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Summer Undergraduate Research Expo

August 7, 2025
McNamara Alumni Center
Memorial Hall
2:30 – 4:30 PM

Undergraduate Poster Presentations
Listed Alphabetically by Presenting Author

Presenters should be at their posters at the following times:
2:30 – 3:30 even numbered posters
3:30 – 4:30 odd numbered posters

1.	**Shannon Aide** *Next Gen Cellulosics for Rheology Modification* **Advisor:** Theresa Reineke **Mentor:** Nathan Rackstraw **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** University of Wisconsin-La Crosse **Abstract:** Many materials contain cellulose ethers to modify their texture and ability to flow. Such materials include personal care products, paints, adhesives, and coatings. A demand exists for water-soluble cellulose ethers, and available synthetic processes have certain flaws. Current industrial syntheses utilize an inefficient heterogenous process requiring interaction of reagents between multiple phases. A homogenous process involving imidazolium acetate ionic liquids as the solvent and catalyst provides a solution. However, the reaction degrades the ionic liquid, removing the benefit of a recyclable solvent. Reaction of cellulose with imidazolium chloride ionic liquids and moderate base added hydrophobic character to the polymer for separation from the ionic liquid before hydrophilic reagent addition, so ionic liquid could be recycled for repeat reactions. Imidazole was identified as the optimal base allowing progression without ionic liquid degradation. Successive reaction with a mild base and hydrophilic reagent, such as epoxide or alkyl halide, added hydrophilic character for partial water solubility. The reaction sequence was expanded with use of allylated reagents at the second step to allow for subsequent thiol-ene click reactions that could include more water solubility in the polymer. Investigation of catalytic amounts of imidazolium acetate in the first reaction may lead to improved outcomes.
2.	**Andrea Alaniz** *Nanomechanical Characterization of Additively Manufactured 316H Steel via Nanoindentation* **Advisor:** Nathan Mara **Mentor:** Minh-Tam Hoang **Sponsoring Program**: MRSEC **Home Institution:** University of Texas at Rio Grande Valley **Abstract:** Structural materials in nuclear reactors must withstand years of exposure to extreme temperatures, radiation fluxes, and corrosive environments. Next-generation reactor designs require alloys where performance in such environments must be reliable. Elevated-temperature creep testing, to determine alloy lifetime to failure, can take a few hours to years to complete over relevant temperatures and stresses. The focus of this project is to quickly determine creep performance in additively manufactured (AM) reactor steels using high throughput nanoindentation to supply most of the data required to predict creep lifetime to rupture. These new test protocols enable rapid development of high-temperature AM materials though an understanding of their microstructure-property relationships in less time than for bulk tensile creep testing. AM reactor steels such as 316H austenitic stainless are characterized by nanoindentation to determine hardness and elastic modulus under varying temperatures and strain rates. Electron backscatter diffraction (EBSD) maps are used to determine the microstructure of the AM reactor steels before and after creep. Our initial results on AM materials reveal a heterogeneous microstructure where nanoindentation can be used to understand the local mechanical properties across microstructural gradients in grain size/morphology and composition.
3.	**Aiden Aldinger** *Benchmarking the Kinetic Activity of Platinum-Group catalysts for Alkaline Water Splitting Applications* **Advisor:** Kelsey Stoerzinger **Mentor:** Mohammad, Asaf Zaki **Sponsoring Program**: Independent Research **Home Institution:** University of Minnesota Twin Cities **Abstract:** Platinum metal catalysts are the leading materials for the hydrogen evolution reaction (HER) and hydrogen oxidation reaction (HOR), which are fundamental half-reactions in electrochemical energy conversion systems like electrolyzers and fuel cells. The objective of this study was to develop a systematic procedure to reproducibly measure the intrinsic kinetic activity of HER and HOR on platinum-group catalysts in alkaline media. Electrochemical measurements were performed using a rotating disk electrode (RDE) setup, with a glassy carbon disk drop-casted with a platinum-based catalyst. Collected data were corrected for solution resistance (iR drop), and HOR currents were further corrected for mass transport limitations using Koutecký–Levich analysis to obtain kinetic currents. Hydrogen underpotential deposition (HUPD) was used to estimate the electrochemically active surface area, allowing for normalization of kinetic current densities. The kinetic data were then fit to the Butler–Volmer equation to extract the charge transfer coefficient (α) and exchange current density (j_0). Comparison of the measured exchange current density and Tafel plots to literature shows similarities, with a measured exchange current density of 0.71 mA/cm² showing good agreement, suggesting the procedure may provide an accurate approach for benchmarking HER and HOR activity in alkaline electrolytes.

4. **Evette Allari**
Investigating Stress-Induced Stability Changes in Infliximab via Native Ion Mobility-Mass Spectrometry and Collision-Induced Unfolding
Advisor: Varun Gadkari
Mentor: Eledon Beyene
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Oberlin College
Abstract: Monoclonal antibodies (mAb) are a class of biotherapeutics prominent in the biopharmaceutical industry due to their high specificity and limited adverse effects. They are commonly used to treat cancers and autoimmune disorders. However, mAbs can experience stress conditions in their production pipeline that impact stability and higher-order structure (HOS). Ion mobility mass-spectrometry (IM-MS), paired with collision-induced unfolding (CIU), has been used to probe the stability of mAbs. Using this technique, the stability of the IgG1-based drug Infliximab has been investigated under various stress conditions. Infliximab samples underwent heat, freeze-thaw, acidic, and basic stress conditions to mimic adverse environments that mAbs may experience in the production process. Results suggest that Infliximab is moderately destabilized from thermal stress and stabilized from pH stress. In the future, this data will complement an investigation into how stress conditions impact the activity of Infliximab in its binding to tumor necrosis factor alpha (TNF-a).

5. **Olivia Avila**
Investigating AI Reliance in a Mobile vs. AR Environment
Advisor: Zhutian Chen
Mentor: Amanda Elvarsdóttir
Sponsoring Program: Human-Centered Computing
Home Institution: Columbia University
Abstract: As Augmented Reality (AR) headsets become more integrated in everyday life through advancements and recent releases by companies like Meta and Google, understanding how users make decisions in AR compared to mobile interfaces is worth investigating. Therefore, this project seeks to discover and understand what unique factors of AR influence user decision-making with AI-generated suggestions, with implications for future AR decision support systems. Building on previous research in human-AI collaboration, we designed 9 decision making tasks to measure AR's influence on AI usage vs. a mobile's influence. We conducted an experiment in which we compared the outcomes of each task done first with a mobile phone interface, to the outcome of the same tasks done again by the same participant but with an AR interface highlighting AI's suggestion.

6. **Kevin Babashov**
Reinforcement Learning in Iterated Prisoners' Dilemma with Monitored Trust and Cooperation Levels
Advisor: Maria Gini
Mentor:
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota Twin-Cities
Abstract: In an era marked by widespread misinformation and decentralized decision-making, the ability of autonomous agents to discern trustworthiness is vital. This research investigates whether integrating dynamic trust metrics into reinforcement learning frameworks enhances cooperative behavior and decision-making efficiency in multi-agent environments. Using a modified Iterated Prisoner's Dilemma setting, agents evaluate trust through both direct interaction history and peer-generated trust scores. Four environments, each with distinct trust propagation mechanisms, are tested. A model-based reinforcement learning approach is employed, leveraging Monte Carlo Tree Search (MCTS) augmented with Graph Neural Networks (GNNs) to simulate outcomes and optimize agent strategies. The study aims to determine which trust configurations most effectively promote cooperation and allow agents to avoid exploitative interactions. Results will provide insight into how trust-aware learning can improve autonomous system performance in contexts such as cybersecurity, autonomous trading, and decentralized networks.

7. **Salviya Balami**
Guided Grasp: Enabling Autonomous Pick-and-Place on SPOT with Low-Cost Teleoperation
Advisor: Karthik Desingh
Mentor: Adam Imdieke
Sponsoring Program: Human-Centered Computing
Home Institution: California Institute of Technology
Abstract: This project explores a cost-effective framework for enabling Boston Dynamics' SPOT robot to autonomously perform pick-and-place tasks in real-world environments. The central objective is to train SPOT to identify and manipulate nearby objects without human intervention by utilizing teleoperation and imitation learning. To facilitate safe and remote data collection, a low-cost, half-scale model of SPOT's arm was developed using CAD and servo motors. Through Python-based control and the Robot Operating System (ROS), the system captures synchronized visual and positional data from teleoperated demonstrations. This data is used to train neural networks that map visual inputs to robotic actions. The broader goal is to support assistive robotics applications, particularly for individuals with physical limitations. This work demonstrates that teleoperated data collection with simplified hardware can effectively bootstrap learning for complex, real-world robotic tasks.

8. **Elijah Berg**
Developing Polymer-Supported N-Heterocyclic Carbenes To Enhance Organocatalyst Reusability and Recovery
Advisor: Jessica Lamb
Mentor: Briana Krupinsky
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota Twin Cities
Abstract: N-Heterocyclic carbenes (NHCs) are known for their versatility as organocatalysts. However, they are incredibly air sensitive, making them difficult to work with. To bypass this issue, the "masking" of these NHCs with small molecules has been studied. Past research has shown that alcohols, carbon dioxide, and isocyanates, can be used to mask NHCs. The Lamb Group has focused on the ability of carbodiimides (CDIs) to be tunable masks for NHCs, controlling the release temperature of the NHC. Despite having control over the release of NHC-CDIs, there has not yet been an observed way to isolate our adducts from solution to reuse. We hypothesize that a polymer-supported NHC-CDI will be able to recapture NHCs from solution and allow us to catalyze numerous reactions without losing reactivity over multiple cycles, enhancing NHC reusability and recovery. Previous literature has demonstrated the ability of vinyl CDIs to copolymerize with styrene. We plan to reproduce this literature and test the ability of NHCs to form adducts with the CDI repeat units. Thus far, we have formed a new NHC-CDI adduct from NHCs and the previously reported vinyl CDI monomer. Future work will entail adding NHCs to the polymer, and recycling the solid-supported NHC in organocatalysis.

9. **Patrick Bindzus**
Unmasking the Biomechanical Driver: Thorax Muscle Mass as a Novel Predictor for Cricket Call Intensity Beyond Whole Body Size
Advisor: Mingzi Xu
Mentor:
Sponsoring Program: UROP/URS
Home Institution: Department of Ecology, Evolution, and Behavior University of Minnesota
Abstract: Sexual selection in crickets is largely shaped by female preference for specific male song traits, with song intensity emerging as a particularly influential factor. Previous research has shown that females favor louder songs, even over other important acoustic characteristics such as pulse period, suggesting that song intensity is a strong target of selection. While intensity has been linked to body size, the anatomical basis of this relationship remains poorly understood. In this study, we investigated whether thoracic muscle mass, which is a key biomechanical component in song production, is a determinant of song intensity in male crickets of the genus Laupala. Thoracic muscles power wing movement, the mechanism through which crickets produce song. We quantified thoracic muscle mass as well as body size and recorded song intensity across individuals. Muscle mass and body size, but to a lesser degree, was positively correlated with song intensity. Then, controlling for body size, we found that muscle mass is the prime determinant of song intensity. This indicates that thoracic muscle mass, independent of overall body size, contributes significantly to song intensity. Our findings suggest that thoracic muscle development may be under direct sexual selection, driven by female preference for high-intensity acoustic signals.

10. **Sela Boswell**
Characterization of TROP2 Affibodies for Therapeutic Use
Advisor: Ben Hackel
Mentor: Hannah Lembke, Anna Steele
Sponsoring Program: MRSEC
Home Institution: Texas Tech University
Abstract: Molecular targeted therapeutics have empowered cancer treatment by targeting cell surface receptors that appear in excess on tumor cells. Trophoblast antigen 2 (TROP2) is one such receptor, with overexpression in pancreatic, colorectal, lung, breast, and other cancers. Stable, modular miniproteins, such as the affibody, provide an effective means of selective binding and tumor targeting. Previously, a population of TROP2 binding affibody proteins have been engineered. Initial leads were intentionally chosen with mid-nM affinity (Kd from 45 - 440 nM) to enable expression-dependent binding. Subsequent enrichment of the strongest-binding and most stable variants resulted in six variants identified from a stochastic sampling. This study's aim was to characterize the affinity and stability of these variants to identify whether they could be sufficient or further evolved for improved targeting of TROP2. Four variants were produced in E. coli and evaluated by sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE). All variants were evaluated via Sanger sequencing. Two compelling variants were identified, including one that was effectively purified from *E. coli*. The other variant will be expressed as well, and yields will be compared to the desired goal of > 5 mg/L. Future work will aim to identify a lead molecule with K_d < 5 nM, T_m > 70 ℃, and high specificity to progress to therapeutic evaluation.

11. **Kate Brandli**
Cloning, purification, and binding affinity assessment of artificial ATP binding proteins simulating prebiotic polypeptides
Advisor: Burckhard Seelig
Mentor: Peter Winslow
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota
Abstract: Proteins are fundamental to life on Earth and were likely the bridge between abiotic molecules and early life. Guided by the most plausible chronology of amino acid incorporation into the genetic code, previous members of the Seelig Lab made four libraries of 80-mer polypeptides composed of the first 5, 9, 16, and 20 amino acids; amino acids code for peptides that make up proteins so these libraries serve as a model for prebiotic proteins. Each library was put through a selection process to find those that bind to Adenosine Triphosphate (ATP). In an attempt to study the strongest binders from this selection we chose the three most abundant and relatively enriched variants from each library; abundance is the frequency of a particular protein from the library population after selection, and relative enrichment is a measure of the increase in frequency of a protein from the population relative to other proteins, between selection rounds. Expression testing of these variants in the DnaK knockout E. coli strain, EN2, optimized protein yield and efficiency. The variants were purified with affinity chromatography columns and quantified and analyzed. ATP binding assays were performed and structural analysis will follow.

12. **Joan Castañeda Gonzalez**
Asymmetric Copper Catalyzed Dicarbofunctionalization of N-Tosylhydrazones
Advisor: Melissa Ramirez
Mentor: Romualda Aquino
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Washington State University
Abstract: Enantioselective formation of C–C bonds in synthetic organic chemistry is an important approach to establishing molecular complexity, particularly in the synthesis of pharmaceutically relevant small molecules. While aldehydes and ketones are readily accessible functional groups, there are limited applications of Cu for the enantioselective formation of C–C bonds at the central carbon of these functional groups. Herein we report experimental and computational efforts towards developing a Cu-catalyzed dicarbofunctionalization of N-tosylhydrazones for the formation of two new C–C bonds involving an alkyne and a ketone as reaction partners. The proposed mechanism for the transformation of interest involves initial formation of a Cu acetylide and subsequent reaction with an N-tosylhydrazone to generate a Cu carbene. This intermediate is then proposed to undergo an enantioselective migratory insertion for generation of an alkyl Cu intermediate and the first new C–C bond. Density Functional Theory calculations were performed towards evaluating the energetic feasibility of the reaction of interest.

13. **Sam Catania**
Biochemical and functional characterization of cyanide masking reagents in Mycobacterium tuberculosis
Advisor: Ambika Bhagi-Damodaran
Mentor: Murphi Williams
Sponsoring Program: UMN Chemistry- Lando
Home Institution: California Polytechnic State University, San Luis Obispo
Abstract: Tuberculosis is the world's deadliest infectious disease, killing 1.25 million people in 2023 (WHO). Mycobacterium tuberculosis, the bacteria that causes tuberculosis, is rapidly gaining drug resistance to currently utilized antibiotics meaning novel treatments are required. HT-N6 is a small molecule that is redox selective for ferric heme proteins in Mycobacterium. NMR studies demonstrate that HT-N6 is a cyanide-masking drug, meaning it releases cyanide once bound to a ferric heme protein. Initial experiments have shown that HT-N6 is not toxic to mammalian cells at concentrations required to kill tuberculosis. This study aims to test a library of compounds similar to HT-N6 for structure-activity relationships. We determined the activity of each compound by finding the Minimum Inhibitory Concentration (MIC90) in M. tuberculosis and analyzing how changes to the structure of HT-N6 affect its potency. We also tested functional inhibition of HT-N6 by expressing and purifying one of its target proteins, cytochrome bd-oxidase, a heme protein in the mycobacterium electron transport chain. We observed activity in both the crude membrane and purified bd-oxidase which were both inhibited by HT-N6. Overall, our studies bring forth a new mechanism for targeted cyanide delivery in microorganisms for the inhibition of infectious bacteria.

14. **Samuel Chambers**
Polymerizable Lyotropic Liquid Crystal Membranes for Ionic Selective Separation of Lithium
Advisor: Mahesh Mahanthappa
Mentor: Mason Kozody
Sponsoring Program: MRSEC
Home Institution: Iowa State University
Abstract: Increased demand for the critical element lithium has shifted the focus towards the use of direct lithium extraction methods. Herein, we present the use of a polymerizable bioderived surfactant to synthesize an ion-selective membrane as a scalable solution for the recovery of lithium from continental brines. Surfactant molecules, upon the addition of water, will self-assemble into complex assemblies known as lyotropic liquid crystals(LLCs). These LLCs adopt conformations with configured ion-selective channels and tunable pore sizes. The conjugated triene α-Eleostearic acid, a natural product derived from tung oil, was recovered and isolated through saponification and recrystallization, thereby removing uncertainties in phase formation and polymerization behaviour. Surfactants were formed directly by displacing hydrogen with several different cations. These surfactant systems were hydrated to form LLCs, which were characterized with small-angle X-ray scattering(SAXS) and polarized optical microscopy(POM), predominantly forming hexagonally packed cylinders. After LLC formation, multiple unsaturations present in amphiphilic α-Eleostearic acid allow for polymerization to stabilize the desired phase into a mechanically robust matrix, which is often desirable for the integrity of membranes. Polymerization was attempted using UV photo-initiators to induce radical polymerization. Further work will involve characterization of the polymerized membrane, mechanical properties, permeability, and ion-selective properties.

15. **Katherine Coffin**
Low temperature molecular spin decoherence dynamics via Lindblad master equation method
Advisor: Kade Head-Marsden
Mentor: Timothy Krogmeier
Sponsoring Program: MRSEC
Home Institution: Kenyon College
Abstract: Molecular spin systems are an emerging class of qubits with high synthetic tunability and potential for room temperature function. As a starting point for theoretical and experimental development, it is important to understand the dynamics in these systems at low temperatures. Specifically, the transverse relaxation rate (T_2) due to electronic-nuclear spin interactions in the local magnetic environment strongly determines the rate of decoherence at low temperatures. Previous work modeled low temperature decoherence by combining an open quantum system model with electronic structure calculations. In this method, the Gorini-Kossakowski-Sudarshan-Lindblad (GKSL) master equation for the nuclear spin flip-flop mechanism is augmented with explicit *ab initio* electronic structure information, namely by including the hyperfine energy differences in nuclei across an ensemble of molecular configurations in the decay constant of the GKSL equation. This model was successful in predicting experimental trends in two kinds of paramagnetic molecular spin systems: vanadium-oxo and copper-ligand molecules. In this project, the previous vanadium-oxo molecules were modeled with two solvents using a conductor-like polarizable continuum model (CPCM), revealing greater coherence with increasing polarity of solvent. Additionally, four new vanadium molecules were modeled in two different solvents. Further analysis is needed to confirm agreement with experimental trends, effectiveness of CPCM with this model, and dependency of qubit charge-to-size ratio and solvent steric strain on spin-spin decoherence.

16. **Finn Coleman**
Examining the effects of small molecules and polymers on the mechanical properties of poloxamer hydrogels for drug delivery
Advisor: Michelle Calabrese
Mentor: Charles T. Knisely
Sponsoring Program: MRSEC
Home Institution: St. Olaf College
Abstract: Treatment of acute otitis media (middle ear infection) remains difficult because of treatment non-compliance and increased prevalence of antibiotic resistance due to systemic delivery. Thus, a single-dose, local treatment is preferred, and made possible with the FDA-approved aqueous poloxamer 407 (P407). P407 is a triblock copolymer consisting of a poly(propylene oxide) (PPO) midblock and poly(ethylene oxide) (PEO) endblocks, which undergoes thermoresponsive micellization and gelation at certain concentrations. However, the impermeability of the tympanic membrane (TM; ear drum) renders direct treatment difficult, but can be overcome by the addition of various chemical permeation enhancers (CPEs) which facilitate diffusion of the antibiotic ciprofloxacin through the TM. Unfortunately, these small molecules often affect properties such as gelation temperature (T_{gel}), micellization temperature (T_{mic}), stiffness, and formulation stability. To effectively deliver ciprofloxacin, the formulation must form a sufficiently stiff gel by physiological temperature. To achieve an ideal T_{gel}, certain reverse poloxamers (RPs)—which have PEO midblocks, and PPO endblocks— were added to modify micellization and gelation. Rheology, differential scanning calorimetry, and small-angle x-ray scattering demonstrate that each CPE studied decreases T_{gel} of these systems, bringing it further from body temperature. Conversely, the RP 17R4 can be used to bring T_{gel} back up, and forces a two-step process in the ordering of the systems, lengthening the gelation. With this information, the mechanical properties of these hydrogels can be tuned to achieve gelation at body temperature, ultimately resulting in better drug delivery in ear infection treatment.

17. **Kieran Cross**
Development and Characterization of Succinate-Binding Ionophores for Injury Assessment
Advisor: Philippe Bühlmann
Mentor: SK Zubaer Zaman
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Middlebury College
Abstract: Current conventional methods of injury assessment during triage rely on vital signs and physical cues, yet these indicators may not always accurately determine a patient's risk of mortality. Succinate, which accumulates during a partial reversal of the Krebs Cycle resulting from cellular hemorrhaging, has been proposed as a biomarker for determining the severity of injuries. Succinate quantification is limited by present technology since this requires laboratory resources. Ion-selective electrodes are used to quantify the concentration of specific ions, but they are not yet available for succinate. To provide a means for quantifying succinate accumulation via point of care devices, ionophores with trifluoroacetyl groups, known for their ability to bind with other closely-related organic molecules such as carbonate, were synthesized using two distinct pathways: fluoride-catalyzed trifluoroacetylation and metal-halogen-based trifluoroacetylation. Afterwards, the binding constants of the succinate-ionophore complexes were determined via titrations with water and succinate that were monitored with 1H NMR to examine the change in chemical shift of the protons in the complex as the concentration of ligand increased. Ionophores that exhibited a higher binding constant relative to a predetermined baseline constant were considered to be more selective for succinate and ultimately more suitable for use in an ion-selective electrode.

18. **Tyler Delyon**
Automated Detection of Left Ventricular Systolic and Diastolic Pressure to Characterize Function of an Ex Vivo Perfused Heart
Advisor: Paul Iaizzo
Mentor: Ryan Nadybal
Sponsoring Program: ATP-Bio
Home Institution: Ave Maria University
Abstract: Cryopreservation, which preserves organs for longer through extreme cooling, also requires rewarming, where the viability of an organ can be assessed. In order to standardize viability assessment, a baseline model and deviation of normal isolated heart pressure are necessary. As one data file spans hundreds of thousands of data points, human analysis would be time-consuming. This study digested the data collected through monitoring left ventricular pressure from isolated swine hearts in the Visible Heart Laboratory and generated a model that characterizes pressure decline over time. Pressure data were captured using a catheter placed transmurally into the ventricle and connected to a voltage transducer. A Python script was written to read and smooth the data using a 50 Hz filter to identify the systolic and diastolic pressure points. A median filter was used to smooth the pressure points before interpolation was performed. A mean trend and standard deviation were calculated from the interpolated data. In comparison to a human reader, the script was able to identify the target systolic and diastolic points with greater than 99% accuracy. By having a tool to evaluate ventricular function, additional studies can be conducted to investigate the factors that influence the preservation of the heart.

19. **Thomas Denton**
Probing Electric Field During Plasma-Liquid Interactions Using Raman Spectroscopy
Advisor: Renee Frontiera
Mentor: Killian MacFeely, Colin Clay
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Reed College
Abstract: As part of the movement away from rare-earth based catalysis, nonthermal-plasma driven solution electrochemistry (PDSE) has emerged as a promising alternative. However, the magnitude of the electric field of nonthermal plasma-liquid interactions *in situ* has not been quantitatively measured. This presents a major roadblock to predicting the redox capability of these systems. In this contribution, we report the construction of a laser system and its usage to measure molecular probes that report the electric field magnitude in an aqueous liquid film irradiated by a nonthermal, helium fed atmospheric pressure pin-to-surface discharge-driven plasma jet, measured using Raman spectroscopy.

20. **Brooklynn Dobson**
Medium Elliptical ACR Phantom For MRI
Advisor: Michael Garwood
Mentor: Angela Teeple, Ben Parkinson
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota - Twin Cities
Abstract: In order for an MRI machine to be accredited by the American College of Radiology (ACR), the machine needs to be tested by an ACR phantom. A phantom is a physical model that is used to simulate the properties of tissue and for quality assurance of a medical imaging machine. The ACR phantom has a cylindrical shape that is bigger than the adult human brain and has physical corners. With the typical MRI scanner, the corners are not an issue, as they can be spatially encoded with the homogenous magnetic field. With the portable MRI machine in Dr. Garwood's lab, these corners become problematic due to the inhomogeneity of the magnetic field, causing image distortion correction algorithms to fail. To analytically account for the distortion in these corners, we created two elliptical ACR phantoms; one where the internal parts of the phantom are alongside the vertical axis, and the other where the parts are along the horizontal axis. We found that by creating two elliptical ACR phantoms that have their components in the horizontal and vertical planes, we can do quality assurance on the portable MRI scanner.

21. **Shurui Du**
The Agentopia Times: Understanding and Mitigating Hallucinations in Multi-Agent LLM Systems via Data Journalism Gameplay
Advisor: Qianwen Wang
Mentor:
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota, Twin Cities
Abstract: Large Language Models (LLMs) can produce hallucinations, meaning confident but incorrect responses. These mistakes can mislead users if not handled carefully. In this project, we present The Agentopia Times, an educational simulation game that helps users understand and reduce hallucinations through multi-agent coordination. The game takes place in a virtual newsroom, where players interact with agents acting as writers, editors, or analysts. By clicking on agents, users can insert hallucinations and explore how biased behavior affects the final results. Our system includes different types of hallucinations that reflect common failure patterns in LLMs. Players choose a dataset, assign hallucinated agents, and apply strategies such as voting strategy or sequential strategy to find and fix errors. After each round, the game generates a report with a score and feedback, encouraging users to try different approaches and improve over time. This game combines technical learning with interactive play. It is designed to help both students and general users think more critically about AI-generated content. By testing strategies and seeing their effects, players gain insight into how teamwork and coordination can reduce misinformation in AI systems.

22. **Vee Edwards**
Machine learning to predict and interpret substituent effects on aryne stability.
Advisor: Jan-Niklas Boyn
Mentor: Daniel Gibney, Lauren Way
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Whitman College
Abstract: Arynes are compelling precursors in synthetic chemistry due to the extensive range of chemical reactions they can undergo, including those producing densely substituted arenes. A recently developed aryne synthesis method requires only mild conditions of blue light or mild heat, opening the possibility of production of arynes with many functional groups at any position on the aryne ring. However, testing all combinations of functional groups is synthetically intractable. In this work, two predictive ML models were trained using computationally calculated Gibbs free energies of reaction. The first model was trained on a high dimensional, uninterpretable feature space to screen for synthetic viability of substituted arynes, which likely depends only on the ΔG_R of converting precursor to aryne. This model is able to predict ΔG_R for aryne synthesis with reasonable accuracy, including for arynes containing functional groups not seen in training. The second model was trained with smaller datasets composed of features understandable to humans and predicts the Gibbs free energies of synthesis as well as cis and trans dimerization of the aryne to gain insight into the effects of substituent properties on aryne stability. However, high error in this model necessitates further development.

23. **Jacob Emert**
Employing Decarboxylation to Study Field Effects
Advisor: Jessica Hoover
Mentor: Nandha Karthikeyan
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Ball State University
Abstract: Decarboxylative coupling reactions are used to form new C-C bonds using benzoic acids as coupling partners, and transition metals as oxidants and catalysts. One example of a metal- mediated decarboxylative coupling reaction utilizes silver as the oxidant wherein the silver coordinates the carboxylate and mediates decarboxylation. Previous investigation of well-defined silver-benzoate complexes revealed that the rate of decarboxylation is dependent on the field effect of the substituent. The field effect describes the electrostatic influence of a substituent on the electronic structure or reactivity of a molecule. Field effects are underexplored, and most studies have been computational in nature. Experimental insight into these phenomena remains scarce and there is still debate over whether they are through-space or through-bond effects. This work targets new experimental insights into field effects, by studying a series of silver carboxylate complexes and how the position and number of nitro-substituents on the carboxylates impact the rate of decarboxylation, and by extension, the field effect. The rate of decarboxylation will be measured using ^{1}H NMR spectroscopy. From the observed trends in decarboxylation, we will elucidate how different structural parameters - such as distance and dihedral angles between substituents, aromaticity, and number of substituents - influences the field effect.

24. **Grace Everts, Sam Kenney**
Opioid Overdose Response & Detection System
Advisor: Lana Yarosh
Mentor: Mindy Zhao
Sponsoring Program: Human-Centered Computing
Home Institution: Harvey Mudd College, Macalester College
Abstract: Opioid overdoses are incredibly dangerous and often life-threatening. Opioid overdoses are marked by a dangerously low breathing rate, which, if not addressed quickly enough, can cause permanent brain damage or death. Luckily, the easily administered drug naloxone almost immediately reverses the fatal effects of opioid overdose. Our project addresses how we can best detect and respond to an opioid overdose in public space. We are using the A121 MM-Wave Radar Sensor to detect depressed breathing rates indicative of an overdose. The A121 can detect chest movement through chairs, beneath coats, day or night. With statistical comparisons between radar and "real" breath data, we work to improve its accuracy and fine-tune its parameters. Alongside this work, we are developing a community overdose response system with the goal of empowering bystanders to administer naloxone during public overdose events. We are building a wired network of microcontrollers that will respond to an overdose alert from our RaspberryPi-Sensor system. In response to an overdose, our network will alert EMS and bystanders, dispense naloxone, and direct responders to the location of the overdose.

25. **Arabella Garcia**
Evaluating the protective role of glycosylation in antibody structure and stability by collision induced unfolding
Advisor: Varun Gadkari
Mentor: Rowan Matney, Eledon Beyene
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Glycosylation of antibodies contributes to antibody structure, stability and function. Immunoglobulin G1 (IgG1), the most common antibody in human serum, is commonly bioengineered to produce biotherapeutic antibodies used in various treatments. In this study, we use ion mobility-mass spectrometry (IM-MS) and collision-induced unfolding (CIU) to investigate the role of glycosylation in maintaining higher order structure and stability under stress conditions. A native deglycosylation protocol was optimized where IgG1 was deglycosylated by co-incubation with excess PNGase F (New England Biolabs). Deglycosylated IgG1 was isolated from the reaction mixture using size exclusion chromatography. Deglycosylated IgG1 samples were exposed to heat and freeze-thaw stress conditions, and analyzed by IM-MS and CIU. Preliminary CIU data indicates that IgG1 structure only subtly changed in response to freeze-thaw stress. A noticeable destabilization relative to the control was observed when the deglycosylated sample was exposed to heat conditions. An additional feature in the unfolding of the IgG1 was noticed in the stressed glycosylated samples. This indicates that stress conditions are inducing heterogeneity in IgG1 structure, with the deglycosylated structural populations unfolding differently during CIU measurements. Ongoing work is focused on evaluating additional forms of stress, and future work will evaluate these effects on commercially available bioengineered biotherapeutics.

26. **Jaime Garcia Jr**
Effect of weak magnetic fields on micelle formation of poloxamers
Advisor: Michelle Calabrese
Mentor: Krista Hauseman
Sponsoring Program: MRSEC
Home Institution: The University of Texas at Rio Grande Valley
Abstract: Poloxamers are triblock copolymers that consist of a hydrophobic midblock (polypropylene oxide (PPO)) and two hydrophilic endblocks (polyethylene oxide (PEO)). Due to this amphiphilic structure, poloxamers in solution form micelles, a self-assembled nanoscale structure with a hydrophobic core and hydrophilic corona, when above a critical micelle concentration (CMC) and critical micelle temperature (CMT). When exposed to low-strength magnetic fields, poloxamer solutions micellize and further self-assemble to form ordered soft solids. Magnetic field-driven ordering of poloxamers is not fully understood. One current hypothesis is that magnetic fields affect the hydrogen bonding structure of water, decreasing the solubility of PPO and driving micellization. To investigate the effect of hydrogen bonds in this system, solvents of differing hydrogen bond strengths (H_2O and deuterium oxide (D_2O)) were used to create poloxamer solutions, which were then ordered using magnetic fields. The modulus and structure of the resulting soft solids were measured using small amplitude oscillatory rheology (SAOS) and small angle X-ray scattering (SAXS). It was found that solutions made with D_2O, which has 0.2-0.3 kcal/mol stronger hydrogen bonds than H_2O, experienced a faster magnetic field-driven phase transition but resulted in similar micelle sizes and structures. These results show that solvent hydrogen bonding strength impacts magnetic field-driven ordering but that perhaps the breaking of hydrogen bonds by the magnetic field is not the sole mechanism. This work is important because magnetic fields may be used as a novel parameter to impact block copolymer assembly, which has uses in fields such as membranes, photonics, and biomedical materials.

27. **James Gómez Faulk**
Designing an Optimal Taper Between Media of Different Refractive Indices
Advisor: Shaul Hanany
Mentor: Scott Cray
Sponsoring Program: Physics REU
Home Institution: Case Western Reserve University
Abstract: This presentation will outline the process of designing an optimal taper between media of different refractive indices to create sub-wavelength structures which act as a cryogenically robust anti-reflection coating (ARC). An abrupt change in index of refraction causes reflection of incident light. To combat this phenomenon, an effective ARC is designed to minimize reflective loss. The presented design features an optimal refractive index transition based on the Klopfenstein transmission-line impedance taper. Two-dimensional effective medium theory closely approximates this optimal index transition via physical structures cut into the substrate medium. The resultant taper behaves as a high-pass filter which is optimal in the sense that it yields minimum in-band reflectance for a given length of taper, and a minimum length of taper for a tolerated in-band reflectance. Additionally, a sample design is presented which serves as a practical filter for Cosmic Microwave Background detection.

28. **Darian Gonzalez**
Core-crosslinking of block copolymer micelles
Advisor: Tim Lodge
Mentor: Evan Danielson
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Diblock copolymers, composed of two chemically distinct polymer blocks connected via a covalent bond, can self-assemble into nanoscale spherical structures known as micelles in the presence of a block-selective solvent. In concentrated solutions, these micelles can further organize onto a lattice, which disorders upon reaching the order-disorder transition temperature (T_{ODT}). Near the ODT, there is a redistribution of micelle sizes as well as the presence of free chains brought about by a mechanism known as chain exchange. The goal of this study is to determine whether chain exchange plays a role in determining $T_{ODT.}$ To test this, a poly(styrene)-b-poly(ethylene-alt-propylene) diblock copolymer (PS-PEP) was synthesized using reversible addition–fragmentation chain transfer polymerization (RAFT) from a PEP macro-RAFT agent. The PS block contains coumarin moieties capable of forming crosslinks, which, in micelles with PS cores, can inhibit chain exchange. Solutions of PS-PEP micelles were prepared in squalane at 30 wt% and annealed at 120 °C. Small-angle X-ray scattering (SAXS) revealed spherical micelles with core radii of ~58 Å and low polydispersity (σ ~9.6–9.7 Å), indicating well-defined structures. The copolymer exhibited a narrow molecular weight distribution ($Đ$ = 1.01), supporting uniformity in micelle formation. These results will be compared to the same system in which the micelle cores have been crosslinked and thus cannot change size or allow for the escape of single chains. This study will further our understanding of ordering behavior in block copolymer solutions, which is often complex and influenced by dynamic processes.

29. **Mikaylah Hanson**
Developing Automated Photometry Tools and Telescope Infrastructure for Rapid Transient Discovery
Advisor: Patrick Kelly
Mentor: Matt Anderson, Mandeep Gill
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota - Twin Cities
Abstract: The earliest light from violent cosmic events, such as supernovae and neutron star collisions, holds critical scientific information, but capturing it demands rapid-response telescopes and precise data analysis. The Total-Coverage Ultra-Fast Response to Binary-Mergers Observatory (TURBO) is developing one of the fastest facilities for high-cadence transient detection. TURBO's imaging requires efficient, automated photometric tools to extract, calibrate, and analyze lightcurves. This project addresses these needs by implementing a Python-based photometric module as part of TURBO's larger data reduction pipeline. Key features include optimal aperture determination, aperture correction, galaxy masking, limiting magnitude estimation, and cross-matching with the Pan-STARRS catalog. A standalone forced photometry tool allows team members to input specific coordinates to generate lightcurves directly from the pipeline's database. The module was tested on the Type II supernova SN 2024bch to demonstrate its ability to extract accurate photometry from high-cadence observations. In addition to software development, this project contributed to the physical construction of TURBO's telescope enclosures on Magdalena Ridge, NM. Together, these hardware and software advancements lay the groundwork for TURBO to capture the earliest phases of transient events, offering new insights into the origins and environments of cosmic explosions

30. **Ross Hebel**
Synthesis of Polyethylene-Polyester Triblock Polymers for Nanoporous Membrane Application
Advisor: Marc Hillmyer
Mentor: Brenden Hoehn
Sponsoring Program: Center for Sustainable Polymers
Home Institution: Gustavus Adolphus College
Abstract: Covalently bonding two or more incompatible macromolecules produces microstructured block polymers useful for nanoporous membrane preparation. In this research, we prepared polyethylene-polyester triblock polymers and selectively degraded the polyester, producing nanoporous polyethylene (PE) membranes. Previous work used polylactic acid (PLA) and PE to develop these membranes; however, the high segregation strength of these two blocks led to poor melt processability, leading to defects in the membranes. The aim of this study is to examine slightly more compatible polyester block types while still maintaining sufficient segregation to prevent breakout crystallization which alters the microstructure of the material during cooling. Rheological testing indicates 40-70 kg/mol polycaprolactone (PCL)-PE triblocks are more melt processable than PLA, while still maintaining its melt microstructure at low temperatures, confirmed by small angle x-ray scattering. However, increasing the polymer size can diminish melt processability as the segregation strength increases. The polyester polypentadecalactone (PPDL) has an even lower interaction parameter than PCL, making it more melt processable at high molar masses. However, the synthesis of high molar mass PPDL-PE triblocks is difficult due to the higher likelihood of transesterification and slow reaction times. Fine-tuning these syntheses will allow for triblock molar mass selectivity while still maintaining processability.

31. **Aubrie Hetherington**
3-D Printing Bioreactors for Continuous Cell-Free Gene Expression
Advisor: Vincent Noireaux
Mentor: Aset Khakimzhan
Sponsoring Program: Physics REU
Home Institution: Gettysburg College
Abstract: Cell-free transcription-translation (TXTL) reactions are used to build a variety of biochemical systems outside cells, such as genetic circuits. Yet, on their own, cell-free reactions last for 10-12 hours, which limits the complexity of potential genetic circuit designs. To prolong these reactions, a bioreactor needs to continuously supply nutrients to the TXTL solution through a permeable membrane. Current bioreactors are costly, single-use, low-throughput, and incompatible with standard fluorescence readers, which prevents temporal monitoring. Utilizing 3-D printing, we have created a cost-effective and fluorescence reader-compatible bioreactor to prolong the TXTL reactions by tens of hours. We have tested our designs by measuring the transport of dyes of different molecular masses across the bioreactor membrane. We have shown that we can control the size of molecules crossing the membrane. We are now moving on to the continuous feeding of TXTL reactions.

32. **Andrea Irizarry**
Neurotransmitter Detection with Carbon Dot-modified Microelectrodes
Advisor: Christy Haynes
Mentor: Rhea Caldwell, Eleni Spanolios
Sponsoring Program: Center for Sustainable Nanotechnology
Home Institution: University of Puerto Rico at Cayey
Abstract: Neurotransmitters play an important role in the nervous system, making them crucial for studying brain function and neurological diseases. For example, dopamine's imbalance can lead to Parkinson's disease. Common methods for detecting neurotransmitters are often costly, lack accessibility, and require a complex preparation of the sample. Electrochemical analysis with microelectrodes is a simple, low-cost method for detecting neurotransmitters with great sensitivity and selectivity. Carbon-fiber microelectrodes are well-known for their biocompatibility and reactive surface chemistry. This work focuses on modifying carbon-fiber microelectrode surfaces with amorphous polymeric carbon dots presenting a range of surface charges to enhance neurotransmitter interactions at the surface of the electrode with electrostatic attraction. This will increase the sensitivity of the electrode towards charged neurotransmitters during chronoamperometric measurements, providing a simple and accessible method for in vitro detection of neurotransmitters.

33. **Sofiya Ismagilova**
Testing the optimal storage parameters polymeric micelle-based delivery systems
Advisor: Theresa Reineke
Mentor: Sidharth Panda, Michael Leyden
Sponsoring Program: Independent Research
Home Institution: UMN Twin Cities
Abstract: mRNA-based therapeutics allow direct cytoplasmic protein expression without genomic integration, offering a safer alternative to DNA-based approaches. However, mRNA is inherently unstable and requires a delivery vehicle. While viral vectors and lipid nanoparticles (LNPs) have proven effective, concerns over toxicity, immunogenicity, and cost have driven interest in polymer-based vectors. Polymeric micelles—formed from amphiphilic block copolymers—offer design flexibility and low-cost production. When complexed with nucleic acids, they form micelleplexes. Prior studies identified A7-based micelles as top-performing in GFP expression and lung-specific delivery in vivo, but little is known about their long-term stability. This study examines how buffer (PBS vs. water), storage temperature (room temperature, 4 °C, −20 °C), and duration (1, 3, and 6 weeks) affect A7-mRNA micelleplex structural and functional stability. Transfection efficiency and mRNA retention were assessed. Preliminary data show that water-based storage consistently preserved transfection better than PBS. Notably, micelleplexes stored in water at −20 °C retained or slightly exceeded the performance of fresh samples. No mRNA release was detected under any condition, confirming structural stability. These findings establish −20 °C in water as the optimal storage condition for A7 micelleplexes and offer a reproducible framework to assess long-term storage stability in other polymer-based delivery systems.

34. **Glorianna Junokas**
Ranking Cryoprotective Agents by Vitrifiability
Advisor: John Bischof
Mentor: Casey Kraft
Sponsoring Program: ATP-Bio
Home Institution: Simpson University
Abstract: A key component in the cryopreservation of organs and tissues is to use high concentrations of cryoprotective agents (CPAs) to prevent damage from ice formation. The goal of this project is to rank cryoprotective agents based on their ice avoidance properties at 1 C°/min cooling. A prior ranking was published at 70 C°/min cooling, however we chose 1 C°/min cooling since 1 C°/min is around the achievable cooling rate for the center of a human-sized organ. In this study, we investigated four common CPAs: dimethyl sulfoxide, propylene glycol, ethylene glycol, and formamide. CPA solutions were prepared at 30 to 55 w/w % total CPA concentration in water then visually assessed for ice formation after cooling below -140°C. For single-component CPA solutions, our ranking was dimethyl sulfoxide (best) > propylene glycol > ethylene glycol > formamide (worst). In this study we observed significant interaction effects, with 2-component CPA solutions outperforming 1-component CPA solutions and 3-component CPA solutions outperforming 2-component CPA solutions. Of all CPA solutions tested, dimethyl sulfoxide + ethylene glycol + propylene glycol was the best, achieving ice avoidance at 35 w/w % total CPA concentration at 1 C°/min cooling.

35. **Vishal Karuppasamy**
Virtual Nature Immersion for Well-Being: Do Universal Design Principles Transcend Individual Preferences?
Advisor: Victoria Interrante
Mentor:
Sponsoring Program: Human-Centered Computing
Home Institution: University of Southern California
Abstract: Virtual reality (VR) nature immersion shows promise for enhancing well-being and attentional restoration, particularly for populations with limited access to real natural environments, such as elderly care home residents and chemotherapy patients. However, debates persist regarding whether individual preference differences negate general principles of restorative environmental design—for instance, whether features like biomass or water universally enhance restoration. Challenging this perspective, we hypothesize that population-level effects of environmental features exceed individual variance in predicted restoration outcomes. Using a crowdsourced sample, participants will evaluate perceived restoration after envisioning immersion in diverse VR environments, including forests, canyons, and scenes with or without water features. We will statistically partition variance into two components: (1) Within-environment variance, reflecting individual preference differences, and (2) Between-environment variance, capturing population-level design effects. We anticipate significantly greater between-environment variance, indicating that systematic design choices shift restoration expectations consistently across populations despite individual preferences. This work addresses skepticism about generalizable VR design insights. Findings will inform equitable deployment of VR nature experiences for vulnerable populations by clarifying contexts where universal design principles complement personalized preferences.

36. **Meryem Koksal**
Embodied Avatars: Gender Differences in Self-Reports of Cybersickness
Advisor: Evan Suma Rosenberg
Mentor: Tongyu Nie
Sponsoring Program: Human-Centered Computing
Home Institution: Grinnell College
Abstract: Investigating gender differences in reports of cybersickness can help develop methodologies to improve the accessibility of VR technologies. Previous research has found that men tend to report lower cybersickness scores than women, with underreporting by men suggested as a possible explanation. We aim to investigate this potential cause through two consecutive studies. In the first study, male participants will report cybersickness symptoms under two conditions while completing navigation tasks in a VR environment. In the second condition, participants will also wear a sensor that measures both heart rate and galvanic skin response and will be told that deception can be detected. In a follow-up study, we will examine the Proteus effect by comparing symptoms reported by male and female participants when they are embodied in either same-gender or gender-swapped avatars. We hypothesize that men will report higher - potentially more accurate - cybersickness scores when they believe that they are being monitored for deception. We also expect that self-reports from both men and women may be influenced by embodying a gender-swapped avatar. If supported, these findings would suggest that gender-based stereotypes influence self-reporting of cybersickness in VR, informing considerations of gender differences in the design and development of VR environments.

37. **Kaitlyn Leffler**
Polarized Total Internal Reflection Fluorescence Microscopy
Advisor: Joachim Mueller
Mentor: Isaac Angert
Sponsoring Program: Physics REU
Home Institution: New Mexico Institute of Mining and Technology
Abstract: Light microscopy is widely used in the life sciences to characterize biological samples. Because photon detectors measure light intensity, which is proportional to the square of the electric field amplitude, all phase information is lost. However, the vectorial nature of the electric field, characterized by its polarization, carries valuable information. This information is experimentally accessible by manipulating the polarization state of the light emitted by the sample before detection. Of particular interest is the ability to track the orientation of cell membranes as they undergo processes that involve changes in membrane curvature, such as endocytosis or viral budding. In this work, we develop advanced microscopy instrumentation based on a total internal reflection fluorescence microscopy modality that exploits the interaction of polarized light with a lipophilic dye, DiIC18, that labels the plasma membrane with excitation and emission dipoles approximately parallel to the bilayer. We outline constraints on the design of the optical system due to the polarization properties of individual optical elements, and analyze the final performance of the optical system. We explore the use of this technique to investigate details of retroviral assembly that are not readily accessible with standard imaging methods, particularly in relation to human immunodeficiency virus 1.

38. **Zoe Lipschultz**
Computational Design of Metal Oxides: Machine Learning-Accelerated Oxygen Diffusivity Predictions
Advisor: Chris Bartel
Mentor: Armand Lannerd
Sponsoring Program: MRSEC
Home Institution: University of Chicago
Abstract: The growth of cloud computing and AI has driven a surge in energy demand, prompting the search for energy-efficient computing technologies. Electric field control of metal oxides has shown some promise in meeting this challenge. In electrolyte-gated devices, metal oxides may respond to an electrical bias electrostatically or electrochemically. The latter is of particular interest as it drives the formation and annihilation of oxygen vacancies to control material properties. The ability of oxygen to move through these metal oxides—its diffusivity—is critical to enabling the electrochemical mechanism and is the primary focus of this project. Oxygen diffusivity can be extracted from ab initio molecular dynamics calculations, which simulate atomic motion from first principles. However, these calculations are computationally expensive, limiting simulation timescales and thereby diminishing the ability to capture diffusion events. Universal machine learning interatomic potentials (uMLIPs) offer a solution to this problem. These are graph neural networks trained to reproduce first-principles results at a fraction of the cost, enabling accurate longer-timescale MD simulations. In this project, we implemented and assessed the performance of uMLIPs for predicting oxygen diffusivity of metal oxides. We first reproduced established first-principles results for the cubic perovskite oxygen conductor, $Na_{0.5}Bi_{0.5}Ti_{0.96}Mg_{0.04}O_{2.96}$, using uMLIPs. We then explored diffusivity in $La_{1-x}Sr_xCoO_{3-\delta}$, a well-studied material for electrolyte-gated devices, to understand the effect of cation composition and oxygen vacancy concentration on oxygen diffusion. These analyses demonstrate how uMLIPs can be used to investigate oxygen transport in metal oxides for accelerated materials design.

39. **Jasmine Liu**
Characterizing Reaching Motion for Age-Conditioned Movement Generation
Advisor: Stephen Guy
Mentor: Shelby Ziccardi
Sponsoring Program: Human-Centered Computing
Home Institution: Harvey Mudd College
Abstract: It has been shown that human movement strategies mature as individuals age, but integrating these insights into animation remains both challenging and underutilized. In this work, we analyze over 25,000 human reaches collected from individuals engaging with motion-based, augmented reality games. We used this data to characterize movement capabilities from diverse populations and develop a convolutional autoencoder that maps reach trajectories into a compact latent space. From these encodings, we predict both the age of the individual and future movement trajectories. The project's ultimate goal is to develop a tool that takes in guiding points and generates a realistic human trajectory conditioned on age. This tool would help accelerate human reaching animation and represent realistic motion strategies in differently aged digital characters.

40. **Nicolas Manning**
Improving Mechanical Integrity in Carbon-Based Microneedle Sensors
Advisor: Andreas Stein
Mentor:
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Lock Haven University of Pennsylvania
Abstract: The integration of nanostructured carbon into all-solid-state ion-selective electrodes (SC-ISEs) allows miniaturized, calibration-free sensing with greater signal stability. Two routes were pursued to fabricate microneedle electrodes. First, colloid-imprinted mesoporous (CIM) carbon was obtained by polymerizing resorcinol–formaldehyde in the presence of colloidal silica, casting the resin–silica blend into PDMS molds, carbonizing, and etching the template. The resulting high-surface-area carbon microneedles were examined by SEM and nitrogen sorption (BET) to verify structural integrity and porosity. Second, mechanically robust arrays were fabricated by covalently attaching Super P carbon to gold substrates through diazonium chemistry. Using *p*-phenylenediamine, a single diazonium layer grafted amide coupling sites, while an alternative route was used form a dual diazonium interface. Both schemes strengthened the gold–carbon junction without markedly affecting conductivity, which is sufficient for potentiometric readout because current remains negligible. NMR and FTIR will confirm bond formation. By combining controlled pore architecture with chemically bonded interfaces, the resulting SC-ISE platforms overcome brittleness and contact instability, opening a path toward long-lived ion-selective microneedle sensors suitable for on-skin or *in vivo* monitoring. Future efforts will focus on integrating reference membranes and validating ion selectivity under physiologic conditions *in vitro* and *in vivo* trials.

41. **Ellen Mathews**
Investigation into the synthesis and characterization of periodate-oxidized cellulose nanomaterials for advanced self-assembling hydrogels and antibacterial coatings
Advisor: Boya Xiong
Mentor: Ji Qin
Sponsoring Program: MRSEC
Home Institution: Macalester College
Abstract: Cellulose, the most abundant natural polymer, is an ideal sustainable alternative to petroleum- based materials due to its excellent mechanical properties and renewability. However, traditional cellulose nanocrystals (CNCs) suffer from aggregation, instability, and lack intrinsic antibacterial capabilities. Sterically stabilized nanocrystalline cellulose (SNCC)—comprised of crystalline cellulose cores flanked by amorphous chains—overcomes these limitations through enhanced dispersion stability via steric hindrance, intrinsic antibacterial activity (via covalent cross-linking with bacterial membrane proteins), and self-assembly properties (via hemiacetal bonding). These attributes make SNCC promising for applications in self-assembling hydrogels and antibacterial coatings. Dialdehyde-modified cellulose (DAMC), an amorphous and soluble byproduct generated during cellulose oxidation, provides a unique mechanism to modulate the amorphous-to-crystalline ratio in SNCC-based materials, optimizing hydrogel elasticity and coating flexibility. However, our understanding of how the SNCC/DAMC synthesis process, including product separation and the effects of oxidation time and heating time, influences sample purity, aldehyde content, particle size distribution, and crystallinity remains incomplete. This summer, we have investigated the SNCC/DAMC separation process as well as the effects of varying oxidation durations (42, 72, and 144 hours) and heating periods (1, 2, and 6 hours) during SNCC synthesis, generating nine distinct SNCC/DAMC variants. Analytical methods including FTIR (chemical functional group), DLS (particle sizing), and hydroxylamine hydrochloride titration (oxidation degree), have been employed to elucidate a comprehensive "process-structure-performance" relationship. This research advances fundamental understanding and offers practical guidelines for optimizing SNCC/DAMC properties and synthesis, facilitating their application in innovative antibacterial coatings and self-healing hydrogels.

42. **Nick Mazzoni**
Computing Massive Five-Point Amplitudes from On-Shell Methods
Advisor: Zhen Liu
Mentor: Ishmam Mahbub
Sponsoring Program: Physics REU
Home Institution: University of Massachusetts-Amherst
Abstract: Over the past two decades, complex momentum shifts have enabled the computation of previously intractable scattering amplitudes. One such shift scheme—the all-line transverse shift for massive particles—has recently been applied to compute four-point electromagnetic and gravitational Compton amplitudes involving massive higher-spin particles. This method has also been shown to extend constructibility to five-point amplitudes with four massive external legs up to spin-5/2 in the gravitational case. In this work, we compute the electromagnetic and gravitational five-point amplitudes for four equal-mass scalars coupled to a photon or graviton. These results are particularly relevant to modeling Kerr black hole scattering. Our amplitudes are manifestly free of spurious poles. To support our computation, we also employed an inverse-soft approach, reconstructing the five-point amplitude from its soft limit. We are currently extending this analysis to the gravitational amplitude for spin-5/2 particles.

43. **Anya Morris**
Explainable AI: Visuals towards AI Education
Advisor: Qianwen Wang
Mentor:
Sponsoring Program: Human-Centered Computing
Home Institution: Colby College
Abstract: The use of AI, especially LLMs like ChatGPT, is so widespread that it is becoming common knowledge in certain parts of the world. Despite their everyday use by many, the computational side of LLMs are not widely understood by general users. This can lead to misuse or misinformation of the popular technology. Therefore, our research poses the question: What are good ways to educate the public on LLMs? Our hypothesis is that the most effective method includes an explanation of the inner workings of LLMs, followed by a discussion of their capabilities and limitations using visualizations. We believe that users may better understand which tasks they are or are not good at once they have a grasp of how LLMs work from a technical standpoint. To test this, we have created a website that utilizes visualizations of explainable AI. After introducing the topic, we discuss data, pretraining, word predictions, capabilities like genre imitation, and limitations like bias. Given more time, we would create a study comparing users' learning experience from no tutorial, a text tutorial, and our visual tutorial.

44. **Ntsika Mtwa**
Imaging-based 3-D particle tracking system for characterization of firebrand particle dynamics
Advisor: Jiarong Hong
Mentor: Yue Weng
Sponsoring Program: MRSEC
Home Institution: Brown University
Abstract: The spotting phenomenon, involving firebrand generation, transport, deposition, and reignition, is a major component of wildfire spread. Previous work has been done to explore firebrand transport and generation using experimental and numerical methods, though to our knowledge, this is the first field investigation of firebrand kinematics using 3-D Lagrangian particle tracking. Our study focuses on characterizing 3-D firebrand kinematics with the goal of improving the accuracy of firebrand transport models and gaining new insights into inertial particle dynamics in atmospheric flows. We use a 3-D particle tracking velocimetry system to capture trajectories from firebrands generated in an outdoor bonfire under weak atmospheric conditions. This study aims to uncover the underlying physics of firebrand dispersion and offer practical guidelines for wildfire prevention.

45. **Christopher Nieves**
SERS Characterization of Bacterial Metabolites for Foodborne Pathogen Detection
Advisor: Christy Haynes
Mentor: Mahmoud Matar Abed
Sponsoring Program: Center for Sustainable Nanotechnology
Home Institution: University of Puerto Rico, Cayey
Abstract: Pathogenic microbes cause approximately 48 million foodborne illnesses annually in the United States, with bacteria accounting for an estimated 39% of cases according to the CDC. Listeria monocytogenes and Salmonella enterica are among the most common bacterial pathogens responsible for food contamination and hospitalizations. Early detection of these foodborne pathogenic bacteria could significantly reduce hospitalization rates and prevent potential outbreaks. While many approaches exist for bacterial detection, an indirect method involves analyzing their purine metabolism byproducts. This work explores surface-enhanced Raman spectroscopy (SERS), a technique that leverages plasmonic nanostructures to significantly enhance the Raman scattering signal, to detect foodborne pathogens by characterizing key metabolites produced by Salmonella enterica and Listeria monocytogenes. We fabricate plasmonic metal film over nanospheres (FONs) as biosensors by leveraging linear polymers as affinity agents. These substrates enhance Raman scattering sensitivity, allowing construction of calibration curves for purine metabolism byproducts including adenine, guanine, xanthine, and hypoxanthine. Additionally, bacterial stress-inducing experiments will be performed to characterize metabolic changes in these pathogenic bacteria under various conditions.

46. **Lydia Nyambane**
SNR Predictor Using Machine Learning
Advisor: Michael Coughlin
Mentor: Argyro Sasli
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota - Twin Cities
Abstract: LISA is a space-based gravitational-wave detector that will enable discoveries in the millihertz regime. It is expected to detect gravitational waves from a wide variety of sources, including extreme-mass-ratio inspirals, galactic binaries, and mergers of massive black holes. This project was done in mind of computational costs using traditional methods like Parallel Tempering Markov Chain Monte Carlo (PTMCMC) sampling and reversible-jump MCMC (RJMCM) which are also computationally and time intensive, but still incorporated into the algorithm. Therefore a machine learning approach was adopted to accelerate computation time, while maintaining the same accuracy. The primary objective of the machine learning algorithm is to predict the signal-to-noise ratio (SNR) as accurately as possible, relative to values computed using traditional techniques. This method will be integrated into the EREBOR Global Fit pipeline – a technique used to extract multiple overlapping signals from LISA data – resulting in up to a tenfold speed-up in computation time.

47. **Ndiana Obot, Arianna Lam, Rohan Joshi**
PALM: A Low-Cost, Wearable Vibrotactile and Thermal Feedback Device for Upper Limb Prostheses
Advisor: Zhinan Wang
Mentor: Isabella Montanaro
Sponsoring Program: Other
Home Institution: Hinsdale South High School
Abstract: An estimated 2.3 million Americans live with limb loss, and 30% are affected by upper limb amputations. 185,000 amputations are performed in the U.S. annually, and around 6–7 out of every 10,000 births involve congenital upper limb differences. Despite technological advances, upper limb prosthetic abandonment remains widespread—ranging from 24% to over 70%—largely due to a lack of sensory feedback and the high cost of advanced devices. Existing feedback methods, such as targeted muscle reinnervation (TMR), are invasive, expensive, and often inaccessible. To address this, we developed a non-invasive, low-cost, and self-contained vibrotactile and thermal feedback device, PALM (Prosthetic Adaptive Limb Module), compatible with most upper limb prostheses. The system integrates thermistors, heater fabrics, a Peltier module for thermal feedback, and a computer vision pipeline using an ESP32 camera and various embedded Image Feature Extraction algorithms for texture analysis. A K-Nearest Neighbors (KNN) regression model estimates surface roughness with near real-time responsiveness and maps it to a vibrotactile actuator for haptic output. All components are compact, lightweight, and collectively cost under $90. The device avoids surgical procedures and calibration-heavy systems, offering a scalable solution to enhance embodiment, reduce abandonment, and improve prosthesis functionality in daily use.

48. **Elise Ozers**
Evaluating the stability of amph-antigens in the gut mucosa towards bioengineering enhanced vaccines and immunotherapies
Advisor: Brittany Hartwell
Mentor: Erin Templeton
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota, Twin Cities
Abstract: Mucosal barrier tissues and associated lymphoid tissues are promising targets for vaccines and immunotherapies. While well motivated by mucosal biology, mucosal delivery of protein antigens (Ags) can be limited by mucociliary clearance, tight epithelial junctions, and degradative protease and pH conditions. Amphiphile-Ags (amph-Ags) have overcome clearance and transport challenges, however, this study evaluated if amph-Ags are protected from degradative mucosal conditions. Ovalbumin (OVA), HIV antigen glycoprotein D (gD), and their amph counterparts were tested for degradation in simulated gastric fluid (SGF) conditions. With OVA, a protein that forms oligomers under harsh conditions to protect from degradation, amphiphile conjugation resulted in more protein degradation than soluble OVA. However, with gD, amph-gD was protected from degradation at one minute when soluble gD was not. When amph-gD was preincubated with alpha- or beta-lactalbumin, proteins that can bind the lipid of the amph-Ag and dissociate micelle formation, antigen protection decreased by 97% in the alpha group, and 98% in -beta. Across all gD groups, there was no antigen signal by five minutes. These results indicate that for non-oligomerizing proteins, amph conjugation provides protection from mucosal proteases via micelle formation. However given the time scale and mechanism of amph delivery, mucosal degradation remains a limitation.

49.	**Helen Parker** *Earlier Warnings for High Intensity Solar Flares Using X-rays* **Advisor:** Lindsay Glesener **Mentor:** Yixian Zhang **Sponsoring Program**: Physics REU **Home Institution:** Illinois State University **Abstract:** Solar flares emit intense electromagnetic radiation when they occur. These can cause significant problems, such as disrupting GPS signals, power grids, and satellites if plasma ejections from these flares reach the earth's magnetosphere. While coronal mass ejections (CMEs), which can commonly be forecast with a few days' notice, cause the most severe impacts, solar flares also carry serious threats, including radio blackouts. Early notice of solar flares which may pose problems to our instruments enables timely operational reactions, mitigating possible disturbances. Currently, we have access to near real-time soft X-ray (SXR) data, which provides a few minutes warning, but the time delay in hard X-ray (HXR) data transmission is much greater. In this work, we examine SXR and HXR time evolutions to determine if HXR information correlates to its corresponding SXR, and to assess the predictive power of HXRs on large solar flares. Considering nonthermal electron acceleration is generally followed by thermal plasma heating, we find it is typical for HXR peaks to occur before SXR peaks in large solar flares.
50.	**Lucas Pasdo** *AFM Lithography with Local Anodic Oxidation* **Advisor:** Ke Wang **Mentor:** Shiyu Guo **Sponsoring Program**: Physics REU **Home Institution:** University of Pittsburgh **Abstract:** Graphene based electronics offer many advantages compared to conventional metal electronics. Graphene's higher conductivity and higher carrier mobility, as well as its 2D structure, make it an exciting possibility for fabricating quantum electronics. Our lab has been focused on constructing a quantum dot out of graphene. In order to do this a narrow constriction is required, which mechanical cutting is unable to provide. Therefore we have been developing a method that utilizes local anodic oxidation, which provides the accurate cuts of graphene that will be necessary to construct a quantum dot.
51.	**Dev Patel** *Temporal Spatial Region-GPT: Dataset Curation for Grounded Spatiotemporal Reasoning in Autonomous Vehicles* **Advisor:** Seongjin Choi **Mentor:** **Sponsoring Program**: UROP/URS **Home Institution:** University of Minnesota - Twin Cities **Abstract:** An important concern in developing current autonomous driving (AD) systems is the "Curse of Dimensionality". When driving, one has to be concerned with not only an incredible number of objects, but properties like the size and speed of each of those objects. AD systems, specifically those implemented with Vision-Language Models (VLMs). Previous work, namely SpatialRGPT, has addressed this by creating more robust and grounded dataset collection pipelines. Specifically, SpatialRGPT uses a multistage pipeline that segments and labels 2D images to get accurate 3D point cloud recreation. This work seeks to build upon SpatialRGPT's work by proposing that spatiotemporal reasoning, not just spatial reasoning, is required for robust VLM applications in AD. To accomplish this, multiple frames of 2D images with their 3D annotations are interpreted in sequence, encoding the motion of these objects across time. This allows for the model to understand the direction and speed of objects across multiple frames. To summarize, the dataset pipeline takes multiple 2D images, annotates them with 3D point cloud data, relates multiple frames from the same video, and generates question-answer pairs from a template. These pairs can be rephrased with other Large Language Models and then used to annotate training images.
52.	**Evan Pouliot** *Using GLAFIC software and multipily lensed images to model the mass distribution of lensing cluster RX J2129* **Advisor:** Patrick Kelly **Mentor:** Birendra Dhanasingham **Sponsoring Program**: Physics REU **Home Institution:** Gustavus Adolphus college **Abstract:** I used GLAFIC software to create a mass model for galaxy cluster RX J2129 that can successfully replicate several observed multipily lensed objects. I discuss the successes and failures I had while using this strategy.

53. **Avyukt Raghuvanshi**
Astrophysical or Terrestrial: Machine Learning classification of gravitational-wave candidates using multiple-search information
Advisor: Michael Coughlin
Mentor: Andrew Toivonen
Sponsoring Program: Independent Research
Home Institution: University of Minnesota
Abstract: Low-latency gravitational-wave alerts provide the greater multi-messenger community with information about the candidate events detected by the International Gravitational-Wave Network (IGWN). Prompt release of data products such as the sky localization, false alarm rate (FAR), and τ_pastro values allow astronomers to make informed decisions on which candidate gravitational-wave events merit target of opportunity (ToO) follow-up. However, false alarms, often referred to as "glitches," where a gravitational-wave candidate, or trigger, is the result of terrestrial noise, are an inherent part of gravitational-wave searches. In addition, with the presence of multiple gravitational-wave searches, different searches may have varying assessments of the significance of a given trigger. As a complement to quantities such as τ_pastro, we provide a Machine Learning (ML)–based approach to determining whether candidate events are astrophysical or terrestrial in nature, with a classifier that utilizes multiple pipeline information in its feature space. This classifier has a performance Area Under the Receiver Operating Characteristic Curve (AUC) of 0.96 and accuracy of 0.91 on the Mock Data Challenge training set and an AUC of 0.94 and accuracy of 0.88 on events from the Advanced LIGO (aLIGO)'s and Advanced Virgo (AdVirgo)'s third observing run (O3) observing run.

54. **Harrison Redfern**
Methods for Measuring Polarized Microwave Field Distribution
Advisor: Dan Dahlberg
Mentor:
Sponsoring Program: Physics REU
Home Institution: Carleton College
Abstract: The typical solution to Maxwell's equations describes a plane wave in which field strength in the radial direction perpendicular to the axis of propagation is either left unspecified or approximated as uniform. To investigate the true spatial extent of a photon's electromagnetic field, we seek to measure the effective cross-sectional size of a 10 GHz linearly polarized microwave by studying interactions with various polarizers. This allows us to determine an approximate interaction diameter of a photon, which is useful knowledge for better understanding interactions within a photo-optical apparatus and developing a classical model for the size and energy distribution of a photon.

55. **Reilly Riemer**
Synthesis of C3-Substituted Endochin-like Quinolones
Advisor: Alex Grenning
Mentor: Akash Gogate
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Smith College
Abstract: Endochin-like quinolones (ELQs) are active pharmaceutical intermediates that have been developed because of their bioactivity against toxoplasmosis, but ELQs often suffer from low solubility due to their high crystallinity. ELQs face further challenges as alkyl substituted molecules are metabolized at the C3-substituted position, and many highly bioactive ELQs feature a C3 biaryl ether which also leads to lower solubility due to pi-pi stacking interactions. Through the attempted synthesis of two target ELQs, the work described herein addresses the limitations of ELQ solubility and metabolic stability via the synthetic modification of the C3 position. Firstly, a nucleophilic aromatic substitution reaction with a secondary alcohol substrate followed by an aromatic ortho-Claisen rearrangement introduces a quaternary center at the C3-substituted position to block metabolism. In addition, a Pd catalyzed Suzuki cross-coupling between the iodinated and ethylated quinoline core and a hindered boronic ester creates a hindered biaryl ether at the C3 position, increasing the dihedral angle to interrupt pi-pi stacking interactions. These synthesized ELQ precursors provide a proof of concept for the further development of these substrates.

56. **Airam Rivera**
Characterization of Polymer Degradation for Controlled Peptide Release in Melanoma Vaccine Development
Advisor: Chun Wang
Mentor: Sandra Shahriar
Sponsoring Program: MRSEC
Home Institution: University of Puerto Rico at Humacao
Abstract: Despite advances in immunotherapy, treatment options for metastatic melanoma remain limited. A promising strategy involves targeting the BRAF V600E mutation, found in approximately 50% of melanoma cases. This mutation produces a tumor-specific peptide that can be used to develop a vaccine that stimulate the immune respond with novel injectable liquid polymer called CAP-O1. CAP-O1 consists of polycaprolactone (PCL) units linked by hydrolytically labile ortho-ester bonds, which degrade in the presence of water. Once injected, the polymer is expected to gradually release the peptide, promoting a sustained immune response—particularly $CD8^+$ T cell activation. We investigated the degradation of CAP-O1 under physiologically relevant conditions using Nuclear Magnetic Resonance (NMR) spectroscopy. Our results show complete monomer degradation in about two weeks at pH 5 and within two days at pH 3, indicating faster degradation in acidic environments. Slower degradation is anticipated at pH 7. CAP-O1 was also compared to a structurally similar polymer, CAP-OB1, which contains a propyl substitution at the ortho-ester bond. Due to its increased hydrophobicity, we hypothesize that CAP-OB1 will degrade more slowly under the same conditions. This comparative study supports the selection of optimized polymer systems for controlled peptide release, potentially improving the efficacy of melanoma vaccines.

57. **Alejandro Rodriguez**
TEM study of DNA Decorated Noble Metal Nanoparticle Using Python-based Software for Quantitative Analysis
Advisor: Andre Mkhoyan
Mentor: Rishi Raj
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Transmission Electron Microscopy-based imaging is a crucial method of specimen characterization due to its capability to study materials at the atomic-scale using a high energy electron beam . This project focuses on the computational analysis of DNA decorated noble metal nanoparticle (NP) TEM images acquired under phase and Z-contrast conditions. Processing these TEM micrographs will allow for a better understanding of the morphological and structural properties of these NPs. Utilizing the digital processing software SimpliPyTEM, quantitative data such as particle size, particle density, and spatial distribution can be extracted. By employing scripting tools and automation, analyzing TEM images becomes more accurate and consistent when compared to manual methods. The findings from this project aim to support broader biomedical applications, in which precise control and understanding of particle size is crucial. Applications such as enhanced drug delivery, fluorescence bioimaging, increased detection and control of biomedical activity, could all be improved by manipulating the particle morphology of these systems. Furthermore, this project also serves to highlight the growing role of computational tools in materials characterization. Emphasizing the importance of open-source platforms and scripting in nanomaterial analysis, exhibiting interdisciplinary application of computational processing in advanced nanoscale research.

58. **Gabrielle Ross-Harvey**
Iron Oxide Encapsulation in Liposomes for Targeted Hyperthermia
Advisor: Samira Azarin
Mentor: Senjuti Karmaker
Sponsoring Program: MRSEC
Home Institution: Stony Brook University
Abstract: Ovarian cancer remains the most fatal gynecological cancer due to late detection and subsequent metastasis. Magnetic hyperthermia, which uses heating by a magnetic field to trigger cancer cell apoptosis, has emerged as an alternate therapeutic modality to traditional treatment. Magnetoliposomes, lipid-based particles loaded with magnetic nanoparticles, are being developed for this noninvasive, thermal therapy. Our research advances these developments by loading iron oxide nanoparticles (IONP) into liposomes capable of generating heat with magnetic hyperthermia to treat ovarian cancer. We implemented two commonly practiced methods of liposome synthesis to evaluate their efficiency at encapsulating IONPs: thin film hydration and freeze-thaw methods. While both methods averaged optimal liposome diameters of 76.9 ∓ 0.123 nm, the freeze-thaw method encapsulated a higher concentration of IONPs, which is advantageous. We explored centrifugation parameters to remove free IONPs, resulting in stable magnetoliposome sizes of 71.2 ∓ 1.03 nm. To test heating efficacy, magnetoliposomes were subjected to an alternating magnetic field, and we observed a temperature increase of 1.1 ℃ in 60 seconds, indicating further optimization is needed. Overall, this work demonstrates our capacity to load IONPs into liposomes, which can potentially generate sufficient heat for tumor-killing as a promising noninvasive treatment for other hard-to-cure cancers.

59. **Yaneiska Ruiz Torres**
Understanding and Manipulating the Electrical Double Layer in Electrocatalysis
Advisor: Kelsey Stoerzinger
Mentor: Mohan Aditya Sabbineni
Sponsoring Program: MRSEC
Home Institution: Universidad Ana G. Méndez - Cupey Campus
Abstract: Electrocatalysis is central to sustainable energy technologies, enabling key interfacial redox reactions that drive clean energy conversion and storage systems. The performance of electrocatalysts is critically governed by the electrode–electrolyte interface, where charge transfer, reactant adsorption, and interfacial dynamics collectively determine reaction rates and selectivity. A promising approach to enhance catalytic performance without altering the underlying atomic structure is through precise modulation of the electrical double layer (EDL). By tuning the chemical and electronic properties of this interfacial region, one can systematically control surface electronic states and adsorption characteristics, thereby influencing reaction kinetics and product selectivity. This study explores interfacial tuning strategies through the functionalization of platinum (Pt) and gold (Au) surfaces using a novel class of organic ligands known as N-heterocyclic carbenes (NHCs). These ligands can modulate the local electronic environment of active sites and reorganize the interfacial water structure within the EDL, both of which are expected to impact electrocatalytic behavior. The influence of NHCs at varying surface coverages on the hydrogen evolution reaction (HER) will be systematically investigated using cyclic voltammetry (CV). Enhanced current responses at a given overpotential in a three-electrode configuration will serve as indicators of improved catalytic kinetics.

60. **Yukti Sah**
Equity in Clinical Trial Participation for Deep Brain Stimulation in Parkinson's Disease
Advisor: Anant Naik
Mentor: Jacob Weiner
Sponsoring Program: Independent Research
Home Institution: University of Minnesota - Twin Cities
Abstract: Deep brain stimulation (DBS) is a well-established neurosurgical treatment for advanced Parkinson's disease (PD), improving motor symptoms and quality of life in select patients. Equitable access and clinical trial representation are essential for ensuring therapy generalizability. This study reviews ongoing DBS for PD (DBS-PD) trials, focusing on disparities in design and participant demographics. A systematic ClinicalTrials.gov search identified DBS-PD trials from 1999–2025. Trial characteristics—including year, funding, and geographic region—were extracted, and NIH funding was linked using a custom offline tool. Gender and racial disparities were quantified via the Gender and Racial Disparity Indices. RStudio regression models assessed associations between trial characteristics and enrollment disparities. Preliminary analysis showed an increase in DBS-PD trials and female enrollment over the past two-decades. Of 414 trials, 44 reported both race and gender data, with a noticeable white male overrepresentation aligning with known PD demographics. Significant predictors of racial disparity were identified: trials conducted in certain regions (OR = 0.20, p = 0.03) and with higher NIH funding (OR ≈ 1, p = 0.02) had overall lower disparity. No significant predictors were found for gender disparity. Despite progress, persistent enrollment gaps underscore the urgent need for intentionally inclusive, regionally representative, NIH-supported clinical trial frameworks.

61. **Phaedra Salerno**
Investigation of Salt Nucleation via Deep Learning–Based State Predictive Information Bottleneck
Advisor: Sapna Sarupria
Mentor: Porhouy (PH) Minh
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Williams College
Abstract: Nucleation—the first step in crystal formation, wherein molecules or particles begin forming an ordered phase—underlies many natural and industrial processes. However, direct experimental observation is difficult due to the short length- and timescale of the event, making molecular dynamics simulations a vital tool. Salt nucleation is particularly relevant to industry, as controlling nucleation via chemical additives is crucial to inhibit plug formations. Salt nucleation can occur via a one-step mechanism, adhering to classical nucleation theory, or a two-step mechanism at high supersaturation, where an amorphous cluster first forms, followed by a crystalline reordering within the amorphous cluster. However, the exact concentration at which the mechanism switches from one-step to two-step is debated. We leverage a deep learning state predictive bottleneck (SPIB) approach to learn the reaction coordinate from nucleation trajectories at key concentrations to resolve discrepancies in past studies. We hypothesize that SPIB can resolve the number of metastable states that nucleation trajectories go through at a given time lag, ultimately revealing the number of energy minima and, thus, whether nucleation at such concentrations occurs via one or two steps. Although preliminary, this approach promises new mechanistic insights into salt nucleation and improved strategies for additive design in industrial contexts.

62. **Eduardo Sánchez**
Cationic Polymers for mRNA Delivery
Advisor: Theresa Reineke
Mentor: Sidharth Panda, Janey Sowada
Sponsoring Program: MRSEC
Home Institution: University of Puerto Rico at Humacao
Abstract: Genetic diseases arise from impaired protein production of cells. This makes mRNA, a precursor to proteins, a promising novel therapeutic tool for treating genetic disorders. However, mRNA's instability makes it susceptible to degradation and requires protective delivery systems. Cationic polymer-based carriers offer flexibility due to their modifiable structures, but while previous studies have optimized these for pDNA, siRNA, or Cas9 delivery, mRNA delivery remains less explored. This research aims to address that gap through the combinatorial synthesis of two polymer libraries that self-assemble into diblock and triblock micelles. Each library will feature amphiphilic polymers with varied cationic side chains differing in three key physical aspects: (1) bulkiness, (2) pKa, and (3) hydrophilicity. These polymers will be tested to examine their ability to deliver mRNA in vitro, alongside assessments of cellular uptake and mRNA release. The findings will provide insights into how polymer structure influences delivery efficiency, guiding the design of more effective mRNA vectors for the future. The study will also explore polymersomes, vesicle-like carriers capable of shielding mRNA from degradation, offering further advancement in mRNA-based therapies and the development of next-generation delivery systems.

63. **Ryan Schulte**
Cationic ring-opening polymerization of lactones derived from isoprene, butadiene, and CO_2
Advisor: Ian Tonks
Mentor: Madhur Bhatt Christopher Webber
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Augustana University
Abstract: Carbon dioxide (CO2) has been widely considered an ideal sustainable polymer feedstock due to its prevalence as industrial waste. As a result, the telomerization—or cotelomerization—of CO2 with 1,3-dienes to form disubstituted □-lactones has become an important area of study. One less investigated 1,3-diene for this application is isoprene. While currently sourced from petroleum, isoprene is also a biomolecule that has the potential to be sourced from bio-based feedstocks, making it ideal for sustainable polymer synthesis. Previous work showed that the cotelomerization/hydrogenation sequence with butadiene and isoprene yielded two coupled lactones, 3-ethyl-6-(prop-1-en-2-yl)tetrahydro-2H-pyran-2-one (EtPeP) and 3-ethyl-6-methyl-6-vinyltetrahydro-2H-pyran-2-one (EtVMeP), and the butadiene homocoupled lactone, 3-ethyl-6-vinyltetrahydro-2H-pyran-2-one (EtVP). Polymerization studies showed that EtVMeP is unable to undergo anionic ring-opening polymerization as it terminates further growth when incorporated as a chain end. Alternatively, cationic ring-opening polymerization (cROP) is another method of polymerization that could unlock the polymerization of a more substituted lactone such as EtVMeP. Herein, we report the independent synthesis and cROP polymerization studies of disubstituted lactones EtPeP, EtVMeP, and related lactones.

64. **Aiswarya Senthil**
Guided Immersion: The Impact of a Preamble in Virtual Nature Experiences for Stress & Attentional Fatigue Recovery
Advisor: Victoria Interrante
Mentor:
Sponsoring Program: Human-Centered Computing
Home Institution: Cornell University
Abstract: This study investigates the extent to which a preamble providing guidance and intent can enhance the restorative effects of virtual reality (VR) forest-bathing experiences, aligning with research emphasizing the benefits of mindful engagement in nature. Drawing on Attention Restoration Theory (ART), we hypothesize that promoting more thoughtful attention will better evoke "soft fascination," allowing depleted directed attention to replenish. Based on Stress Reduction Theory (SRT), we also anticipate that the preamble will lead to increased parasympathetic nervous system activity, supporting stress recovery. Participants will undergo an n-back stress induction task before immersion in a realistic VR nature environment. Restoration will be assessed via physiological (heart rate, GSR), psychological (PANAS, PRS), and behavioral measures (walking speed, head rotation). We expect that participants who receive the preamble and in-experience guidance will exhibit enhanced psychological wellness and faster physiological restoration compared to those who do not. By demonstrating that intentional guidance can amplify the benefits of VR nature exposure, this research has the potential to offer insights for designing more effective digital mental health interventions. The findings may contribute to the development of scalable, technology-based tools supporting the United Nations' Sustainable Development Goal of promoting mental health and well-being.

65. **Tomas Sepulveda**
Development of Fused 1,2,3-Triazole-Based HDAC/BRD4 Inhibitors for Chronic Neuropathic Pain
Advisor: William Pomerantz
Mentor:
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota Twin Cities
Abstract: Abstract: Due to limited and ineffective clinical treatments, combination therapies of two or more drugs have emerged as valuable and safer approaches to combat neuropathic pain. Evidence has linked inflammation to pain through upregulation of pro-inflammatory cytokine expression, regulated by epigenetic mechanisms reliant on post-translational acetylation of histones. Histone deacetylases (HDACs) and Bromodomain and Extraterminal (BET) proteins have been shown to be overexpressed in neuropathic pain models, with synergistic effects as a result of co-inhibition of BET and HDAC proteins. Here, we propose the development of a dual HDAC/BET inhibitor based on NV1127. NV1127, which is readily synthesized and possesses low molecular weight, has ideal properties to serve as a basis for dual inhibitor design. By generating tool compounds to study neuropathic pain via epigenetic mechanisms, we hope to expand our understanding of neuropathic pain's pathophysiology and uncover new avenues of treatment. Synthetic progress towards a first-generation inhibitor will be described.

66. **Amin Sharif**
Making Counting Easy: An Expository Look into Polya Theory.
Advisor: Victor Reiner
Mentor:
Sponsoring Program: TRIO McNair Scholars Program
Home Institution: University of Minnesota Twin Cities
Abstract: Enumerative combinatorics is an area of math concerned with counting the number of distinct configurations for a set of discrete objects. Some examples of this are poker hands, configurations of chess pieces, isomers of a chemical compound, and configurations of atoms in a crystal structure. Polya's Enumeration Theorem (a.k.a Polya counting) is a powerful tool that counts the number of distinct arrangements while accounting for geometric symmetry. This research is focused on using symmetry-based counting techniques to better classify structures based on rotation and reflection. We will also discuss some applications of Polya counting, including isomer identification.

67. **Edha Sharma**
Developing a Surface-Normalized Framework to Quantify and Compare Plastic Degradation Across Environmental Studies Using Specific Surface Degradation Rate (SSDR)
Advisor: Boya Xiong
Mentor: Sarah Ziemann
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota - Twin Cities
Abstract: Plastic degradation is widely reported in environmental literature, yet inconsistencies in experimental design and data reporting limit comparability and reproducibility across studies. This research aims to standardize degradation metrics using the Specific Surface Degradation Rate (SSDR), a surface-area–normalized approach to quantify degradation performance. Through a comprehensive review of over 4,000 peer-reviewed studies, approximately 300 were selected for detailed analysis based on data completeness and relevance. The resulting dataset captures polymer types, environmental compartments, degradation conditions (e.g., temperature, UV intensity), and performance metrics. Degradation was categorized based on mass loss, size distribution, and dissolved organic carbon (DOC). SSDR values were calculated using established methods to enable consistent, surface-normalized comparisons across diverse studies. This work supports cross-study analysis of plastic degradation under lab-based and natural conditions and highlights widespread gaps in experimental reporting, such as the omission of surface area or exposure metrics. By enabling quantitative comparison, this research improves the use of environmental degradation data across both academic and industrial contexts. Ultimately, the findings support more informed material design and regulatory efforts by identifying polymers and conditions associated with faster or slower degradation.

68. **Emily Skime**
Confirmation Distribution of Psaf Compounds and Receptors
Advisor: Ilja Siepmann
Mentor: Suranjan Paul
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Bemidji State University
Abstract: Understanding the conformational behavior of perfluorinated hydrocarbons is critical to understanding their physical properties. Recent experiments suggest that perfluoro-octane conformation may form helical conformations, instead of the expected linear structure. To investigate this hypothesis, a series of dihedrals scans were run from ethane to octane, and their corresponding perfluoro counterparts. This was conducted by using ORCA by optimization under structural constraints and comparison of potential energies for both moieties. The initial calculations show that fluorinated molecules show they have more stability than the hydronated ones. We would also like to do bond length analysis and pairwise interaction analysis.

69. **Anna Spak**
Applications of Walsh Operator Circuits on the Variational Quantum Eigensolver
Advisor: Kade Head-Marsden
Mentor: Koray Aydoğan, Anthony Schlimgen
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of Rochester
Abstract: Among the many methods available for studying the electronic structure of molecules, the Variational Quantum Eigensolver (VQE) applies quantum computing to the variational principle to determine the ground state energies of molecules that may not be able to be computed classically. When choosing an ansatz to prepare a trial state for use in this algorithm, chemists face a choice between circuits constructed from known chemical information about the problem, like the Unitary Coupled Cluster (UCC) ansatz, or circuits without this information, which may not be able to construct the optimal solution to the problem. We show that circuits composed of Walsh operators, representing dilated matrices with states encoded along their diagonal, are a useful alternative: at the cost of an ancilla qubit, they can represent any possible state without using information specific to the problem, and in trial problems demonstrate better or comparable accuracy to UCC ansatzes, in many cases with fewer entanglement gates.

70. **Hannah Stevens**
Estimation of the Cross-Correlation Between the Anisotropic Stochastic Gravitational Wave Background and Galaxy Over-Density
Advisor: Vuk Mandic
Mentor: Alex Granados
Sponsoring Program: Physics REU
Home Institution: Miami University
Abstract: We estimate the cross-correlation between the anisotropic Stochastic Gravitational Wave Background (SGWB) and distribution of galaxies mapped by the Sloan Digital Sky Survey (SDSS). By cross-correlating two independent observables we anticipate higher signal-to-noise ratio and better sensitivity to detect SGWB anisotropy. Using SGWB data from both the third and beginning of the fourth observing runs of Advanced LIGO (O3 and O4a), we are able to improve upon our previous estimation as a result of greater detector sensitivity and longer timespan. To account for contribution from transient GW sources (such as mergers of binary black holes) we run the analysis with and without shot noise, so as to account for the fact that shot noise may mask clustering anisotropy. Expanding on previous work, we describe large-scale GW emission from astrophysical sources with a kernel parameterized by a Gaussian function. We find 95% upper limits on kernel amplitude of 1.2×10^{-32} erg cm^{-3} $s^{-1/3}$ without shot noise and 0.99×10^{-32} erg cm^{-3} $s^{-1/3}$ when shot noise is included, tightened by more than 50% by the inclusion of O4a data. We show that increased detector sensitivity and longer observation time allow us to further constrain the parameters of this kernel.

71. **Laurel Sun**
Investigating Potential of Social Navigation with Companion Robots in Outdoor Settings
Advisor: Stephen Guy
Mentor: Zach Chavis
Sponsoring Program: Human-Centered Computing
Home Institution: University of Maryland
Abstract: Outdoor parks and trails play a critical role in fostering healthy, active lifestyles and supporting sustainable communities. To support and encourage a broader range of people to increase their time spent outside, this project investigates the practicality of deploying robot companions to naturally accompany people walking both indoors and outdoors. Our multi-modal sensing model combines distance sensors and computer vision to localize potential people and obstacles in the robot's environment while ensuring that the robot respects social norms and personal space during interactions with other park users. Finally, we deployed and evaluated the model on a real robot in field settings.

72. **Nat Sutton**
Beyond the Scope of SCoPe
Advisor: Michael Coughlin
Mentor: Daniel Warshofsky
Sponsoring Program: Physics REU
Home Institution: Central Washington University
Abstract: The Zwicky Transient Facility (ZTF) has collected the light curves of over two billion sources since 2018. The SCoPe project uses machine learning to classify those light curves to allow that data to be usable without requiring manual classification. Because of the quantity of data and the variety of variable sources, it is impractical to run the machine over two billion sources if a variable source not within the machine learning dataset is of interest. This project aims to provide a framework for researchers to identify a type of variable source within the ZTF dataset that falls outside the existing boundaries of the SCoPe project. Using white dwarf binaries as an example, this project provides a framework for using a decision tree to identify new classes of variable sources within ZTF data. With the hyperparameters used, the accuracy of these identifications were over 90%.

73. **Juan Tamez**
Ion-Selective Electrodes for Portable, Instant, and Continuous pH Measurements
Advisor: Andreas Stein
Mentor: Maria Komal Vivek James
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Ion sensing offers invaluable insight into electrolyte and pH levels, which can inform paramedics' decisions when treating serious trauma victims. Current technology is time-consuming, requires training, and does not provide the continuous measurements necessary to save lives immediately after an accident. This project focuses on miniaturizing ion sensing techniques for wearable patches using a supporting polymer membrane, microneedles, ion-selective membranes (ISMs) that employ ionophores and ionic sites, and a solid-contact layer of porous carbon for accurate, continuous measurements of ions. An electrode and reference electrode system is necessary for the first portion of this experiment, which requires synthesis of the carbon inks and ISMs to coat microneedles which are then embedded in a mechanically robust polymer membrane. Proper sealing of the polymer membranes and the coated microneedles is necessary to avoid a water layer formation on the needle surface. The second phase targets potentiometric testing of the electrodes for various analytes including pH, potassium (K^+), and calcium (Ca^{2+}). Early results demonstrate high accuracy and low potential drift with respect to time when testing the pH sensor against a conventional pH electrode. Tests have shown delamination of microneedle coatings, so mechanical properties need optimization to prevent water layer formation on the solid contact which has caused inconsistent measurements in the past. With these findings, future objectives include improving mechanical stability of coatings, minimizing potential drift to mitigate the need for frequent probe conditioning, developing a water layer test, and refining ion selectivity of the ISMs to prevent interference from secondary electrolytes.

74. **Liwen Tang**
Applying Boosted Decision Trees for Very-High-Energy Gamma-Ray Detection and Analysis with VERITAS
Advisor: Lucy Fortson
Mentor: Deivid Ribeiro
Sponsoring Program: UROP/URS
Home Institution: SchoSchool of Physics and Astronomy
Abstract: The detection and analysis of very-high-energy (VHE) gamma rays produced by relativistic jets in quasars face significant challenges due to overwhelming hadronic cosmic-ray backgrounds. I am training Boosted Decision Trees (BDTs) with unsupervised learning to separate VHE gamma rays from other cosmic rays by using simulated data. The BDT learns to assign each event a score between -1 (likely hadron) and 1 (likely gamma), and I pinpoint the optimal classification threshold by finding where the gamma and hadron probability curves intersect. After training, we applied the model to real VERITAS data to identify gamma candidates and reconstruct source spectra to do the validation by comparing to the Crab Nebula's known spectrum.

75. **Aysa Tarana**
Long-Term Immunological Memory at the Maternal-Fetal Interface and Cross-Generational Immune Protection Against Listeria Monocytogenes
Advisor: Nathan Schuldt
Mentor: Sarah Burger
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota Twin Cities
Abstract: Microbial exposure plays a crucial role in shaping immune responses, which is especially important during pregnancy when the mother is protecting and tolerating her fetus. This study investigates how diversified microbial exposure influences fetal survival in pregnant mice infected with Listeria monocytogenes (Lm). We hypothesized that pregnant Natural Microbial Exposure (NME) mice would exhibit greater fetal survival than Specific Pathogen-Free (SPF) mice when exposed to Lm. Our findings indicate that SPF mothers were more likely to die from infection, whereas NME mothers demonstrated higher survival rates. However, SPF pup survival was higher than that of NME pups. These results highlight the complex relationship between microbial exposure and immune development, emphasizing the need for further research into immune adaptation during pregnancy.

76. **Alice Tidmarsh**
Metal-based Flexible Optical Metamaterials: Fabrication and Mechanical Testing
Advisor: Vivian Ferry
Mentor: Yidenekachew Donie
Sponsoring Program: MRSEC
Home Institution: Harvey Mudd College
Abstract: Optical metamaterials, composed of patterned arrays of sub-wavelength structures, are an emerging technology allowing for the precise control of light. In particular, flexible metamaterials are of interest in healthcare for their potential use in wearable medical technology. Implementation of metamaterial-based technologies requires efficient mass production methods and metamaterials that maintain their efficacy under continued use. Many current metamaterial production methods are subtractive, leading to substantial material waste. Previous work has established an additive method using nanoimprint lithography to produce arrays of wells and ink dragging to selectively deposit functional material within these wells. Successful selective deposition of any ink relies on its distinct rheological properties. To create inks for the selective deposition of chiral gold nanoparticles, we assessed a number of binary solvent compositions, including isopropanol, ethanol, methanol, and acetone mixed with water. Of the solvents tested, a 5:1 ethanol/water composition produced the largest areas of consistent selective deposition. Once produced, flexible metamaterials must maintain performance over many bending cycles to be reliable. To evaluate this, we monitored the reflectance spectra of silver-based optical metamaterials over 10,000 bending cycles. No significant change in the optical response was observed, likely due to the support provided by the matrix surrounding the silver features. Our observations show that by tuning the rheological properties of the ink, a range of functional materials can be patterned into structures with reliable long-term optical performance. This demonstrates the potential of the additive patterning approach discussed here for efficiently producing durable metal-based optical metamaterials.

77. **Austin Tinkey**
Molecular Mechanisms Governing Soil Carbon Stabilization: Adsorption of Lignin Degradation Products to Iron Oxide Minerals.
Advisor: Rene Boiteau, R. Lee Penn
Mentor: Alek Rabago
Sponsoring Program: Independent Research
Home Institution: University of Minnesota
Abstract: Organic carbon (OC) sequestered in soils represents the largest land reservoir of carbon (C) on Earth's surface and regulates both soil and surface water quality. Association of OC with iron (Fe) oxide mineral surfaces is a critical mechanism for protecting it from mineralization to CO_2. This Fe oxide-associated OC is structurally similar to lignin, a highly aromatic heterogenous biopolymer which comprises ~60% of plant woody tissue. Specialized soil microbes enzymatically degrade lignin, resulting in small aromatic molecules studded with phenol, carboxyl, and catechol functional groups. These functional groups are known to interact with Fe oxides to form Fe-OC complexes. However, the structural motifs governing the adsorption of lignin degradation products to Fe-oxide minerals are not completely understood. To address this knowledge gap, adsorptive capacities of model lignin degradation compounds to goethite, a common Fe-oxide mineral in soil, were evaluated using adsorption isotherms generated via batch experimentation across a pH range of 4-8. Caffeic acid and catechol exhibited significantly greater adsorption than p-coumeric acid, particularly at high pH, indicating the importance of ortho-benzenediol functional groups for surface adsorption. These findings provide insight into the lignin degradation pathways that are likely to enhance OC associations with Fe-oxide minerals in soils.

78. **Andrew Toensing**
Synthetic Progress Towards Ring-Expanded and Contracted Antivirulence Agents
Advisor: Adam Duerfeldt
Mentor: Alexis Stoorza
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota - Twin Cities
Abstract: Multidrug-resistant urinary tract infections are a major threat to public health. The development of antivirulent small molecules is a promising strategy to treat infection while reducing selective pressure for bacteria to evolve resistance. Activation of the CpxRA two-component signaling system in Gram-negative bacteria has been shown to reduce expression of virulence factors in uropathogenic E. coli (UPEC). Previously, we have reported the development of 2,3,4,9-tetrahydro 1H-carbazol-1 amines, which inhibit CpxA phosphatase activity in UPEC, resulting in sustained indirect activation of the CpxRA system. First-generation structure-activity relationship (SAR) studies established Cpx26 (EC50 of 1.1 μM) as a promising lead. In a murine UPEC model , Cpx26 significantly reduced bacterial recovery in urine and kidneys and trended toward reducing bacterial recovery in bladder tissue. Here, we report the ongoing synthetic efforts for second-generation if C-ring expanded/contracted analogs. Because of the necessity of the (R) configuration at the C1 amine for activity, this approach emphasizes minor changes to the position of the amine in three-dimensional space. Analogs generated from this study SAR is expected to provide the basis for further investigation of this chemotype as potential antivirulence agents and elucidate new avenues for structural optimization.

79. **Antonio Torres**
Chiral Molecules under Surface Enhanced Raman Spectroscopy
Advisor: Renee Frontiera
Mentor: Arghya Sarkar
Sponsoring Program: MRSEC
Home Institution: Normandale Community College
Abstract: Chiral nanoparticles influence biological processes such as taste perception and drug absorption, yet they return weak optical activity when detected by conventional Raman spectroscopy. In this study, gold nanoparticles were employed as plasmonic enhancers to amplify Raman optical activity, enabling more sensitive detection of chiral signatures. The nanoparticles were characterized using both circular dichroism (CD) spectroscopy and surface-enhanced Raman spectroscopy (SERS). The optical responses of left- and right-handed nanoparticles were analyzed to assess the relationship between handedness and chiroptical activity. Igor, a specialized software specializing in curves, was used to quantify and compare the CD and SERS spectra. These results contribute to a better understanding of chiral plasmonic metamaterials and the mechanism of far and near field response

80. **Lotus Ufondu**
Optimizing Cryoprotective Agent Formulations for Lung Vitrification
Advisor: John Bischof
Mentor: Zonghu Han
Sponsoring Program: ATP-Bio
Home Institution: University of California, Los Angeles
Abstract: Cryopreservation is essential for storing biological tissues and organs until transplantation. Vitrification is a method that cools tissues so quickly that ice crystals do not have time to form. It uses high concentrations of cryoprotective agents (CPAs) to lower the freezing point of water and prevent injury from ice crystal formation. However, at high concentrations, CPAs can stress cells and harm the tissues they are meant to protect. In this study, we aim to optimize CPA formulations for lung tissue vitrification by testing different combinations on rat lung slices and evaluating how well they preserve healthy, living cells. We tested two newer CPA components that have not been widely studied: 2-Methyl-2,4-Pentanediol and 2,3-Butanediol, and compared them to traditional components used in CPAs. Preliminary results suggest that 2-Methyl-2,4-Pentanediol is more damaging to lung tissue than 2,3-Butanediol. This difference in toxicity shows how important it is to choose CPAs that protect tissues without causing additional stress. Our findings will support the development of safer and more effective lung vitrification methods for future transplantation. These optimized formulations may also enhance the preservation of other delicate tissues and improve preclinical drug testing models.

81. **Rana Umran**
Reactivity Studies of Discrete Cluster Models of Layered Ternary Cu_2MoS_4
Advisor: Gwendolyn Bailey
Mentor: Shatha Alabbad
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Drury University
Abstract: Transition metal chalcogenides are cost-effective, earth abundant materials offering tunability through changing the transition metal, adding additional metals, changing the chalcogen used, and through structure modification. These materials are attractive for their use in separations, catalysis, and semi-conductors among other applications. Layered ternary Cu_2MoS_4 systems are reportedly active for electrocatalytic hydrogen evolution and crude oil cracking. This project includes the stepwise synthesis and characterization (^{1}H NMR) of discrete cluster models of Cu_2MoS_4 to investigate their reactivity as functional analogs for transition metal chalcogenide materials. Reactivity studies were conducted to examine the cluster's ability to facilitate small-molecule activation relevant to catalysis. These studies provide insight into how these molecular models can inform the mechanistic understanding of layered transition metal chalcogenide materials, supporting the development of efficient, earth-abundant catalysts for sustainable chemical transformations.

82. **Andrew van de Ligt**
Michael Addition-Based Modification of Biochar for Enhanced PFAS Removal
Advisor: Rene Boiteau
Mentor: Anil Timilsina
Sponsoring Program: Independent Research
Home Institution: University of Minnesota Twin Cities
Abstract: Per- and polyfluoroalkyl substances (PFAS) removal and remediation is of increasing importance in industrial systems. Biochar demonstrated potential for PFAS removal with some limitation in removal efficiency and kinetics for industrial trace level application. This study investigated the use of engineered biochar for decontamination of perfluorooctanoic acid (PFOA), a model PFAS compound. Biochar was modified via Michael addition by reacting it with poly(ethylene glycol) methyl ether thiol (mPEG-SH) to enhance surface area and amphiphilicity. This functionalization was designed to create a more chemically compatible and flexible adsorption network better suited for capturing PFOA as well as a broader spectrum of PFAS contaminants. The reaction scheme was first validated using coumaric acid with glutathione and mPEG-SH in the presence of triethylamine, with successful reactivity confirmed via LC-HRMS analysis prior to biochar functionalization. PFOA removal kinetics were assessed by filtering the treated solution and quantifying residual PFOA via LC-MS. Results showed that while the mPEG-modified biochar exhibited improved suspension stability, it did not significantly enhance PFOA removal as compared with unmodified biochar. Planned work includes characterizing polymer attachment using FTIR, DLS based particle size analysis, testing amine functionalized polymers for improved PFAS affinity, and applying the mPEG-biochar to possible heavy metal remediation.

83. **Olivia Vickers**
Side Chain Fluorination of Poly(oxazolidinones) Towards High Dielectric Materials
Advisor: Jessica Lamb
Mentor: Elizabeth Rogan
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Middle Tennessee State University
Abstract: A capacitor stores and releases electrical energy by retaining charge on two conductive plates. As the size of the capacitor and the overall device decreases, less surface area is available to store the charge, so materials with high dielectric constants are used to sustain performance. One encouraging candidate for dielectric materials is polyoxazolidinones (POxa), which are a rising subclass of polyurethanes. POxa have many desirable characteristics, including high thermal stability, high glass transition temperatures, and high polarizability due to the strong dipoles oriented in the repeat unit. Preliminary work in the Lamb Lab has established that POxa have high dielectric constants, indicating great potential as a dielectric material. Given fluorine's known ability to enhance polymer dielectric abilities, it is hypothesized that its addition to POxa will have the same effect. This project aims to improve upon the dielectric properties of POxa by fluorinating the side chains of the polymer via monomer design and post-polymerization modification to methodically tune them to facilitate further reduction of capacitors in size. Beyond enhancing capacitor performance, this research will provide fundamental knowledge of polymer dielectric materials and their broader applications to the field of advanced electronics.

84. **Patrick Wang**
Galaxy Zoo Tidal Tails: Developing a Euclid Galaxy Merger Workflow for Zooniverse
Advisor: Hayley Roberts
Mentor:
Sponsoring Program: Physics REU
Home Institution: Haverford College
Abstract: The first Euclid Quick Data Release (Q1) was published in March 2025 and contained millions of distant galaxies captured at resolutions higher than ever before. With the help of Zooniverse volunteers and Galaxy Zoo's Zoobot machine learning algorithm, we have compiled a large dataset of Euclid galaxy mergers to be classified by future volunteers in a similar fashion. Here, we describe how we developed the selection criteria for this sample and how they were refined for a new merger-specific Zooniverse workflow. We also describe the tidal feature classifications that we decided to include in this workflow, and the approach we took to develop its instructions

85. **Cyrus Watrin**
Effects of Architecture and Size on Symmetric Multiblock Copolymer Compatibilizers at Homopolymer Interfaces
Advisor: Kevin Dorfman
Mentor: Ben Magruder, Ashutosh Nehete
Sponsoring Program: Independent Research
Home Institution: University of Minnesota
Abstract: In a system of incompatible polymers A and B, it is known that an AB block copolymer additive compatibilizes the mixture by self-assembling to interfaces, mitigating interfacial tension. We are studying the effect of adding high molecular weight multiblock copolymers, both linear and star architectures, using Self-Consistent Field Theory (SCFT), a literature standard computational mean-field approach to model equilibrium polymer behavior. SCFT enables large, efficient sweeps of parameters like block size and segregation strength for each architecture. We are particularly interested in the amount of copolymer needed in a system to saturate the interfaces and reach zero interfacial tension, and analyzing how these parameters affect this concentration threshold. We have found this threshold to decrease by a -2/3 power with block length, increase roughly logarithmically with segregation strength, and rise but decreasingly so with the number of blocks. Our analysis also suggests that in the strong segregation limit, architectural effects vanish. Additionally, we have found that star and linear copolymers containing the same number of blocks never meaningfully differ in performance.

86. **Rafael Whynman**
Modeling of a High Density Reconfigurable Photonic Metasurface
Advisor: Ognjen Ilic
Mentor: Daniel Kindem, Yujie Luo
Sponsoring Program: MRSEC
Home Institution: Boise State University
Abstract: Tunable metasurfaces have the capacity to impact a variety of fields, whether it be through their implementation within holographic displays, beam steering, or optical sensing. Phase change materials (PCMs), which are materials that change their optical properties via applied voltage, can be implemented within metasurfaces to result in different reflectance spectra. Yet, there are limitations on the density of the unit cells that make up those metasurfaces, as thermal crosstalk limits the ability to reliably change the phase of the PCMs. Therefore, it is vital to develop a simulation model that can reliably demonstrate the efficacy of a new unit cell design, where a cavity is implemented to mitigate thermal cross talk. The objectives of this research are to first develop reflectance models within an electromagnetic solver, then develop a set of refractive indices via experimental characterization. UV-visible Spectroscopy and Fourier-transform infrared spectroscopy are the experimental means of characterization. Both methods are vital in providing refractive indices across a broader range of applied wavelengths. Finally, a COMSOL model will be developed to determine if the application of voltage pulses will reliably change the phase of both intended and adjacent GST structures. Due to the exploratory nature of this research, expected outcomes are to find a viable design that results in multiple reflectance spectra, and the controlled phase change of GST per unit cell.

87. **Ashley Wise**
Development of Protein-Observed 19F NMR Method to Characterize a Multi-Domain BPTF Protein and Synthesis of New Inhibitors
Advisor: William Pomerantz
Mentor: Molly Sneddon
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Winona State University
Abstract: MYCN is responsible for the development of many cancers, including neuroblastoma. MYCN cannot be effectively targeted due to its dynamic structure and shallow binding pocket. However, targeting the upstream genes that influence the expression of MYCN, such as bromodomain (BRD) and plant homeodomain (PHD) finger transcription factor (BPTF), is possible. MYCN is typically inaccessible for transcription due to its location on the histone complex. However, BPTF can bind to the histone tails, allowing access to the gene through nucleosome sliding. BPTF binds to histone tails by two domains, the BRD and the PHD finger. Thus, the inhibition of BPTF would prevent expression of MYCN by maintaining transcriptional inaccessibility. Current inhibitors focus on the BRD domain, which has a lower affinity for MYCN than the PHD finger. Current work is ongoing to develop a dual inhibitor. Current methods examining the BPTF inhibition offer limited insight structurally. PRoF19 addresses this gap, due to F19's sensitivity to environmental changes. As inhibitors are screened, the NMR peak shifts are a measure of inhibitor binding. Fluorination and NMR assessment of the BPTF BRD-PHD are under study here to aid in the development of neuroblastoma therapy.

88. **Ivan Yuan**
Mechanistic Investigation of Metal Catalyzed N-N Bond Forming Reactions Through Dehydrocoupling
Advisor: Ian Tonks
Mentor: Zoe Fish
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Rice University
Abstract: This project focuses on the use of first-row transition metals to transform iminoanilines into 2H-indazoles, a pharmaceutically-relevant N-N bond containing heterocycle. Here, we leverage N-N dehydrocoupling reactions, where a proton-coupled electron transfer is performed using an oxidant-base pair and promoted by a transition metal Lewis acid. A screening of common metal chloride salts, using both stoichiometric and catalytic quantities of metal, shows that reaction yields are not directly associated with the electronic configuration of the metal center, and that Fe, Co, and Cu chloride precatalysts demonstrate the best catalytic properties. Model reaction intermediates containing X-type metalacyclic groups were synthesized from iminoaniline ligands using Ti, Fe, and Cu chlorides, with the first deprotonation of the aniline nitrogen occurring spontaneously due to coordination-induced bond weakening. Additionally, an imido complex was accessed by using $TiCl_2(NMe_2)_2$ as the metal source. Reactivity tests with these metallacycles using a mild TEMPO oxidant and varying amounts of base show that one equivalent of base is necessary to yield the 2H-indazole from Fe (III) and Ti complexes. The use of the oxidant alone can produce the 2H-indazole from the Ti imido and Fe (II) metallacycles with a lower yield, suggesting differences in reaction mechanisms with different metal centers.

89. **Dylan Zeilinger-Johnson**
Maximizing entanglement in open quantum systems using the Unified Master Equation
Advisor: Kade Head-Marsden
Mentor: Mikayla Fahrenbruch, Koray Aydogan
Sponsoring Program: UMN Chemistry - CTC
Home Institution: University of Minnesota - Twin Cities
Abstract: Effective modeling of quantum systems requires the simulation of environmental loss, which is often seen as a roadblock in developing quantum technologies. However, coupling to an environment can also allow for the stabilization of highly entangled states, assuming that the system parameters are tuned properly. To find the system parameters that maximize entanglement, we thus optimize entanglement negativity by varying any number of system parameters. In order to model the systems and their environmental interactions in a physical way, we use the Unified Master Equation, which allows us to microscopically model the environment while still preserving density matrix trace, complete positivity, and detailed balance. We then apply these methods to the Transverse-Field Ising Model and provide optimization results for this system.

90. **Judith Zhu**
Surface-Functionalized Silica Nanoparticles for Anionic Molecule Loading and Delivery in E. coli
Advisor: Christy Haynes
Mentor:
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota
Abstract: The anionic cell envelopes of Gram-positive and Gram-negative bacteria provide a barrier to the delivery of negatively charged molecules due to charge repulsion. This poses a significant challenge in studying the structure and function of bacteria and the delivery of antibiotics, among other applications. This project aims to explore the utility of silica nanoparticles (SiO2 NPs) as carriers of anionic cargo while minimizing negative impact on bacteria. Ultraporous mesostructured nanoparticles (UMNs) and mesoporous silica nanoparticles (MSNs) were synthesized, characterized, and incubated with either BODIPY-ATP-γ-S, a fluorescent probe, or green fluorescent protein-expression pDNA (GFP pDNA) to evaluate their capacity to load these cargoes of various structures and sizes. Nanoparticles were functionalized with (3-aminopropyl)triethoxysilane (APTES) or N-[3-(trimethoxysilyl)propyl]ethylenediamine (NPD) moieties and performance was compared to unfunctionalized NPs. We hypothesized that these positively charged motifs would overcome the charge repulsion barrier. Herein nanoparticle toxicity was assessed in E. coli to evaluate biocompatibility. Ongoing work will include further investigation of nanoparticle toxicity, bacterial association studies, and cargo delivery efficiency into live bacterial cells.

91. **Ishani Zimmerman**
Analyzing Bio-Orthogonal Probes for Prenylated Proteins using Flow Cytometry
Advisor: Mark Distefano
Mentor: Harinarayanan Kottala
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Pomona College
Abstract: Prenylated proteins are a class of proteins that are post-translationally modified with isoprenoid groups (farnesyl or geranylgeranyl diphosphates) and are implicated in a variety of biological functions, cancers, and neurodegenerative diseases. Quantifying prenylation levels is crucial to study the pathology of these diseases. To achieve this, bio-orthogonal probes mimicking the natural substrates are installed onto the prenylated proteins via metabolic labeling, which can be measured using flow cytometry. Here, we measure the incorporation of three different probes using flow cytometry in COS-7 cells with and without environmental modification. The probes analyzed are two pan-prenylation probes, C15AlkOH and C15AlkOPP, and one probe that is more selective to geranylgeranylated proteins- C15PentOPP. We aim to compare probe labeling efficiency and also demonstrate the selectivity of C15PentOPP using farnesylation and geranylgeranylation specific inhibitors. Cells were cultured, treated with and without inhibitors and probes, labeled with TAMRA-azide via copper-catalyzed click reaction, and analyzed with flow cytometry. Results indicate that C15AlkOPP has higher incorporation than C15AlkOH, and overall probe incorporation decreases for C15AlkOPP and C15PentOPP with farnesyl transferase (FTI) and geranylgeranyl transferase (GGTI) inhibitors. However, the selectivity of C15PentOPP for geranylgeranyl proteins could not be demonstrated using flow cytometry.

Teacher Poster Presentations
Listed Alphabetically by Presenting Author

92. **Cassandra Lydon**
Exploring Passive Cooling Through Porous Polymers: A Student Experiment in Climate-Conscious Material Science
Advisor: Chris Ellison, Vivian Ferry
Mentor: Emily McGuinness
Sponsoring Program: MRSEC
Home Institution: White Bear Lake High School
Abstract: In my experience as an educator, today's students are deeply engaged with the challenges facing modern society, especially climate change. Major contributors to carbon emissions, often called the "grand challenges", include how we generate electricity, manufacture materials, transport people/goods, produce food, and manage temperature. Science students are expected to understand complex systems and develop the problem-solving skills needed to address them. These challenges provide a framework for that learning. To explore the challenge of staying cool, we are developing a student experiment to investigate: "Instead of cooling entire buildings, can we cool ourselves using textiles designed for passive daytime radiative cooling (PDRC)?" PDRC textiles, such as nanoporous polyethylene, are being researched for their ability to passively lower body temperature. Potentially, students will examine how material color/texture affects absorption and emissivity by creating polylactic acid (PLA) films from transparent 3D printer filament and adding porogens (coarse/fine salt, coarse/fine sugar, and polyvinyl alcohol), which will later be removed. Students will then measure optical and thermal properties using a Vernier light sensor and an infrared thermometer.

93. **Jake Pundsack**
Why so Fe-w phytoplankton? A Storyline-Driven Oceanography Unit for High School Classrooms
Advisor: Rene Boiteau
Mentor: Nicole Coffey, Anil Timilsina
Sponsoring Program: MRSEC
Home Institution: Melrose Area High School
Abstract: The Southern Ocean is home to relatively few phytoplankton despite having high nitrate concentrations because it is limited by iron availability. While this is a critical area of study as we seek solutions to climate change through carbon sequestration, few curricular resources exist at the high school level to engage students in modern breakthroughs in oceanography. In this comprehensive unit, students explore the ecological implications of iron fertilization, such as carbon sequestration, population dynamics, and the cycling of matter, through inquiry-driven investigations of real-world phenomena. Students follow protocol to conduct experiments discovering iron's impact on *Chlorella vulgaris* population growth and primary productivity, analyze global ocean data on nutrient and iron concentrations from the GEOTRACES program to model nutrient cycling, and apply the Redfield Ratio to evaluate whether the Southern Ocean is capable of sequestering the excess carbon dioxide produced from fossil fuel combustion each year. In doing this, students engage in cutting-edge areas of study to critically evaluate real-world environmental engineering solutions to climate change while mastering NGSS biology standards.

94. **Jayson Sandeen, Nita Worthley**
Degradation of Plastics in a High School Classroom
Advisor: Boya Xiong
Mentor: Sarah Ziemann
Sponsoring Program: MRSEC
Home Institution: Eden Prairie High School, North Branch High School
Abstract: Our work this summer was to create a curriculum about the degradation of plastics to bring to our high school classrooms. This curriculum provides students with a hands-on opportunity to incorporate environmental science, chemistry, and real-world consequences of plastic pollution. This lab engages students to test different degradation techniques such as photoweathering, mechanical abrasion, and biochemical degradation. By analyzing the data, students will learn about the chemical and physical properties of different types of plastics and how that can impact our environment. The lab involves critical thinking, collaboration, environmental literacy, and scientific practices associated with the 2019 Minnesota Science Standards. It also leads to the importance of sustainability and biodegradable plastic alternatives. Bringing this lab to the classroom makes environmental chemistry relevant for our students and empowers them to become informed stewards of our planet.