima Shifa Machingal

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Physics

Advisor: Matthias Plum

Physics

Abstract: IceAct is an array of compact imaging air-Cherenkov telescopes located at the surface of the IceCube Neutrino Observatory at the South Pole, which can withstand the harsh environment. Each telescope contains 61 highly sensitive light sensors, called silicon photomultipliers, which are coupled to cone-shaped light guides made of Polymethyl Methacrylate (PMMA) to collect light signals. Two IceAct telescopes have been taking data since 2019 and show promising capabilities for improving current studies of low-energy cosmic ray induced air showers.

For accurate measurements, the response of each sensor pixel must remain stable. However, aging and environmental conditions can cause changes in the optical opacity and signal response of the pixels. In this study, we calibrate all 61 pixels using single-muon signals and normalize the response of each pixel by assuming that a single muon generates an identical signal in every pixel.

Oral Presentation

Graduate Student

Presentation Number: 411

Presentation Title: Effect of Friction Stir Processing on the Microstructure and Mechanical Performance of Low-Carbon Steel under Arctic Temperature

Student Name: Varun Vasudevan Pushpa
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Materials and Metallurgical Engineering

Advisor: Dr. Grant Crawford
Materials and Metallurgical engineering

Abstract: Cold-climate infrastructure and defense systems operating in Arctic conditions require structural materials that maintain high strength and ductility at sub-zero temperatures. This work investigates the effect of FSP on the microstructural evolution and mechanical performance of low-carbon steel at both ambient and sub-zero temperatures. FSP was used to refine the microstructure through severe plastic deformation and dynamic recrystallization. At sub-zero temperature ($-60 \pm 2^\circ\text{C}$), mechanical testing showed a significant increase in both yield and tensile strength while preserving good ductility. Both yield and tensile strength increased in the processed samples from 375 and 529 MPa to about 485 and 700 MPa, respectively, at room temperature. AT -60°C , both yield and tensile strength increased from 392 and 588 MPa to about 516 and 773 MPa, respectively. Ductility was observed to decrease after FSP at room temperature and -60°C , from 40.8 and 49.6% to about 49.6 and 35.5%. A detailed characterization was conducted to evaluate microstructural evolution and post-fracture analysis to clarify the structure–property relationship. The improved mechanical properties at room and sub-zero temperatures demonstrate the effectiveness of FSP in tailoring microstructures for Arctic environments. The development of a uniform, recrystallized microstructure contributed to improved strain accommodation at sub-zero temperatures. These findings confirm that FSP-modified low-carbon steel is a promising material for lightweight armor used in Arctic applications.

Oral Presentation
Graduate Student

Presentation Number: 412

Presentation Title: Investigation of HiPIMS-Deposited Multilayer Nitride Coatings for Extreme Arctic Environments

Student Name: David Pienta

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Department of Materials and Metallurgical Engineering

Advisor: Dr. Forest Thompson

Department of Materials and Metallurgical Engineering

Abstract: Increasing Army operations in Arctic environments demands the development of material systems that can handle extreme cold, thermal cycling, and icing. Protective coatings for these applications must also be hard, durable, and have reduced ice adhesion strength. Current anti-icing coatings struggle to meet these requirements, so a multilayer transition metal (TM) nitride architecture, centered on aluminum nitride (AlN) was proposed. AlN has a uniquely high thermal conductivity, and good wear properties, both of which can be tuned through the choice of multilayer co-material and deposition parameters.

It is hypothesized that controlled multilayering of AlN and TM nitride co-material will produce anisotropic thermal conductivity through phonon scattering via layer interface. Such anisotropy may promote lateral heat spreading while limiting cross-plane heat loss, providing enhanced resistance to ice accumulation. Additionally, layer thickness and composition can be tuned for erosion resistance, and optical absorption, enabling solar assisted ice melting.

This study seeks to develop multilayer AlN/TM nitride coatings using reactive High-Power Impulse Magnetron Sputtering (HiPIMS) to engineer defect density, layer interfaces, and optical absorption. Deposition parameters including pulse length, kick voltage, substrate bias, and pulse frequency will be systematically varied to tailor ion energy and film density. Defect density will be characterized through Scanning Electron Microscopy, X-Ray Diffraction, Transmission Electron Microscopy and Raman spectroscopy, while Time Domain Thermal Reflectance will be used to measure thermal transport properties. The processing-structure-property relationships for AlN/TM nitride multilayer coatings for Arctic environments will be established as an outcome of this research.

Oral Presentation

Graduate Student

Presentation Number: 413

Presentation Title: Influence of Surface Heterogeneity on Biofilm Attachment and Stability on Patterned 2D hBN-Cu Systems

Student Name: Niaz Morshed Faysal

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Joseph John Thalakkottor

Leslie A. Rose Department of Mechanical Engineering

Abstract: This study explores the preferential attachment and biofilm development of *Citrobacter freundii* on a chemically heterogeneous surface composed of hexagonal boron nitride (hBN) patterns embedded in a copper (Cu) layer deposited on a silicon (Si) substrate. The heterogeneity arises from the contrasting chemical reactivity of inert hBN and reactive Cu regions. The objective is to assess whether such patterned 2D material systems can influence microbial colonization behavior.

Biofilm formation was first evaluated under static conditions using Scanning Electron Microscopy (SEM) and Confocal Laser Scanning Microscopy (CLSM). These techniques quantified bacterial coverage, surface roughness, and biofilm thickness across hBN and Cu domains. Results revealed substrate-specific differences in biofilm morphology and density, suggesting that surface chemistry governs microbial attachment dynamics.

To examine environmental resilience, a dynamic exposure experiment was conducted using a custom-built setup that simulated hydrodynamic shear stresses and introduced environmental constituents such as ions, organic matter, and native microorganisms. The dynamic study assessed biofilm adhesion strength, mechanical stability, and redistribution under flow conditions.

These combined investigations—static and dynamic—offer insights into microbial behavior on chemically heterogeneous surfaces, with implications for designing antifouling coatings and bio functional materials for real-world applications.

Oral Presentation

Graduate Student

Presentation Number: 414

Presentation Title: Stem cell derived nanoparticles for Bone Regeneration

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Biomedical engineering

Advisor: Dr.Jue Hu

Biomedical engineering

Abstract: Stem cell-derived nanoparticles, such as extracellular vesicles (EVs), play critical roles in intercellular communication and tissue regeneration. Among them, apoptotic extracellular vesicles (ApoEVs) have attracted increasing attention due to their unique biological properties, including the ability to transfer bioactive molecules and modulate recipient cell behavior; however, their role in osteogenic regulation remains incompletely understood. In this study, we generated ApoEVs from human bone marrow–derived mesenchymal stem cells (hBMSCs), human adipose-derived stem cells (hADSCs), and human gingival fibroblasts (hGFs) using different induction methods. We characterized stem cell-derived ApoEVs and treated hADSCs with different doses. We found that hGFs produced the highest concentration of ApoEVs under optimized induction conditions. Our results showed that ApoEVs were successfully internalized by hADSCs and macrophages and induced osteogenic differentiation of hADSCs in a dose-dependent manner. These findings indicate that ApoEVs possess great potential in regulating mesenchymal stem cell osteogenic differentiation and provide experimental evidence and theoretical support for further MSC-EV development and future clinical translation of innovative and effective cell-free therapies, offering new opportunities for large craniofacial defect repair and other tissue regeneration.

Keywords: apoptotic extracellular vesicles; hADSCs; osteogenic differentiation; tissue regeneration

Oral Presentation

Graduate Student

Presentation Number: 415

Presentation Title: Meta-Analysis of GHG emissions measured under different crop productions methods.

Student Name: Stella Glover-Simmons
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Civil and Environmental Engineering

Advisor: Dr. Heidi Sieverding and Dr. David Clay
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Abstract: Background: Reported agricultural greenhouse gas(GHG) fluxes differ widely across field studies due to variation in measurement methods.

Objective: To evaluate how management and methodological choices influence inferred emissions.

Methods: A control-treatment percent-change approach was applied across studies examining tillage, cover crops, fertilizer and irrigation regimes, chamber configurations, and statistical modeling.

Results: Emissions of CO₂, N₂O, CH₄, and reactive nitrogen species (NO, NH₃) were highly sensitive to methodological decisions. Differences in chamber type and model specification produced large shifts in estimated fluxes, occasionally exceeding 100%.

Conclusions: Percent change is an interpretable, decision-relevant effect size that improves cross-study comparability, particularly when controls have low or negative baselines.

Measurement methods matter and can substantially alter the results of GHG emissions within field studies

Oral Presentation
Graduate Student

Presentation Number: 416

Presentation Title: Leveraging Extensional Rheology for Mapping of Predictive Diameters in Electrospun Fibers

Student Name: Kelly M. Sutko

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Chemical and Biological Engineering

Advisor: Dr. Travis Walker

Chemical and Biological Engineering

Abstract: Electrospinning is a commonly used technique to create micro- and nano-scale fibers with high surface area and functionality, which can then be used to create, amongst other items, high-value ultrafiltration membranes. However, creating fibers with both predictive and reproducible diameters can vary based on the characteristics of the solution, such as surface tension, fluid elasticity, and viscoelastic jet stability. The aim of this research is to create a rheological framework to predict and generate consistent fiber diameters during electrospinning. Fluid elasticity and surface tension can be measured via DoS and contact angle measurements. Surface tension measurements help us determine the threshold between electro spraying and electrospinning. If fluid elasticity increases, then the jet stability will increase yielding more uniform fibers and less bead formation based on the timescale for electrospinning. The results can give an overview of material behavior within different regimes that can reduce the continuous trial and error of electrospinning parameters.

Oral Presentation

Graduate Student

Presentation Number: 417

Presentation Title: Process Engineering of Thermophilic Exopolysaccharides for Sustainable Metal Recovery

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Chemical and Biological Engineering

Advisor: Dr. Tanvi Govil

Chemical and Biological Engineering

Abstract: Thermophilic bacterial exopolysaccharides (EPS) present a compelling platform for coupling high-temperature fermentation with the production of structurally robust, bio-based polymers. Operation at elevated temperatures inherently reduces contamination risk and enhances process resilience; however, EPS fermentation poses significant engineering challenges, including viscosity-driven oxygen transfer limitations, mixing constraints, and metabolic competition between biomass formation and polymer synthesis. This study investigates both batch and fed-batch bioreactor production of EPS from a thermophilic bacterium, coupled with systematic process optimization to enhance titer and volumetric productivity while maintaining stable rheological performance. Critical operational parameters were refined through a sequential engineering strategy: (i) temperature and pH were calibrated to balance biomass accumulation with polymer synthesis rates, (ii) substrate type and concentration were optimized to mitigate carbon inhibition and oxygen transfer constraints prevalent in highly viscous broths, and (iii) the carbon-to-nitrogen ratio was adjusted to redirect metabolic flux toward polysaccharide biosynthesis. These insights were integrated into a controlled fed-batch feeding strategy that maintained low residual substrate concentrations, stabilized pH and dissolved oxygen profiles, and alleviated viscosity-induced mixing limitations. Our ongoing experiments evaluate thermophilic EPS for heavy metal extraction from coal fly ash, positioning this work as a biologically driven and environmentally responsible alternative to conventional chemical extraction methods. By integrating high-temperature fermentation with targeted metal recovery, this study advances a sustainable pathway for valorizing industrial residues while reinforcing the role of thermophilic bioprocess engineering in next-generation resource recovery technologies.

Oral Presentation

Graduate Student

Presentation Number: 418

Presentation Title: NO CELLS, NO PROBLEM: EXPLORING THE POTENTIAL OF CELL-FREE SYSTEMS

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Advisor: Dr. Tanvi Govil

Chemical and Biological Engineering

Abstract: Polyhydroxyalkanoates (PHAs) are biodegradable biopolymers with strong potential as sustainable alternatives to petroleum-derived plastics. However, widespread industrial adoption remains limited by high production costs, cellular variability, and the complexity of downstream processing. To overcome these barriers, we are developing a cell-free biomanufacturing platform that decouples polymer synthesis from cellular growth constraints and enables precise enzymatic control over PHA production. Our approach integrates a multi-enzyme cascade designed to complement a thermophilic corn stover-to-acetate conversion pathway, establishing a modular framework for controlled polymer biosynthesis. The required enzymes were successfully expressed in *E. coli* BL21 using IPTG-inducible vectors, and SDS-PAGE analysis confirmed protein expression at expected molecular weights. Enzymatic functionality was validated through a refined HPLC method employing calibrated standards to confirm substrate conversion, intermediate formation, and cofactor cycling with reproducible retention profiles. Ongoing efforts focus on kinetic optimization and full cascade integration, with reactions transitioning to the BioLector XT microbioreactor system for controlled, real-time monitoring and scalability assessment. Parallel work aims to enhance yield, recovery efficiency, and reproducibility of cell-free-produced PHAs. By accelerating the shift towards a sustainable biopolymer industry, our efforts contribute to global initiatives aimed at curbing the projected accumulation of 12 billion metric tons of plastic waste in landfills by 2050. Through strategic manipulation of synthetic multi-enzyme pathways, our work paves the way for the establishment of "Bio-Precursor Industries" worldwide, marking a significant step towards a more environmentally conscious future.

Oral Presentation

Graduate Student

Presentation Number: 419

Presentation Title: Extending Agricultural Life Cycle Assessment: A Framework for Quantifying Cross-Boundary Impacts and Evaluating Novel Mitigation Strategies in Midwest Cropping Systems

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Advisor: Dr. Heidi Sieverding
Civil & Environmental Engineering

Abstract: Agricultural impacts are often evaluated independently, ignoring how cross-boundary transport depresses adjacent yields. This study develops a two-farm life cycle assessment for maize, coupling an upwind source farm to a downwind neighbor farm via cross-boundary flows and yield penalties. Impacts (per 1 kg grain) were modeled using ReCiPe 2016 (H) midpoint impact method to capture climate-stressed yield-denominator amplification. Drought/rewetting increased the source's global warming 21.6% (0.45 kg CO₂ eq) and marine eutrophication 36.4% (0.0012 kg N eq). Imported burdens and steeper yield penalties (15-28% neighbor vs. 10-18% source) caused the neighbor's global warming and marine eutrophication to exceed the source by 4.4% (0.47 kg CO₂ eq) and 8.3% (0.0013 kg N eq). Intensified herbicides caused drift-driven toxicity inequity, yielding higher freshwater ecotoxicity on the neighbor (0.19 vs. 0.14 kg 1,4-DCB eq). Compounded vulnerabilities spiked neighbor global warming 55% above the source (1.50 vs. 0.97 kg CO₂ eq) alongside 57.7% neighbor yield losses. Heavy rainfall with unmitigated drainage raised neighbor marine eutrophication 80.9% over the source (0.0038 vs. 0.0021 kg N eq), whereas edge mitigation reduced delivered nitrate 80%, restoring near-parity. An emergent biopolymer mulch reduced particulate transfer but raised source global warming 8.9% (0.49 vs. 0.45 kg CO₂ eq), making benefits conditional on high-vulnerability settings. Future work should extend this to multi-field networks for targeted mitigation screening.

Oral Presentation
Graduate Student

Presentation Number: 420

Presentation Title: Development of a Craniofacial Implant-on-a-Chip Model to Evaluate Cell Migration and Osteogenesis on 3D Scaffolds

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Nanoscience and Biomedical Engineering Department

Advisor: Dr. Jue Hu

Nanoscience and Biomedical Engineering Department

Abstract: Currently, craniofacial defects remain a big challenge in clinic due to the limited availability of donor graft. The increasing demand for bone grafting has led to a focus on alternative bioengineering approaches. Biomaterial-mediated tissue engineering scaffolds are promising alternatives for autologous bone grafts. To test the function of those scaffolds, animal models have been largely used. However, serious concerns persist due to the variability among preclinical animal models from different genetic backgrounds, as well as the complicated biology interactions that hinder the mechanistic understanding. Thus, there is an urgent need to develop in-vitro model systems to better evaluate these scaffolds under microphysiological environment. We recently developed an innovative craniofacial implant-on-a-chip platform to support the pre-clinic evaluation process. The device mimics a microenvironment experienced by a transplanted craniofacial bone scaffold, which contains a circular space at the center for a scaffold insert and a microfluidic channel that encloses the space. We hypothesize that this device will enable monitoring of cell behavior at the blood-scaffold interphase. Both mouse and human cells will be cultured on the scaffold inserts to test platform's broad applicability as an evaluation platform. Cellular behaviors, including cell migration, cell proliferation, and osteogenic differentiation, will be analyzed. Hydrogel and nanofiber-modified 3D printed scaffolds will be used as model scaffolds to test our device. The scaffold will be used not only to support cell attachment but also as a drug delivery system. Our preliminary data revealed that our platform could support mice cell proliferation and migration. This research is in response to the NIH and FDA's new initiative, which aims to reduce the use of animal experiments. Ultimately, our craniofacial implant-on-a-chip is expected to offer validation, equivalence, and perhaps outperform animal testing.

Oral Presentation

Graduate Student

Presentation Number: 421

Presentation Title: 4140 Steel Cold Spray Depositions via Heat Treatment of Feedstock Powder and In-Situ Self Peening

Student Name: Nathan Staley

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Materials Science and Engineering Program

Advisor: Grant Crawford

Metallurgy

Abstract: As high costs and manufacturing time overruns become increasingly common, efficient repair of steel components using cold spray deposition technology is gaining importance. However, producing high-strength cold-sprayed materials suitable for structural steel repairs remains challenging due to intrinsic material system limitations and the cost for helium carrier gas for cold spray processing. This work aims to produce and characterize stable 4140 steel cold spray coatings for structural repair applications using nitrogen carrier gas. 4140 steel powders were heat treated under vacuum at various temperatures to evaluate how processing parameters influence mechanical properties and, consequently, cold spray-ability. To improve deposition characteristics, heat-treated powders were blended with in-situ 4140 steel peening agents. Mechanical performance was assessed using tensile strength testing, three-lug shear strength testing, microhardness testing, and nanoindentation. Powder and deposition microstructures were characterized through optical microscopy, scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), and transmission electron microscopy (TEM).

Oral Presentation

Graduate Student

Presentation Number: 422

Presentation Title: Influence of CrN Coating Architecture on Tribological Behavior in Arctic Conditions

Student Name: Elyse Jensen

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Materials & Metallurgical Engineering

Advisor: Forest Thompson

Materials & Metallurgical Engineering

Abstract: Wear and friction are system responses, not material properties, meaning operating conditions and environmental conditions can affect material behavior. In simulated Arctic environment testing, past studies have observed that the friction coefficient of chromium nitride (CrN) coatings deposited by physical vapor deposition (PVD) techniques is sensitive to the combinations of water vapor availability and coating surface temperature.

This study focuses on understanding how CrN coating adhesion layer composition affects friction and wear in Arctic conditions. CrN coatings were deposited with chromium, titanium, and CrN bond layers using reactive magnetron sputtering. The coating microstructure was characterized using scanning electron and transmission electron microscopy. Elemental and phase compositions were acquired using energy dispersive x-ray spectroscopy and x-ray diffraction. The mechanical properties and surface topography were investigated with nanoindentation testing, indentation adhesion testing, scratch adhesion testing, and laser scanning confocal microscopy. To investigate the tribological performance of the CrN coatings in simulated Arctic environments, CrN-coated high strength stainless steel flats were tested against alumina ball bearings using a modified low temperature ball-on-flat tribology geometry capable of controlling dewpoint. Dry sliding wear tests were conducted at both cold (-20 °C) and warm (30 °C) surface temperatures in low dew point (<-20 °C) air. Post-wear analysis was conducted using optical and laser scanning confocal microscopy on the resulting wear scars of the ball and flat.

Data collected was used to correlate the CrN coating architecture and properties with tribological behavior. The results of this research provided insight into how various CrN coatings perform in simulated Arctic conditions and give insight into how CrN coatings may be better developed or utilized in oscillating sliding wear applications in cold regions.

Oral Presentation

Graduate Student

Presentation Number: 423

Presentation Title: Tributary Macroinvertebrate Drift Providing Food Resources to the Mainstem Kootenai River

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Chemistry, Biology, and Health Sciences

Advisor: Dr. Lisa Kunza

Chemistry, Biology, and Health Sciences

Abstract: The Kootenai River is a large, oligotrophic river that relies on tributary resources to sustain the mainstem food web dynamics. Among these critical food resources are macroinvertebrates, particularly for higher-level consumers like fish. We examined the diel abundance of macroinvertebrate drift on three tributaries during three consecutive summers. Expected diel trends would follow cyclic patterns with peaks in drift abundance occurring at night. In this research, only a few samples conformed with what was expected. The remaining samples have peaks at different times of the day, either not following a clear cyclic pattern or having peak drift occur during the day. Site characteristics tend to influence the composition of macroinvertebrates present. The sites with lower water velocity have higher numbers of the mayfly *Paraleptophlebia* sp. and members of the family Corixidae, both macroinvertebrates that prefer slower-moving waters. Although there are differences in composition among site locations, some key taxa remain similar among all samples. The *Baetis* sp. mayfly is the most abundant macroinvertebrate for all but two samples, with an average abundance of 40.4% and a range of 1.7% - 71.2%. Macroinvertebrate drift is a critical component to understanding food resource availability in large oligotrophic rivers and promotes informed conservation strategies.

Oral Presentation

Graduate Student

Presentation Number: 424

Presentation Title: Electronic States and Optical Response in 2D Layered Lead-Halide Perovskites

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Physics

Advisor: Steve Smith/Tula R. Paudel

Nanoscience & Biomedical Engineering/Physics

Abstract: Two-dimensional organic-inorganic layered lead-halide perovskites (Benzylammonium)₂PbX₄ (X=Cl,Br,I) offer a simple route to study how composition and thickness control electronic and optical behavior in bulk crystals and exfoliated flakes. Using first-principles density functional theory, we calculated the band structure, projected density of states and charge-density maps for monolayer and bilayer (Benzylammonium)₂PbBr₄. We identify optically inactive surface states that appear in few-layer slabs. These states arise from carbon p-orbitals on surface organic groups; the relevant carbon atoms are separated by more than 10 Å and their wavefunctions do not overlap with the Pb s/p states that form the valence bands. As a result, these surface states do not produce a measurable signal in linear optical spectra. Calculations of band structure and optical response for X=Cl, and I reveal systematic, halide-dependent trends across the series. Experimentally, bulk X=Cl, and I crystals are characterized for surface morphology and elemental composition by SEM/EDX. While X=Br is exfoliated into thin flakes (confirmed by optical imaging) and examined by SEM/EDX and AFM to verify composition and determine thickness after exfoliation. Optical reflectance is measured for both bulk and exfoliated samples using a custom setup that was designed, assembled, and commissioned in our lab, probing the thickness- and composition-dependent optical transitions for comparison with theory. Future work will extend the study to linear and nonlinear electronic and optical properties in both bulk and exfoliated samples.

Oral Presentation

Graduate Student

Presentation Number: 425

Presentation Title: A New Self-Peening Approach to Enhance Microstructure and Mechanical Properties of Cold Sprayed 316L Stainless Steel.

Student Name: Kyrian Odo

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Material Science and Engineering

Advisor: Dr. Grant Crawford

Material Science and Engineering

Abstract: Cold spray deposition of 316L stainless steel often produces porous coatings due to limited particle deformation and weak inter-particle bonding, leading to inferior performance compared to wrought 316L. While post-treatments such as annealing, HIP, and laser re-melting enhance bonding and reduce porosity, they increase cost and complexity, limiting scalability. In-situ densification with foreign shot-peening media improves coating properties but risks contamination and material incompatibility. This study presents a novel in-situ self-peening approach using the same 316L powder as both deposit and peening media. Mechanical milling enhances the hardness and size of the peening powder, which is then blended with gas-atomized powder for cold spray deposition. This technique markedly improves particle deformation and metallurgical bonding, yielding coatings with lower porosity, higher hardness, and increased strength. The self-peening method offers a contamination-free, scalable solution for dense, high-integrity 316L coatings, potentially eliminating the need for extensive post-processing.

Oral Presentation

Graduate Student

Presentation Number: 426

Presentation Title: Physics Informed Inverse Design and Crashworthiness Optimization of Hexagonal Composite Ring Structures

Student Name: Nahid Sarker

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Chemical and Biological Engineering

Advisor: Monzure Kazi-Khoda

Chemical and Biological Engineering

Abstract: Crashworthy composite energy absorbers require designs that maximize energy absorption (EA) while limiting initial peak force (IPF), yet optimization remains challenging due to complex failure mechanisms and limited experimental data. This study presents a physics-informed inverse design framework for hexagonal fiberglass/epoxy composite rings under quasi-static compression. Composite specimens were fabricated and tested under two loading configurations to obtain force–displacement responses for model development and validation. A physics-informed neural surrogate was developed that predicts absorbed energy and derives crushing force through automatic differentiation, enforcing exact work-energy consistency and improving physical reliability. Three variants, a data-driven network (DDNS), a soft-constraint, and a hard-constraint PINN, are trained as 20-member bootstrap ensembles and evaluated under interpolation and unseen-angle extrapolation protocols. On extrapolation to an untrained fiber orientation, the hard-constraint PINN achieves load $R^2 \geq 0.85$ and the soft-constraint PINN $R^2 \geq 0.80$, both significantly outperforming the DDNS ($R^2 = 0.70$, $p < 0.001$) and conventional surrogates, including Random Forest ($R^2 = 0.26$) and Gaussian Process ($R^2 = 0.30$). The hard-constraint PINN produces the best-calibrated uncertainty among all variants (conformal factor = 2.14 vs 3.99 for DDNS), indicating that its wider confidence bands honestly reflect prediction difficulty. For inverse design, the surrogate is coupled with Gaussian process Bayesian optimization jointly across loading configurations, supported by a probabilistic classifier penalizing implausible combinations. All optimizers recover target EA and IPF within 3% error; GP-BO achieves comparable accuracy using 3.3× fewer surrogate evaluations than per-configuration methods.

Oral Presentation

Graduate Student

Presentation Number: 427

Presentation Title: Comparative Evaluation of High-Order Finite-Volume Methods for Unsteady Laser-Induced Plasma Flows

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Dr. Prasoon Diwakar, Dr. Sonya Dick

Leslie A. Rose Department of Mechanical Engineering

Abstract: Nanosecond laser ablation generates highly transient compressible flow characterized by rapid energy deposition, steep pressure gradients, and shock formation. Accurate numerical simulation of these laser-driven flows requires robust high-order spatial discretization capable of resolving discontinuities while preserving smooth solution features. This thesis presents the development and verification of a two-dimensional finite-volume solver for modeling laser-induced gas dynamics, with emphasis on evaluating high-order reconstruction schemes in shock-dominated regimes.

The compressible Euler equations are solved using a conservative formulation with explicit Runge–Kutta time integration and Rusanov flux evaluation. Spatial discretization is performed using first-order upwinding, WENO3, WENO5, and TENO5 reconstruction schemes to systematically assess accuracy, stability, and computational cost. Verification is conducted through density advection and grid-refinement studies using L2 error norms to confirm formal order of accuracy. Comparative simulations of shock formation and plume expansion are performed to evaluate shock resolution, numerical dissipation, and solution robustness across schemes.

An idealized high-pressure, high-temperature gas bubble expanding into quiescent ambient conditions is used to model the early hydrodynamic response of laser energy deposition. Quantitative metrics include shock location, gradient resolution, convergence behavior, and computational performance. Results demonstrate that higher-order schemes significantly improve shock capturing and reduce numerical dissipation relative to first-order methods, with TENO5 providing improved robustness in strong gradient regions.

This work establishes quantitative relationships between spatial scheme order and solution fidelity in laser-driven compressible flows, providing guidance for high-order CFD modeling of transient laser ablation phenomena.

Oral Presentation

Graduate Student

Presentation Number: 428

Presentation Title: Role of Matrix Effect in Laser Produced Plasma Spectroscopy for Soil Nutrient Quantification

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Abstract: Laser-produced plasmas exhibit significant variation depending on the composition and physical properties of the target material. This variability presents substantial challenges in the analysis of organic materials, as environmental and matrix-related factors strongly influence plasma characteristics. This study demonstrates that matrix effects in organic soils significantly affect plasma temperature, leading to deviations in laser-induced plasma formation. These findings emphasize the need to develop robust machine learning algorithms capable of accounting for matrix effects in organic soils. Incorporating such approaches can enhance the accuracy and reliability of laser-based analytical techniques for soil nutrient quantification.

Oral Presentation
Graduate Student

Presentation Number: 429

Presentation Title: AVS-FE Simulations of Hard Magnetic Soft Materials subject to Steady State Electromagnetic Fields

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Mechanical Engineering Department

Advisor: Dr. Albert Romkes

Mechanical Engineering Department

Abstract: In recent decades, a significant portion of research has been dedicated toward the development of a novel class of smart materials: magneto-active elastomers. Magneto-active elastomers are composite materials that are constructed by embedding magnetic materials into a rubber-like polymer such as silicone. The mathematical models of these materials involve the coupling of the Maxwell equations with near incompressible hyperelasticity. As a result, solving the equations that govern magneto-active elastomers is quite challenging. To overcome this challenge, we present an unconditionally stable finite element formulation, known as the automatic variationally stable finite element (AVS-FE) method, for solving a steady state ideal hard-magnetic soft material model. Following the discontinuous Petrov-Galerkin method (DPG) methodology, the AVS-FE method requires the computation of optimal test functions to guarantee stability. Unlike the DPG method, the AVS variational statement is formulated such that the trial functions are kept in a conforming, weakly continuous Sobolev space. Not only does this reduce the computational cost of the AVS-FE method, it also ensures that the field variables, such as stress and displacement, are continuous throughout the domain. Herein, we present several numerical verification experiments that show the AVS-FE method yields optimal convergence rates for the steady state Maxwell equations, and stable, locking free solutions for the near incompressible hyperelastic equations. Then, we utilize AVS to solve a model of a cardiac catheter made of a hard-magnetic elastomer that is subject to a steady-state magnetic field.

Oral Presentation

Graduate Student

Presentation Number: 430

Presentation Title: Palladium Copper Alloy Nanoparticles with Novel Five-Fold Symmetric Structure

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Nanoscience and Biomedical Engineering

Advisor: Dr. Shan Zhou

Nanoscience and Biomedical Engineering

Abstract: Five-fold symmetry exhibited in nanoparticles is a rare geometrical structure and thus has unique and valuable properties for optoelectronic and catalytic applications. Although five-fold symmetry occurs in nature, especially in flowers and crustaceans, at the nanoscale, this symmetry is forbidden by classic crystallographic rules. Decahedrons, icosahedrons, and similar geometrical shapes have five-fold rotational symmetry but do not have translational symmetry. Both of these qualities are possible simultaneously with the introduction of atomic strain formed along five twinned boundaries. These boundaries separate each of the five crystal domains. Atomic strain provides highly active sites that are useful in many catalytic applications. This project focuses on the unique five-fold symmetric branched structure of palladium-copper alloy nanoparticles. This five-fold symmetric nanoparticle appears to grow from the seed of a decahedron, where atomic deposition forms branches at each of the five corners. The resulting structure resembles a flower with five petal-like branches that are radially symmetric. The combination of copper, palladium, and the twinned strain is expected to give the particle promising performance in catalysis and other applications.

Oral Presentation

Graduate Student

Presentation Number: 431

Presentation Title: Computational Validation of Tolyporphin Derivatives as P-Glycoprotein Inhibitors to Overcome Multidrug Resistance: Quantum Calculations and Molecular Docking

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Department of Chemistry, Biology, and Health Sciences

Advisor: Haiden Nguyen

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Abstract: Multidrug resistance (MDR) driven by P-glycoprotein (P-gp) significantly limits the efficacy of many chemotherapeutic agents. P-gp is an ATP-binding cassette transporter, composed of two distinct domains: nucleotide-binding domains (NBDs) and a transmembrane domain (TMD). The TMD features a large central binding cavity, a vestibule, and an access tunnel, resulting in a broad substrate binding pocket. Despite decades of research, a clinically FDA-approved P-gp inhibitor remains elusive. Tolyporphin A (TppA), a tetrapyrrole-based natural product, has been reported as a P-gp MDR reverser. We hypothesized that conjugating TppA to small organic ligands would enhance targeting of the TMD binding region, particularly the access tunnel. In this study, we evaluated a library of TppA-ligand conjugates using quantum-mechanical (QM) optimization and molecular docking approaches. The results from density functional theory (DFT) calculations at the B3LYP/6-31G(d,p) level revealed that one of the TppA-ligand conjugates exhibits favorable chemical stability and an electronic free energy. Docking studies against apo P-gp conformation indicated enhanced binding affinity of selected TppA-ligand conjugates. Collectively, these findings support the hypothesis that TppA derivatives can effectively engage the P-gp access tunnel, highlighting this region as a promising therapeutic target for overcoming MDR.

Oral Presentation

Graduate Student

Presentation Number: 432

Presentation Title: Roles of Scaffold Topography and Hyaluronic Acid Binding Peptides on Macrophage Differentiation in an Artificial Synovial Membrane Model

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Advisor: Dr. Tugba Ozdemir
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Abstract: Introduction:

Osteoarthritis (OA) and Rheumatoid Arthritis (RA) are debilitating diseases that significantly impact quality of life, causing joint pain, stiffness, inflammation and reduced range of motion. The synovial membrane is a critical component of the joint, mainly consisting of macrophages and fibroblasts lined adjacent to a thin matrix. Both cell types have altered functions during OA and RA. In their attempt to heal the joint, macrophages tend to take a pro-inflammatory role, contributing to inflammation and tissue damage. Hyaluronic acid (HA), a key component of synovial fluid plays a vital role in lubrication and reducing inflammation. During arthritis the molecular weight and concentration of HA is altered, leading to decreased lubrication and increased inflammation. Tissue Engineering aims to build sacrificial scaffolds that can elicit desired cellular outcomes. We hypothesized that scaffold topography and its ability to attract and enhance HA can play significant roles in macrophage differentiation.

Methods/materials:

Using electrospinning, we created nano and microfiber synthetic membranes. To attract HA to these synthetic membranes, we chemically conjugated novel Hyaluronic acid binding peptides (HABPs). THP-1 cells were differentiated into M0 macrophages and cultured on synthetic surfaces. Cell differentiation was tracked using Presto Blue, Pico Green, ELISA (TGF-beta, TNF-alpha, IL-10, IL-1beta, Cellular morphology).

Goals:

We successfully developed nano and microfibrillar scaffolds and functionalized with HABPs onto the scaffolds. We established reproducible and rigorous methodologies to control M0-like macrophages and seeding densities to observe cell response reminiscent of physiological scenarios. The ongoing experiments are focusing on understanding the macrophage responses. The goal of this study is to find a relationship between surface topography, immobilized endogenous HA and macrophage cellular responses in the context of arthritis.

Oral Presentation
Graduate Student

Presentation Number: 433

Presentation Title: Advanced Pretreatment Strategies for Structural Modification of Corn Stover Toward Enhanced Bioconversion to Lactic Acid

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Chemical and Biological Engineering (CBE)

Advisor: Dr. Ivan Salmeron Ochoa
Chemical and Biological Engineering (CBE)

Abstract: Lignocellulosic biomass has been representing a promising renewable carbon source for sustainable bioprocessing; however, its complex and recalcitrant structure limits efficient sugar recovery and downstream fermentation for that purpose. The present work evaluates advanced pretreatment strategies with the objective of modifying the structural organization of corn stover to enhance carbohydrate accessibility and support further lactic acid production. Pretreatment was run under controlled thermal conditions to induce matrix rearrangement, followed by mild chemical processing. Structural modifications were evaluated using Fourier-transform infrared spectroscopy (FTIR), while carbohydrate profiles were quantified through HPLC analysis. Spectroscopic results showed temperature-dependent changes in hydroxyl and aromatic functional groups, suggesting dehydration reactions, lignin reorganization, and partial deacetylation. These structural alterations or rearrangements directly influenced sugar recovery trends.

Compositional analysis identified moderate-temperature treatment as “more suitable”, yielding approximately 5 g/L xylose while preserving fermentable sugars. More severe conditions resulted in carbohydrate degradation and reduced recovery. To evaluate feasibility of these sugar profiles, a synthetic hydrolysate medium was formulated based on the recovered sugar composition and screened using five lactic acid producing bacterial strains. Where, *Lactobacillus plantarum* demonstrated the highest LA yield, demonstrating effective utilization of the pretreatment-derived carbohydrate profile.

These findings demonstrate that controlled pretreatment can strategically alter lignocellulosic structure to improve sugar accessibility while maintaining fermentability. Ongoing research includes the evaluation of supercritical fluid processing as a complementary, low-energy approach for enhanced biomass deconstruction and integration into sustainable biorefinery platforms.

Oral Presentation
Graduate Student

Presentation Number: 434

Presentation Title: Optimization of ultrafast low-temperature Ti₃C₂T_x MXene synthesis via molten NH₄HF₂ salt etching

Student Name: Venera Alimova

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CBHS

Advisor: Dr. Alexey Lipatov

CBHS

Abstract: Two-dimensional transition metal carbides and nitrides known as MXenes attract significant scientific attention due to their high electrical conductivity, large specific surface area and tunable surface terminal groups. Among them, Ti₃C₂T_x is known as promising for sensing and electrochemical energy storage applications. In this work, MXene Ti₃C₂T_x was synthesized by an ultrafast and low-temperature method via selective etching of aluminum from the MAX phase Ti₃AlC₂ using molten NH₄HF₂ salt. The process is performed at 160°C and enables the formation of MXene within only 5–10 minutes. Enhanced diffusion in the molten salt significantly accelerates the etching kinetics compared to conventional aqueous approaches. Importantly, HF is generated in situ during the reaction, improving operational safety. Repeated centrifugation of the MXene suspension in hot water effectively removes residual aluminum oxides and increases overall yield. SEM analysis demonstrates the characteristic layered “accordion-like” morphology of Ti₃C₂T_x. EDS confirms a uniform elemental distribution, and XPS verifies the presence of Ti–O and Ti–F bonds on the surface. The demonstrated molten-salt approach provides a rapid and efficient synthesis route which also may be extended to other MXene compositions, following by systematic investigation of their structure–property relationships, and opens up prospects for a wide range of MXene applications.

Oral Presentation

Graduate Student

Presentation Number: 435

Presentation Title: Experimental and Computational Investigation of Supersonic Retro-propulsion Under Unsteady Conditions

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Abstract: Supersonic retropropulsion (SRP) has emerged as a critical technology for entry, descent, and landing (EDL) of spacecraft, particularly for future Mars missions where delivering large payloads for human missions remains a significant challenge. While many prior computational and experimental investigations have assumed steady freestream conditions, atmospheric entry is inherently unsteady, with continuously varying Mach number and flow properties. The influence of these temporal variations on shock structure and overall aerodynamic behavior has not been fully characterized. This work experimentally and computationally investigates the effects of unsteady supersonic freestream conditions on SRP flowfields. Physical testing was conducted in a supersonic wind tunnel that naturally produces a decelerating freestream over time, enabling examination of plume shock interactions under varying Mach number conditions. Complementary computational fluid dynamics (CFD) simulations were performed and validated against established baseline data. Schlieren imaging was used to visualize shockwave structures and assess flow stability. Results demonstrate that bow shock stability is strongly dependent on nozzle expansion regime. The over-expanded configuration exhibited significant unsteadiness at higher Mach numbers, followed by a transition to a more stable interaction as Mach number decreased. In contrast, moderately and highly under-expanded configurations maintained comparatively steady bow shock structures throughout the test range. These findings contribute to more accurate modeling of retropropulsion systems and support the development of safer and more reliable planetary landing architectures.

Oral Presentation
Graduate Student

Presentation Number: 436

Presentation Title: COSMIC-RAY MASS COMPOSITION CLASSIFICATION WITH MUON-BUNDLE ENERGY LOSS PARAMETERIZATION IN ICECUBE-DETECTOR.

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Abstract: When a high-energy cosmic ray interacts in the atmosphere, it triggers a cascade of secondary particles, including mesons that decay into muons, neutrinos and other particles. These high energy muons are collectively known as a muon bundle. The number and energy of muons in a bundle are linked to the primary energy and mass of the cosmic ray particle. In our model, we account for both the primary energy and the zenith angle of the incoming cosmic ray. We also consider spatial separation between muons as they move through the ice, which lets us include new parameters to better describe the bundle's energy loss. Based on the parameters obtained for various simulated cosmic ray particles for different primary energies and masses, we employ machine learning techniques to determine how effectively these parameters can distinguish between four cosmic ray primary types: proton, helium, oxygen, and iron. By applying the theoretical model to simulated data, we explore how far we can push the limits of identifying cosmic ray types through the energy loss patterns of muon bundles deep within the ice.

Oral Presentation
Graduate Student

Presentation Number: 437

Presentation Title: Adaptation of Endothelial Cells to Chemically Defined Media and Assessment of Phenotype Retention

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Advisor: Travis Walker

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Abstract: Endothelial cells (ECs) are widely used in vascular biology, regenerative medicine, drug screening, and tissue engineering, mostly from their roles in angiogenesis, barrier function, and cell signaling. For many applications, in vitro expansion is essential. However, traditional culture methods rely on serum-containing media that introduce variability from undefined compositions and batch inconsistencies. This impacts reproducibility and creates challenges when scaling or commercializing projects. The creation of a chemically defined media (CDM) provides a controlled and standardized alternative, but ECs must retain their phenotype after adaptation. The goal of this research is to reproduce the fact that ECs can be grown in CDM while maintaining phenotype with the objective of developing a commercially available media. ECs were gradually transitioned from a serum-containing medium to a CDM using a stepwise adaptation protocol. Cells were monitored over multiple passages to assess morphology, proliferation, and phenotypic stability. Assessments of morphology, proliferation trends, and expression of endothelial-associated characteristics were conducted to determine whether adaptation affected EC identity.

ECs were successfully adapted to the CDM and maintained viability through the process. Minor changes in growth kinetics were observed early in adaptation, but proliferation stabilized in later passages. Morphology assessments showed preservation of the characteristic monolayer structure and phenotypic assessments indicated retention of endothelial traits under defined conditions.

These findings suggest that ECs can maintain phenotypic stability following CDM adaptation. By minimizing variability and improving standardization, CDMs can enhance experimental consistency. While future work needs to validate the scalability of the CDM, this work provides foundational evidence supporting the need for a commercially available, chemically defined culture media for ECs.

Oral Presentation

Graduate Student

Presentation Number: 438

Presentation Title: Probing Polarization-Controlled Transport in a Mixed-Dimensional Ferroelectric/Quasi-1D Semiconductor Heterostructure

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Abstract: The integration of ferroelectric materials with low-dimensional semiconductors provides a route to compact electronic memory elements where polarization controls conductivity without continuous power which is particularly important for next-generation low-power and non-volatile electronic devices. Quasi-one-dimensional (1D) semiconductor channels are attractive because they enable further device miniaturization and their small cross-section can reduce electron scattering, supporting more efficient carrier transport. In this work, we fabricate a mixed-dimensional van der Waals heterostructure combining a quasi-1D semiconductor TiS₃ with the layered ferroelectric CuInP₂S₆ (CIPS). To further enhance the device performance, the heterostructure was encapsulated with a thin dielectric h-BN flake and annealed in a controlled environment. After encapsulation and annealing, the device showed improved performance and stronger polarization-channel coupling between the CIPS substrate and the TiS₃ channel, demonstrating clear polarization-dependent transport and memory-like behavior, while also revealing that interfacial effects and environmental sensitivity remain important factors for device stability. Overall, the results confirm the potential of mixed-dimensional ferroelectric devices, while indicating that further interface optimization will be important for achieving more reliable and reproducible ferroelectric memory based on quasi-1D semiconductors.

Oral Presentation
Graduate Student

Presentation Number: 439

Presentation Title: Controlled Delivery of Muscarinic Receptor Agonists to Aid Xerostomia After Head/Neck Radiotherapy

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Abstract: Targeted drug delivery with controlled, sustained release offers a promising solution for managing chronic diseases requiring frequent drug administration while reducing the adverse effects associated with conventional delivery methods. We propose an injectable, composite hydrogel. This system delivers pilocarpine to stimulate gland secretion, offering controlled, prolonged drug release while minimizing side effects. This study optimizes microparticle formulation, release kinematics, and evaluates its impact on regulating amylase secretion in salivary gland epithelium.

Synthesis of Hydrogel Microparticles (HMP): The HMPs will be synthesized utilizing Hyaluronic acid (HA) via inverse emulsion polymerization. The HMPs will be embedded into an HA based commercial hydrogel system. Particles were imaged on a SEM and characterized using DLS and Zeta potential. To evaluate the in vitro drug loading and release, the particles in and out of the hydrogel will be tested for its pilocarpine release and load quantities via HPLC.

Concentration of Pilocarpine was tested on immortalized salivary gland epithelial cells (SGecs) in a 48 well plate treated with a collagen ECM. 3D and 2D SGecs were analyzed for amylase and Nuc-Blue. The SGecs were stained for M1 and M3 receptors for validation.

SEM results showed that utilizing a higher HA molecular weight, higher chemical quantity, longer reaction time for the crosslinking, additional washes, and improved techniques resulted in the best quality of HA microparticles. Utilizing DLS, most of the particles are found to be 1282 nm. The average charge of the particles was -57.6. Pilocarpine release study resulted in HA particles loading and releasing an average of 55% and about 1% per day respectively.

Hydrogels with particles were found to consistently release pilocarpine for 28 days. Between 1mg/mL and 0.1mg/mL is the most optimal dosage concentration. 3D cells secreted more amylase than 2D cells. M3 and M1 receptors were identified.

Oral Presentation
Graduate Student

Presentation Number: 440

Presentation Title: Controlling Background Radiation for Early Warning Supernova Detection with the Deep Underground Neutrino Experiment (DUNE) at Sanford Lab

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Abstract: When completed in the late 2020s, the Deep Underground Neutrino Experiment (DUNE) will be the most advanced neutrino detector built to date, consisting of a particle accelerator sending a neutrino beam from Chicago, IL, to a detector a mile underground at Sanford Lab in Lead, SD. Neutrinos are a fundamental particle with no electric charge, near-zero mass, and are the second most prevalent particles in the universe, with hundreds of trillions streaming through you every second. They also come in three 'flavors': electron, muon, and tau, with each having different masses. DUNE's primary purpose will be to measure the absolute values of the masses, but will also be able to detect neutrinos formed in the supernovae of distant stars, which arrive several hours before the visible light of the explosion, thus also serving a dual purpose as an early warning supernova detector. However, because supernova neutrinos are lower energy, unlike the high energy neutrino beam from Chicago, steps must be taken to reduce and manage similar energy background radiation inherent to every material in order to distinguish supernova neutrinos from it. This is done predominantly via gamma spectroscopy, the use of germanium detectors to measure the radioactivity content of detector components, concrete, rock, etc., as a form of radioactive quality control during the construction of DUNE. Details of these spectroscopic assay efforts will be the focus of this talk.

Oral Presentation
Graduate Student

Presentation Number: 441

Presentation Title: Comparative Study of Pyrolysis and Hydrothermal Liquefaction for the Production of KOH-Activated Pinewood-Derived Porous Carbon for Supercapacitor Applications

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Advisor: Professor Rajesh Shende

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Abstract: Forest residues are an enormous and underused source of lignocellulosic biomass that could be used to make carbon materials in a way that is beneficial for the environment. Pyrolysis and hydrothermal liquefaction (HTL) are two very different thermochemical methods that work in dry, inert conditions and subcritical water environments, respectively. This leads to different carbonization pathways and material properties. This study undertook a systematic comparative analysis to assess the impact of thermochemical conversion pathways, pyrolysis versus hydrothermal liquefaction (HTL), on the structural development and energy storage capabilities of porous carbon derived from pinewood.

Biochar was produced through pyrolysis at temperatures between 600 and 1000 °C in an inert nitrogen atmosphere, whereas hydrochar was synthesized via HTL at 250, 275, and 300 °C under autogenous pressure. Experiments were conducted for both pathways, with and without a surfactant, to assess its impact on pore formation and surface alteration.

Potassium hydroxide (KOH) was used to chemically activate the char material for improving the formation of mesopores and the development of surface area in porous carbon systems. The char was then heated to 800 °C in an inert environment to prepare porous carbon and characterized using SEM, BET surface area analysis, FTIR, XRD, Raman spectroscopy, and elemental analysis to analyze the shape, porosity, crystallinity, and surface functionality.

A direct comparison showed that HTL-derived and pyrolysis-derived carbons have different pore structures and structural properties. These differences are caused by the chemistry of the precursors and the temperature at which they are processed. The optimized porous carbons were further evaluated for supercapacitor applications, given that biomass-derived nanoporous carbons have exhibited encouraging electrochemical performance in energy storage systems.

Oral Presentation

Graduate Student

Presentation Number: 442

Presentation Title: Investigating the post peak critical shear strength of lime stabilized mine tailings materials

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Advisor: Dr. Calvin Tohm
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Abstract: Research focuses on the effect of lime stabilization on engineering properties with fine-grained soils. Lime content was added at 0.1%, 1%, 2%, and 4% by dry weight and cured for 7 and 28 days to assess strength development. Laboratory testing focused on shear strength and other relevant soil design parameters.

Results show an increase in shear strength and a reduction in plasticity with higher Lime content and longer curing time. The pozzolanic reaction (chatted this) continued throughout the curing time which explained the increase in soil parameters. Overall, Lime content improved the soils response and increased the feasibility of lime being utilized in a slope stability scenario.

Oral Presentation
Graduate Student

Presentation Number: 443

Presentation Title: Machine Learning Based Prediction and Optimization of Flattening Ratio and Deposition Efficiency in Cold Spray Deposition of Metallic Powders

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Advisor: Dr. Jeffrey Woldstad, Dr. Grant Crawford
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Abstract: Cold spray is a solid-state additive manufacturing and coating process in which metallic powder particles are accelerated to very high velocities using a stream of compressed gas and deposited onto a substrate through impact induced plastic deformation. Unlike traditional thermal spray techniques, cold spray operates at temperatures lower than the melting point of the material, allowing it to be deposited by intense plastic deformation, and at the same time reducing oxidation, thermal degradation, and unwanted phase transformations. However, predicting deposition behavior remains challenging because key responses such as flattening ratio, which describes particle deformation after impact, and deposition efficiency, which represents the fraction of powder that successfully adheres to the substrate, depend on complex and nonlinear interactions between material properties and processing conditions.

The current study attempts to develop a predictive framework for cold spray deposition behavior using data driven modeling techniques. The experimental data obtained during the cold spray processing of four metallic powders, Al6061, tungsten, tantalum, and nickel, are used to train several supervised machine learning models capable of predicting the flattening ratio and the efficiency of deposition of the process based on the process parameters. The performance of the models will be assessed using evaluation metrics such as the coefficient of determination (R^2), mean absolute error (MAE), and root mean square error (RMSE) to quantify prediction accuracy and model reliability. In addition, genetic algorithm is used to identify optimal combinations of process parameters that maximize flattening ratio and deposition efficiency. The outcomes of this study are expected to improve the understanding of how processing conditions influence deposition behavior in cold spray and provide a systematic approach for selecting and optimizing process parameters.

Oral Presentation
Graduate Student