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Summer Undergraduate Research Expo

August 5, 2021
McNamara Alumni Center
Memorial Hall
4:00-6:00pm

Undergraduate Poster Presentations
Listed Alphabetically by Presenting Author

Presenters should be at their posters at the following times:
4:00 - 5:00 odd numbered posters
5:00 - 6:00 even numbered posters

1.	**Radwa Abdelaziz** *A Dual Readout Growth-Based Viability Assay to Assess Nanoparticle Toxicity in Bacterial Populations* **Advisor:** Christy Haynes **Sponsoring Program**: Center for Sustainable Nanotechnology **Home Institution:** CUNY-Hunter College **Abstract:** Due to the likely release of engineered nanoparticles (NPs) into the environment, there is a need to understand their impact on organisms like bacteria. The growth-based viability (GBV) assay provides a high-throughput and interference-free method to assess the bacterial toxicity of NPs by monitoring bacterial growth upon NP exposure, as measured by optical density. However, bacteria naturally exist as complex and diverse populations, so it is important to develop analytical methods with species resolution to assess NP toxicity to bacteria. This work aims to modify the GBV assay to be a dual-mode readout platform that uses both fluorescence and optical density to assess viability. To achieve this, the bacterium, Shewanella oneidnesis, was modified using plasmids to express red and green fluorescent proteins, and fluorescence was evaluated as a GBV readout mode. To date, two distinct strains of S. oneidensis that emit red and green fluorescence have been successfully used with the GBV assay. The influence of removing antibiotic pressure during culture is under investigation using colony counting assays to assess plasmid loss in the presence and absence of antibiotics, facilitating future experiments exploring NP toxicity.
2.	**Roberto Aguilar** *The Conductivity and Rheology of Salt-Doped Polymer Electrolytes* **Advisor:** Timothy Lodge **Sponsoring Program**: MRSEC **Home Institution:** UTRGV **Abstract:** Liquid electrolytes, which are used in lithium-ion batteries (LIB), show high ionic conductivity and electrolyte contact which help reduce the internal resistance. However, they are not electrochemically stable and very flammable, and thus pose significant safety concerns. Polymer electrolytes have gained much scientific interest recently due to their potential to replace conventional liquid electrolytes. The purpose of this research is to investigate the conductivity and rheology of salt-doped homopolymers as a function of salt concentration. Poly [oligo (ethylene glycol) methyl ether methacrylate] (POEGMA) is the polymer that is going to be worked on for this research. Electrochemical impedance spectroscopy (EIS) is an electrochemical technique to measure the impedance of a system in dependence of the AC potentials frequency also it will be used to measure the conductivity. While dynamic mechanical spectroscopy (DMS) will be used to probe the rheological properties, which is a technique where kinetic properties are analyzed by measuring the strain or stress.
3.	**Christine Alex** *Transitions from quasicrystals to approximants in a crystalline amorphous diblock copolymer* **Advisor:** Mahesh Mahanthappa **Sponsoring Program**: MRSEC **Home Institution:** Southern IL University Edwardsville **Abstract:** Over the past decade, complex topological close-packed particle packings known as Frank-Kasper (FK) phases and related dodecagonal quasicrystals (DDQCs) have emerged as fundamental to the diblock copolymer phase space. Although FK phases theoretically show widespread thermodynamic stability in properly tuned systems, experimentally their formation is often slow and dynamically unfavorable. Little is understood about precise dynamic mechanisms underlying FK phase nucleation and growth. Accordingly, we will examine timescales associated with FK phase formation in a model poly(ethylene oxide)-block-poly(2-ethyl hexylacrylate) diblock via dynamic mechanical analysis (DMA). This involves monitoring the evolution of the storage (G') modulus of the material during isothermal anneals following rapid temperature jumps or quenches. The high time and temperature resolution offered by this indirect measurement of structural development will enable construction of time-temperature transformation diagrams summarizing time dependence of structural maturation within the sample. We anticipate that cooler anneal temperatures will give rise to long-lived metastable DDQCs [PNAS 113, 5167 (2016)], although the fast dynamics displayed by this system [Macromolecules 54, 2647 (2021)] should allow full structural development on experimental timescales.

4.	**Helena All** *Impact of Backbone Length on Strain Hardening in PLA Graft Polymers* **Advisor:** Frank Bates **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** University of Minnesota - Twin Cities **Abstract:** Polylactide (PLA) is a bio-derived and degradable polymer, and is one of the most commonly used sustainable plastics in industry. One of the limiting factors in PLA's commercial use is its poor melt strength, making many processing methods that require uniaxial extension difficult, such as foaming and film blowing. Our research focused on manipulating the parameters in a graft architecture to understand their effects on strain hardening in extensional flows. In the work reported here, we varied the backbone degree of polymerization to monitor the change in melt strain hardening. To do this, we synthesized graft-poly(D,L-lactide) samples of differing backbone lengths using a graft-through ring-opening metathesis polymerization. We found that graft polymers with a greater backbone degree of polymerization strain hardened more during uniaxial extensional rheological measurements, and that there appears to be some critical value of backbone length at which these polymers transition from minimal to a substantial amount of strain hardening. This trend can be used by manufacturers when designing polymers best equipped for processing. Future research could focus on varying other parameters in a PLA graft polymer, such as grafting density or side chain degree of polymerization.
5.	**Karla Aranda** *Understanding the Oxidation Behavior of Polymer-Derived Si(O)C and Doped NbSi2 Ceramics* **Advisor:** David Poerschke **Sponsoring Program**: MRSEC **Home Institution:** New Mexico State University **Abstract:** Recently there has been an increased demand for high temperature structural materials whose properties exceed those of conventional Ni-based alloys and monolithic ceramics. Therefore, we will examine doped NbSi2 and SiC-based polymer-derived ceramics that could show improved resistance to environmental degradation at elevated temperatures. Al, Cr, and Ti-doped NbSi2 ceramics, are made by spark plasma sintering elemental powders followed by annealing. For the SiC specimens, Si-(O)-C powder is mixed with 1 vol% TiSi2 powder and pressed into pellets. These pellets are infiltrated with an allyl-hydrido-polycarbosilane (SMP-10) ceramic-forming polymer precursor. Pyrolysis in argon at 900°C transforms the infiltrated SMP-10 into amorphous Si-(O)-C. The oxidation resistance of the ceramics is explored in temperature ranges of 1100-1400°C inside a tube furnace under a constant flow of dry air. Cross-sectional SEM and EDS analysis are used to characterize the oxidation resistance in both material systems. For the NbSi2 samples we also measure mass change per surface area and the results come close to a goal of mass gain less than 2 mg/cm2. The SiC specimens can show how composition and crystallinity of the polymer-derived Si-(O)-C phase influence oxygen transport and how TiSi2 can be used to gauge the oxygen partial pressure during oxidation tests.
6.	**Gisell Ayala-Corral** *Quantifying the Relationship Between Atmospheric CO2 and the Ocean Heat Content.* **Advisor:** Richard McGehee **Sponsoring Program**: MSROP **Home Institution:** University of Minnesota - Twin Cities **Abstract:** Our current climate crisis is in dire need of attention. The detrimental effects of climate change are more and more real as each day comes. In order to be able to generate solutions to the current climate crisis, one must understand what the climate is and how its system works. For starters, climate is the overarching pattern of the weather in a specific geographical area over a long period of time. On the other hand, the climate system is composed of the interactions between five different elements: the atmosphere, hydrosphere, cryosphere, and lithosphere. These elements are not independent from each other, rather they interact with each other, and are interconnected. An interaction that many scientists and researchers have been looking at is the interaction between the atmosphere and hydrosphere (the different bodies of water on earth). My research project's main focus was to primarily analyze this relationship by looking at the atmospheric CO2 levels (maintained by Scripps Institution of Oceanography at UC San Diego) and the ocean heat content (collected by the Argo Program). After analyzing the data, I then quantified this relationship, which involved integration and using programming languages that facilitated the computations.

7.	**Bailey Ayres** *Search for Weyl semimetal behavior in Co1-xFxS2* **Advisor:** Jeff Walter, Chris Leighton **Sponsoring Program**: MRSEC **Home Institution:** Augsburg University **Abstract:** Pyrite sulfides, specifically FeS_2 and CoS_2, have recently garnered a lot of focus for potential solar cell applications and their interesting magnetic properties. CoS_2 is a metallic ferromagnet that has recently been shown to have properties indicating its proximity to being a magnetic Weyl semimetal. Doping with Fe has been suggested as a route to make this compound a true magnetic Weyl semimetal, thus making $Co_{1-x}Fe_xS_2$ a material system that could provide an excellent platform to study the interplay between magnetism and band topology, which is currently a high interest topic in the solid state physics community. Here, we report the growth of $Co_{1-x}Fe_xS_2$ crystals using a chemical vapor transport (CVT) technique that will be used to investigate the possibility of magnetic Weyl semimetal behavior in this material system. While previous CVT growths of CoS_2 crystals used 700°C and 640°C temperatures, we first pursued growth of CoS_2 at temperatures used for FeS_2 growth (670°C and 590°C), hoping to speed up the eventual growth of $Co_{1-x}Fe_xS_2$ at multiple x. Resulting crystals exhibit a cubic lattice parameter of 5.536Å, S:Co ratio of 1.94:1, and a Curie temperature of 121 K; all consistent with previous reports on CoS_2.. Using this positive result, we have recently grown $Co_{1-x}Fe_xS_2$ at x = 0.0, 0.1, 0.2, 0.3, and also x = 0.0 and 0.3 that had 100mg excess S added in each tube in an attempt to optimize the S:Co ratio near 2. In all cases, crystals of $\gtrsim$ 1 mm size were grown, with x-ray diffraction and energy dispersive x-ray spectroscopy showing promising results of phase pure pyrite structures with lattice parameters and S:(Co+Fe) ratios near ideal. Preliminary measurements on CoS_2 show Anomalous Hall Effect (AHE) signals with sizes that scale with typical ferromagnets . Systematic investigation in AHE as a function of x will be pursued in the crystals recently grown to see if large AHE signals typical in magnetic Weyl semimetals emerge at a specific Fe content.
8.	**Daniel Banegas** *Quasi Distance Magic Graph Labelings* **Advisor:** Bryan Freyburg **Sponsoring Program**: UROP **Home Institution:** University of Minnesota: Duluth **Abstract:** Breakthroughs in the area of magic-type labelings have brought about amazing insights that have furthered our understanding of graphs. Specifically, it has been discovered that distance magic labeling has very practical applications in building tournaments, namely equalized incomplete tournaments (EITs) and fair incomplete tournaments (FITs). However, these discoveries have also illuminated significant limitations of distance magic labeling, which have presented open problems that could perhaps be solved by a new labeling. The initial results of this project included a definition for a labeling similar to distance magic called quasi distance magic with a label set consisting of distinct and mostly consecutive integers: {1, 2, ... , z-1, z+1, … , n+1}. Where z is some integer excluded from the labels such that for all vertices of a graph G with n vertices, the sum of all the neighboring vertex labels equals some integer k. The main results were: a construction for graphs from quasi magic rectangles and a construction for 6-regular quasi distance magic graphs where n is congruent to 2(mod 4)using pairs and triples. These findings were applied to open problems highlighted in past publications yielding the remainder of the results: QEITs, QFITs, labelings for windmill and book graphs.
9.	**Claire Bareilles** *Convection Enhanced Evaporation: A Low-Cost, Modular Brine Treatment Method* **Advisor:** Natasha Wright **Sponsoring Program**: ME **Home Institution:** Humboldt State University **Abstract:** Brine, a biproduct of water desalination and many industrial processes, can be expensive to dispose of especially in small volumes (< 30,000 liters/day). Current treatment and disposal methods are expensive due to large land area requirements and expensive equipment. These high initial expenses aren't cost-effective for industries producing small volumes of brine. The mechanical engineering team that works in Prof. Natasha Wright's lab, in partnership with Quadsun Solar Solutions, have designed a low cost, modular system for treating small volumes of industrial brine that utilizes convection enhanced evaporation (CEE). The REU project objective was to help build a single-tray replica of Quadsun's multi-tray evaporator to compare experimental evaporation rates to our model-predicted evaporation rates. By changing the brine temperature, air speed, and flow rate of the CEE system and determining the evaporation rate using the change in mass of our supply tank, the preliminary results of the analysis found that while there was closer agreement at lower temperatures, as the brine temperature increased the experimental evaporation rate was approximately 50% of the predicted value. Further research is being conducted to determine if this decrease is due to experimental design and or errors in our theoretical model.

10. **Zachary Bauer**
Frank-Kasper Phases in Ternary Oil/Water/Cationic Surfactant Mixtures
Advisor: Mahesh Mahanthappa
Sponsoring Program: MRSEC
Home Institution: Florida State University
Abstract: Ionic surfactants, which are compounds with a hydrophobic tail covalently bonded to an ionic hydrophilic headgroup with a charge-compensating counterion, self-assemble in the presence of water to form lyotropic liquid crystals (LLCs). Self-assembly is driven by the solvation of ionic head groups and aggregation of hydrophobic tails. Anionic alkylcarboxylate and alkylphosphonate surfactants form low symmetry LLCs with quasispherical micelles, called Frank-Kasper (FK) phases. In ternary systems that include a hydrocarbon oil, quasiperiodic phases with local symmetry but no global lattice symmetry form. These quasicrystals are found in composition regions between crystalline and glassy phases and are sensitive to the order of component mixing. This project focuses on studying analogous effects in surfactants with cationic head groups, in order to see if similar effects are observed. The first surfactant LLCs studied is trimethylnonylammonium chloride loaded with water and decane (oil). Two additional systems are studied, one with a bromide counterion to form trimethylnonylammonium bromide, and the other with a twelve-carbon alkyl tail to form trimethyldodecylammonium chloride. The main characterization techniques used are Nuclear Magnetic Resonance (NMR) and Elemental Analysis to confirm product purity and residual water content, and Small-Angle X-Ray Scattering (SAXS) to identify a single or combination of crystalline structures present. Samples for SAXS were prepared by mixing surfactant with water only, with oil then water, or with water then oil, and homogenizing with centrifugation and hand-mixing to target molar compositions. In ongoing studies, these systems are shown to stabilize FK phases and a dodecagonal quasicrystal.

11. **Dawn Blazer**
Correlation between structure and electronic properties in RuO_2 thin films
Advisor: Bharat Jalan
Sponsoring Program: MRSEC
Home Institution: The University of Texas at El Paso
Abstract: RuO_2 which is a good metal which is widely used as electrode material in oxygen evolution reactions and for supercapacitors. Recently, rutile RuO_2 which is a good metal in bulk form, when highly strained, has shown superconductivity at low temperatures. However, the correlation between the structure and electronic properties leading to superconductivity has not been well studied. My research will focus on studying the impact of structure on the electronic properties of RuO_2 thin films. For this purpose, we have grown epitaxial thin films of RuO_2 using hybrid molecular beam epitaxy (MBE) on TiO_2 substrates with different crystalline orientations. The structural quality and lattice parameters of these thin films are investigated using X-ray diffraction measurements. Electrical transport properties of RuO_2 thin films of different crystalline orientations are performed to understand the relation between the structure and electronic properties. Furthermore, electrical transport properties of RuO_2 thin films as a function of film thickness will be studied for the presence of possible thickness dependent metal-insulator transition.

12. **Jade Boysen**
Weyl semimetal behavior in shandite $Co_3Sn_2S_2$ single crystals and thin films.
Advisor: Chis Leighton
Sponsoring Program: MRSEC
Home Institution: Augsburg University
Abstract: $Co_3Sn_2S_2$ (shandite) has recently been found to be a magnetic Weyl semimetal, thus providing an interesting platform to study the interplay between magnetism and band topology. In this work we developed procedures for single crystal growth of shandite using chemical vapor transport (CVT) and optimized the growth of thin films using an ex situ sulfidation technique. In ex situ sulfidation, we sputter a Co_3Sn_2 film and then sulfidize by reacting it with SnS powder at an elevated reaction temperature to create shandite films. Here we report a systematic reaction temperature study, varying between 450 °C and 600 °C . Phase pure crystalline shandite is found at 550 °C, though Co : Sn : S ratio is 3.2 : 2 : 2.5, indicating further optimization is required to approach the desired $Co_3Sn_2S_2$ stoichiometry. We also report progress toward CVT growth of single crystals, by demonstrating the growth of nearly phase pure precursor $Co_3Sn_2S_2$ powder. Further, we report results from a CVT crystal growth using elemental powder precursors, in which small (<1 mg) and fragile crystals were produced. A preliminary Hall measurement on these crystals, however, indicates the promising result of a giant Hall angle of 15%, consistent with previous reports on this magnetic Weyl semimetal.

13.	**Daniel Caballero** *Green Pea Galaxies: Studying their Unusual Properties* **Advisor:** Claudia Scarlata **Sponsoring Program**: Physics REU **Home Institution:** Boston University **Abstract:** Green Pea galaxies were discovered by amateur astronomers when they pointed out that some objects from the Sloan Digital Sky Survey (SDSS) looked unusually like green peas. These galaxies are at redshifts between z=0.15 and z=0.35 and are highly star-forming, which is unusual for such redshifts. I analyzed 23 of these objects by calculating the flux intensity for their emission lines [O III], Ha, Hß and the continuum around them. I recalculated the center of the galaxies to better accuracy than reported by using the [O III] line flux. I also investigated how the flux for the emission lines and the continuum changes with radius but found that they rarely differ for most galaxies. The galaxies have differing shapes when comparing the continuum with the emission lines, for which reason I computed the semi-major and semi-minor axis for each line and continuum. Finally, I determined the emission line ratios to study the dust in the galaxies and their star-forming properties. Going forward, these results should be adjusted according to the seeing and dust in the Milky Way. Moreover, analyzing other emission lines would allow for further study of the galaxies' properties.
14.	**Adam Cahn** *Monocarboxylic acid etching of the metal-organic framework NU-1000* **Advisor:** Lee Penn **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota Twin Cities **Abstract:** Metal-organic frameworks (MOFs) are a diverse family of porous, crystalline materials comprising metal nodes and organic linkers. Their tunability and ability to adsorb gases and other species make them promising candidates for gas separation, heterogeneous catalysis, drug delivery, and other applications. Post-synthetically tuning pore size is beneficial because larger species can be admitted into the framework without compromising the structure and functionality of the as-synthesized MOF. Etching is one method that uses monocarboxylic acids to replace linkers in the framework, severing connections between nodes and widening pores while retaining smaller pores present in the parent structure. Monocarboxylic acids were used in this work to etch NU-1000, a zirconium-based MOF chosen for its outstanding stability and tunability. After heating NU-1000 and acid in N,N-dimethylformamide at 80 °C for 6-24 h, transmission electron microscopy was used to measure changes in particle size. Biphenyl-4-carboxylic acid and benzoic acid at 0.8 M resulted in 3% decreases in particle length, while carbonic acid at 0.1 M resulted in a 15% decrease. Results using acetic acid were inconclusive. Future work will focus on tuning the etching process using acid concentration, temperature, and solvent to systematically alter particle morphology for a variety of applications.
15.	**Brian Carrick** *Small-Angle X-ray Scattering of Poly(benzyl methacrylate) in an Ionic Liquid* **Advisor:** Timothy Lodge **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota **Abstract:** Lower critical solution temperature (LCST) phase behavior arises in polymer solutions due to the formation of well-oriented solvation clathrates between the polymeric solute and solvent. These solutions appear homogeneous at low temperatures but undergo liquid-liquid phase separation upon heating, indicating the solvent quality worsens as the temperature increases. Recent work from our group has shown that the critical compositions of poly(benzyl methacrylate) in 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide ([BMP][TFSI]) are shifted toward polymer-rich concentrations; shifted from the values (ca. 10 wt%) anticipated by Flory-Huggins theory. In this work, we expand upon these studies by characterizing the correlation length of poly(benzyl methacrylate) in [BMP][TFSI] via small angle X-ray scattering for concentrated solutions to assess the solvent quality as these solutions approach the binodal (coexistence) curve. The correlation length is shown to increase with increasing temperature (decreasing solvent quality) and demonstrates a strong concentration-dependence. Furthermore, the power-law concentration and molecular weight dependences of the correlation length were compared to polymer scaling concepts proposed by de Gennes for good solvents and current dynamic light scattering/rheology studies.

16. **Marcus Choates**
Lower Temperature Effects on the Toughness of Poly(lactide) with added Poly(ethylene oxide)-block-Poly(butylene oxide) Diblock Copolymers [5 wt %]
Advisor: Christopher Ellison
Sponsoring Program: MRSEC
Home Institution: Penn State University
Abstract: In today's world, plastics are essential to industry and everyday life. However, as the production of petroleum-based plastics increase so does their accumulation in landfills and leakage into the environment. One way to combat these ramifications is to make plastics sustainable, i.e. biodegradable and biosourced. This lessens the leaching of plastics into the environment and one plastic in particular, polylactide (PLA), has made many advances toward such a future. PLA is a biosourced and industrially compostable polymer and has applications ranging from 3D printing filament to packaging industries. However, PLA becomes very brittle over time due to physical aging. PLA's brittleness decreases its toughness significantly compared to other commercial plastics, which limit its applications. Recently, however, it has been found that mixing the liquid diblock copolymer, polyethylene oxide-polybutylene oxide (PEO-PBO), with PLA, toughens the PLA by initiating uniform crazing when under stress. However a majority of the research done with the PEO-PBO/PLA blend described before has been done at room temperature. We present the effects lower and higher temperatures have on the tensile strength and toughness of isotropic 5% wt. PEO-PBO/PLA blend and propose solutions and specific parameters for the polymer blend to maximize toughness at lower temperatures.

17. **Bethany Costello**
Analysis of Stress States in Spiral-Wound Reverse Osmosis Membranes for Wave-Powered Applications
Advisor: Jim Van De Ven
Sponsoring Program: ME
Home Institution: Union College
Abstract: Reverse osmosis (RO) is a method of water desalination that involves pressurizing a saltwater solution through a semipermeable membrane to produce a freshwater permeate. Powering the RO process with a wave-energy-converter can enable areas with limited access to electricity to use this technology, but can expose the RO membrane to additional stress, strain, and fatigue due to the variability of the wave power. The change in pressure through the system in particular can cause cycles of high stress, leading to fatigue and possible membrane failure. In this project, the stress over a theoretical unfurled leaf of a spiral-wound RO membrane was analyzed as a first step in a fatigue analysis, with a goal of identifying possible failure locations caused by the increased variability of a wave-powered system. A force balance, beam theory, and Navier-Stokes characterizations of the flow between parallel plates were used to produce a system of equations that relates the flow rate of the saltwater feed to the stress experienced by the membrane in different locations. Material properties such as the yield strength and ultimate strength of a used spiral-wound membrane were obtained using tensile testing and were used to identify locations of concern from the stress analysis.

18. **Danu Dahlseid**
Solid Phase Peptide Synthesis of the Protein KIX
Advisor: William Pomerantz
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota- Twin Cities
Abstract: KIX, the 87 amino acid protein, is rich in transcription factors which regulate cancer. By synthesizing both enantiomers using native chemical ligation, they can be crystallized as a racemic mixture to mimic a biologically systemic model where protein-protein interactions will be monitored with respect to aromatic side chain activity. Mass spectrometry confirmed the success of preparing the first 20 amino acids (20mer) of KIX, with a peak of 2529.26 Da. Mass spectrometry also confirmed the success of synthesizing the 40mer with a peak of 4944.97 Da, and the 50mer with a peak of 6148.55 Da. The characterization of the 63mer is still in progress.

19. **Ayla Davilla**
Advisor: Christopher J. Ellison
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: In this summer project, we investigated new methods for addressing the world's current plastic waste problem through recycling. Current recycling methods involve reusing post-consumer material in ways similar to virgin material. Unfortunately, this method is flawed due to inefficient sorting and polymer degradation which lead to depletion of mechanical properties such as tensile strength. In our research, we aim to address the problem of presorting by mechanically blending PET and LLDPE together. When mixing the materials, hydroxy-telechelic polyethylene (PEOH) is added to blends of PET and LLDPE in small amounts to undergo a transesterification reaction with the PET and form copolymer compatibilizers. These blends are then pressed into films and tested. In this process, data is utilized for analysis and data visualization showed vast improvements in the compatibilized LLDPE-PET blends verse the uncompatibilized case. Success was determined using tensile testing. Using the stress verse strain curve, we can calculate the elongation of the polymer to showcase early failure of uncompatibilized samples. Droplets of LLDPE which are found throughout the PET matrix can be measured and characterized using scanning electron microscopy (SEM) to determine their role early breakage.

20.	**Bella Finkel** *The Contribution of Stellar Core-Collapse Events to the Stochastic Gravitational Wave Background* **Advisor:** Vuk Mandic **Sponsoring Program**: Physics REU **Home Institution:** Skidmore College **Abstract:** The stochastic gravitational wave background arises from the superposition of gravitational waves from many independent cosmological and astrophysical sources. We calculate the stochastic gravitational wave background due to stellar core-collapse events in order to identify the signature we could see as noise in a gravitational wave detector like aLIGO, Virgo, KAGRA, or the Einstein Telescope. This noise background is present even if there are no detectable collapses within our own galaxy, and if found it could give us insight into the core-collapse process, which isn't currently well-understood. We collect the energy spectra from many numerical simulations of stellar core-collapse, then calculate the gravitational wave energy density we can expect based on the rate of stellar core-collapse events across the universe. We find that the strength of the stochastic gravitational wave background from stellar core-collapse is a few orders of magnitude below the sensitivity of modern detectors, and so is unlikely to be seen. This means that once the gravitational wave background is found by the upcoming generation of detectors, its analysis can be constrained to other cosmological and astrophysical sources with more significant energy density contributions.
21.	**Alexandra Fresh** *Synthesis of Recyclable Polyesters from Carbon Dioxide and Butadiene* **Advisor:** Ian Tonks **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** Purdue University **Abstract:** Due to its abundance as a greenhouse gas, carbon dioxide is desired as a renewable carbon feedstock in chemical reactions. However, its use in copolymerization with olefins has been difficult due to its thermodynamic stability, in that the propagation step involving carbon dioxide is endothermic. To overcome these thermodynamic obstacles, we have taken advantage of the use of a carbon dioxide-derived lactone monomer intermediate; specifically, 2-ethylidene-6-hepten-5-olide (EHO), created by the palladium-catalyzed telomerization of carbon dioxide and butadiene. From there, the EHO monomer was functionalized through thiol-ene click reactions and full hydrogenation processes, which were then polymerized through an organocatalyzed ring opening polymerization. The resulting polymers' thermal properties were then analyzed.
22.	**Elda Ghebregzabiaher** *Iatrogenic Prion Diseases and CJD* **Advisor:** Jessica Bell **Sponsoring Program**: Northstar STEM Alliance **Home Institution:** Saint Paul College **Abstract:** Human prion diseases, also known as transmissible spongiform encephalopathies (TSEs), were first discovered in Papua New Guinea in the 1950s. The historical context of prion diseases, traces back to the 1910 where more that 1000 cases were identified mostly in women and children in the first 10 months of the investigation by Dr. Carleton Gajdusek. Kuru was the first prion disease that appeared among the New Guinea people and emotional instability, involuntary movement, irregular and difficult gripping were one of the common symptoms. The practice of endocannibalism that was present among the people of Papua New Guinea affected children and women Since the discovery of these deadly diseases, iatrogenic transmission has created a big concern considering the large number of cases that were due to medical practices. The most common human prion disease is Creutzfeldt-Jakob (CJD). CJD, is a fetal degenerative neurological disorder transmitted by an infectious agent called "prion" with an average 12 months incubation period. It can arise sporadically, inherited or acquired by infection.
23.	**Stacy Godfreey-Igwe** *Implications of UV-Weathered Low-Density Polyethylene Surface Mechanical Properties for Microplastic Generation in the Environment* **Advisor:** Boya Xiong **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** Massachusetts Institute of Technology (MIT) **Abstract:** Around 300 million tons of plastic are produced annually; more than 80% end up polluting our air, terrestrial, and aquatic environments. Partial degradation of plastics is considered the major source of microplastics, which pose a threat to many forms of life. We hypothesize that mechanical abrasion of photo-weathered plastics at their surface is a dominant mechanism in generating smaller plastic fragments. While current mechanical analysis of photoweathered plastics is limited to bulk sample (i.e., tensile test), we utilize atomic force microscopy (AFM) and nanoindentation to analyze the changes to surface mechanical properties of low-density polyethylene (LDPE) samples as the material is weathered by UV radiation. By applying contact mechanics models to indentation curves from the AFM, our calculated elastic modulus (Ep) of photo-weathered sample was higher than that of virgin plastic sample (Ev), likely due to a higher crystallinity as measured by differential scanning calorimetry. This trend was also found to be consistent with the nanoindentation experiments. Preliminary abrasion experiments showed a lower normal force that triggers abrasion for the photo-weathered samples as compared to non-weathered samples. This work aims to ultimately model microplastic production to better understand the fate of these plastics once in the natural environment.

24.	**Collette Gordon** *Crystallization Behavior in Aliphatic Polyester Thermoplastic Elastomers* **Advisor:** Marc Hillmyer **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** University of Southern California **Abstract:** ABA triblock thermoplastic elastomers (TPEs) are comprised of hard A domains (high Tg or Tm) bracketing a soft (low Tg) B midblock. These materials are industrially appealing due to their tunable mechanical properties and low manufacturing costs. However, most common ABA TPEs use petrochemical-derived materials, thus heavily contribute to plastic pollution. A type of aliphatic polyester based TPEs (APTEs) that contain semicrystalline poly(L-lactide) (PLLA) as the hard domain and a soft domain of poly(γ-methyl-ε-caprolactone) (PγMCL) presents a sustainable alternative to these commercial materials. Previous work demonstrates that employing an (AB)n star architecture in these APTPEs improves mechanical properties; however, the impact of PLLA crystallinity has not been explored. This research investigates the crystallization behavior in (PLLA-PγMCL)4 star block APTPEs. Synthesized polymers were processed by melt-pressing and then annealed for various times to probe the crystallization behavior. Annealing studies at longer times (48 h) suggest a correlation between mechanical properties and annealing time. With a slight increase in the degree of crystallinity after 1-hour annealing, tensile tests reveal a substantial improvement in the polymer strength and stiffness. This data indicates that tuning the material crystallinity can offer a potential path to tuning the mechanical properties in these APTPEs for various applications.
25.	**Gracie Grimsrud** *Using PolyNeuro Risk Scores of executive function to investigate biological mechanisms of ADHD* **Advisor:** Damien Fair **Sponsoring Program**: UROP **Home Institution:** Masonic Institute for the Developing Brain **Abstract:** ADHD is a self-regulation disorder with deficits in control of attention, action, and emotion, which are core components of executive function (EF). Understanding how the brain manifests EF could unveil potential mechanisms for developing new clinical interventions for ADHD. Prior studies have focused on finding specific networks or regions associated with EF, but are underpowered and produce varying results. Because of this, we suspect that EF mechanisms may be distributed globally in the brain rather than localized. To investigate this, we generated a PolyNeuro Risk Score (PNRS) of EF based on the weighted contribution of distributed, whole-brain connections. We then tested this model on an independent ADHD-enriched sample to determine whether or not EF was associated with ADHD composite scores. We observed a negative correlation between the PNRS of EF and the ADHD composite scores ($r = -0.142$), with the most predictive connections distributed across the entire cortex but preferentially located on several networks. These findings support the notion that an individual brain region or network does not fully instantiate EF. Rather, brain connections covering several networks drive this association between EF and ADHD scores. This approach may strengthen the potential for neural biomarkers of EF-deficit components of ADHD.
26.	**Corbin Gustafson** *Computational Approach For Resizing A Charge Pump On A Hydrostatic Wind Turbine Test Platform* **Advisor:** Kim Stelson **Sponsoring Program**: ME **Home Institution:** Milwaukee School of Engineering **Abstract:** A hydrostatic transmission wind turbine test platform located at the University of Minnesota has been developed to study the performance of hydrostatic wind turbines. Compared to conventional multi-stage gearbox driven wind turbines, hydrostatic transmissions (HST) offer a higher power to weight ratio and reduce the maintenance cost that come with traditional wind turbines. An integral part that ensures that HST operates properly is the charge pump. A charge pump is an additional pump that replenishes internal leakage losses of the pumps and motors. The current HST wind turbine test platform is equipped with an oversized charge pump and has been computationally resized based on thermodynamic models of the HST and flow losses in the system. The required flow rate for the charge pump was determined based on analyzing flow leaving the HST loop through a heat exchanger. The results were used to resize the charge pump to improve the cooling of the hydraulic fluid as well as reduce excessive system noises caused by the oversized charge pump.
27.	**Johanna Harding** *Automating LCO Telescope Submissions* **Advisor:** Michael Coughlin **Sponsoring Program**: Physics REU **Home Institution:** Colby College **Abstract:** Detecting rare transients based on astronomical survey alert streams requires rapid photometric and spectroscopic follow-up. This motivates the use of robotic follow-up facilities, such as those part of the Las Cumbres Observatory (LCO) network, which has telescopes all over the world. Because time is of the essence, we require technology capable of automated submission and handling of observing requests on these systems. In this project, we automate our observing requests for time on the LCO network through a dedicated observing portal. By providing automated submission and monitoring software written in Python, I have demonstrated increased observing efficiency for multiple programs based on this telescope time. Looking forward, integration of these capabilities into SkyPortal, an open-source interface for telescope data filtering and monitoring, is expected.

28. **Astrid Hernandez**
Electrochemical Detection of Reactive Oxygen/Nitrogen Species: The Effect of Different Electrode Coatings on ROS Detection
Advisor: Christy Haynes
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota Twin Cities
Abstract: Nanoparticles are particles 100x smaller than the width of a human hair. They can occur naturally or be developed for industrial purposes. The nanoparticle of interest, nickel manganese cobalt oxide nanoparticles (NMC NPs), are used for electric car batteries. As of now, electric car materials cannot be properly recycled, meaning these NMC NPs are exposed to the environment. According to past research, NMC NPs interact with bacteria in the environment and can produce reactive oxygen and nitrogen species (ROS/RNS). ROS/RNS are highly reactive, short-lived molecules that are produced when a cell is in a toxic or stressed environment. NMC NPs and bacteria can already produce these species on their own, but this interaction produces even more. The objective is to explore how toxic nanoparticles are to bacteria and determine the major ROS/RNS production mechanism. This will be done by coupling electrochemical techniques such as cyclic voltammetry and amperometry with carbon-fiber microelectrodes with different elemental coatings. Different coatings can act as redox mediators on the carbon-fiber surface, making the electrode more sensitive to detecting ROS/RNS. This research will show cyclic voltammetric and amperometric data collected from bare, cobalt oxide coated, and platinum coated microelectrodes to detect hydrogen peroxide, a common ROS.

29. **Nethmi Hewage**
Investigation of silicate induced degradation resistance of multi-phase yttrium and gadolinium zirconate- aluminate compounds
Advisor: David Poerschke
Sponsoring Program: MRSEC
Home Institution: Iowa State University
Abstract: Ceramic coatings are used in jet engines and gas turbines to protect the structural parts of the hot gas path. Single-phase and two-phase coating materials have been studied in-depth, but they don't meet the most demanding performance requirements. Multi-phase coatings could be used to take the advantage of multiple advantageous thermochemical, thermophysical, and thermomechanical properties. Multi-phase rare earth aluminate zirconate coatings in yttria and gadolinia systems have been identified as potential candidates for coating materials. The rare earth (RE) oxide to zirconia ratio has been noted in the past as a key parameter influencing resistance to degradation caused by molten calcium-magnesium alumino- silicate deposits (CMAS). The addition of alumina is anticipated to improve the CMAS resistance. Therefore, it is important to understand how coating compositions with varying molar ratios of $REO_{1.5}$ (RE = Y, Gd), ZrO_2, and $AlO_{1.5}$ could lead to better coating materials. Oxide powders with varying molar ratios of $REO_{1.5}$, ZrO_2, and $AlO_{1.5}$ were synthesized by reverse co-precipitation using calibrated precursor solutions. The powders were sintered at temperatures > 1400°C to produce porous pellets. The goal is to examine the resistance of these ceramic coating materials when they are attacked by CMAS deposits.

30. **Gabe Holum**
Shielding Optimization for Thermal Neutron Calibration of SuperCDMS Detectors
Advisor: Priscilla Cushman
Sponsoring Program: Physics REU
Home Institution: Concordia College in Moorhead
Abstract: Dark matter makes up approximately 27% of the observable universe and yet its nature is unknown. Several culprits have been proposed to be this elusive matter, including weakly interacting massive particles (WIMPs). The Super Cryogenic Dark Matter Search (SuperCDMS) is an international collaboration looking for these WIMPs. SNOLAB is an underground lab where SuperCDMS uses a method involving nuclear recoil within silicon and germanium detectors to detect WIMPs. These nuclear recoil events can be precisely calibrated using thermal neutrons. This project was an investigation into what shielding configuration provides the best thermal neutron capture, and thus the highest thermal neutron flux, to optimize calibration using neutrons. Using a PuBe neutron source, a NaI detector, and bags of salt for Cl-35 neutron capture, it was determined that a setup with 24 steel sheets, two permanent shield walls, consisting of high-density polyethylene and lead, and an additional eight polyethylene sheets provided the largest thermal neutron flux. Adding additional polyethylene walls or a polyethylene floor reduced the amount of neutron capture detected. Optimization can be aided by a simulation using the GEANT4 Monte Carlo.

31.	**Lena Hoover** *Tunable biomass microbeads for personal care consumer products* **Advisor:** Michelle Calabrese **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** University of New Mexico **Abstract:** Biomass microbeads are a viable alternative to microplastics currently used as exfoliants and rheological modifiers in personal care consumer products (PCCPs) like face scrubs and sanitizers. Biomass microbeads are synthesized from renewable feedstocks and designed to be degradable in wastewater systems. We investigated the properties of cellulose and lignin microbeads in compositions ranging between 4 – 8 wt% biomass. The beads were synthesized via dripping, wherein solutions of microcrystalline cellulose and Kraft lignin were dissolved in a 70:30 DMSO and ionic liquid mixture. The solutions were precipitated into various antisolvents (ethanol, acetone, water, 1:1 ethanol/water, and 0.1M HCl) and further deswelled using an extraction solvent (ethanol or water). Using this method, we were able to produce sub-millimeter beads that were comparable in size to the beads used in PCCPs. The mechanical strength of the biomass beads, given by Young's modulus, was characterized via compression testing. While modulus varied for bead type, we were able to imitate the mechanical properties of plastic beads. Additionally, the cellulose beads were able to adsorb dye from water due to surface porosity. Bead degradability and adsorption capabilities allow further applications to include passive environmental remediation of wastewater toxins.
32.	**Cindy How** *Can aerosolized disinfectants from the dental coolant water reduce the spread of SARS-COV-2 through the atmosphere from COVID-positive patients?* **Advisor:** Alvin Wee **Sponsoring Program**: UROP **Home Institution:** UMN School of Dentistry **Abstract:** In routine dentistry, water is used as a coolant with rotary instruments and ultrasonic de-scalers that together generates aerosols during dental procedures. As they are performed on the patient, a primary concern is the potential spread of SARS-COV-2 and other respiratory pathogens to people in the dental treatment setting. Here, we studied the possibility of including disinfectants in instrument cooling water to reduce the production of pathogen-carrying aerosols. In this study, we used phi6, an enveloped bacteriophage, and phi29, a hardshell bacteriophage, as a replacement of the respiratory pathogens during experiments. We examined the viability of these viruses upon aerosolization by the dental high speed handpiece and showed that we are able to detect viable virus aerosols generated by the instrument. We then tested the ability of coolant disinfectants to neutralize these viruses. We will present a brief summary of these studies.
33.	**Christine Huang** *Shear banding in poloxamer worm-like micelles (WLMs)* **Advisor:** Michelle Calabrese **Sponsoring Program**: MRSEC **Home Institution:** Carnegie Mellon University **Abstract:** Shear banding is a flow instability where, beyond a critical stress or shear rate, a homogeneous fluid flow separates into distinct regions of viscosity, shear rate, and underlying structure. Although shear banding has received considerable attention, the mechanism of shear band formation is unclear. Suggested mechanisms in literature include nucleation and growth and disentangle-re-entanglement, but the criteria for selecting one mechanism over another for a given material and flow are unknown. We explore these mechanisms by studying the shear banding evolution of wormlike micelles (WLMs), the archetypical system for these instabilities across a variety of flow conditions. Here, these long, entangled micelles are composed of triblock poloxamers that rearrange and break on slow timescales. The anisotropy of WLMs and changes in the velocity profiles with time are indicative of the underlying mechanism. As shear bands are localized structures that vary in both space and time, particle tracking velocimetry (PTV), a velocity measurement with spatiotemporal resolution, is utilized to characterize shear banding evolution. Furthermore, small-angle neutron scattering (SANS) and shear rheology provide complementary information on the local microstructure and mechanical response of the shear bands, respectively. Together, these three measurements provide a comprehensive picture of shear banding across different length scales.

34.	**Sarah Hueffmeier** *Incidence of Bacterial Meningitis Resulting in Hearing Loss* **Advisor:** Dr. Renu Kumar **Sponsoring Program**: Northstar STEM Alliance **Home Institution:** Century College **Abstract:** Bacterial Meningitis is the inflammation of the meninges caused by bacteria from many different pathogens including Streptococcus pneumoniae, and Meningococcal or Neisseria meningitidis. Bacterial Meningitis has many severe complications affecting the whole body, but this presentation includes complications related to the severity of hearing loss, vestibular dysfunction, and bacterial labyrinthitis. Figure 1, 2, and 3 obtained results of all ages with Bacterial Meningitis from medical records within 1 hospital in The Netherlands from 1985-2015. Figure 4 used GdMRI imaging and audiometric testing on children under 18 years old with Bacterial Meningitis from 2000-2004. Figure 5 did a retrospective study and systemic review of medical records for SNHL in Eastern Denmark from 2013 to 2018. Meningococcal or Neisseria meningitidis and Streptococcus pneumoniae caused the highest incidences of hearing loss. Adults 18 years and older had the highest incidence of hearing loss, not related to age, while children 0 to 3 years and 4 to 17 years had similar incidences. Vestibular dysfunction was mainly caused by Streptococcus pneumoniae. Bacterial Meningitis is still prevalent today. Early diagnosis and treatment are extremely important for a positive outcome. More testing and studies need to be done in order to find better prevention, procedures, and treatments.
35.	**Tyler Hull** *Optimization of Diffusion Contrast Photo Activated Light Microscopy (dcPALM) to Reduce Background Signal.* **Advisor:** Elias Puchner **Sponsoring Program**: Physics REU **Home Institution:** University of South Florida **Abstract:** Diffusion Contrast Photo Activated Light Microscopy (dcPALM) is a microscopy technique that aims to reduce the background signal from tagged proteins resulting in data from only proteins interacting within a certain region of the cell. This is done by marking a region of the cell that will bleach the freely diffusing protein, reducing the background and allowing for detection of interactions that would otherwise be indistinguishable from the background. We used a strain of yeast cells that had tagged nuclear pores, NIC96 and a freely diffusing protein, PGAL, to create artificial noise masking the signal from the nuclear pore. We then used dcPALM to to reduce the noise from the freely diffusing protein and allowed us to detect the signal from the tagged nuclear pore.
36.	**Raey Hunde** *Sequence activity mapping and engineering of lactococcin G* **Advisor:** Benjamin Hackel **Sponsoring Program**: MRSEC **Home Institution:** University of Maryland, Baltimore County (UMBC) **Abstract:** The need for new antibiotics has never been greater due to the increasing threat of antibiotic resistance. New therapeutics are direly needed to resist pathogenic microorganisms, which has led to a swell of research surrounding antimicrobial peptides (AMPs). One such AMP is Lactococcin G, whose activity depends upon the complementary activity of two peptides (α and β) that forms a potassium ion channel in gram positive bacteria. Lactococcin G requires undecaprenyl-pyrophosphate phosphatase (uppP), a transmembrane protein, for activity and is the putative lactococcin G partner protein eliciting antimicrobial activity. We aim to perform deep mutational scanning of lactococcin G and uppP to deduce sequence determinants of lactococcin G activity, uppP susceptibility, and lactococcin G-uppP interaction. In order to deeply quantify sequence activity relationships via SAMP-Dep we must: (1) understand why Escherichia coli is not susceptible to lactococcin G and how to modify E. coli to become susceptible to lactococcin G, mimicking L. lacti s, and (2): establish whether SAMP-Dep works with lactococcin G and determine the conditions at which SAMP-Dep efficiently and accurately pairs AMP sequence to activity. Our work will set the foundation for future researchers to screen lactococcin G activity against uppP at the library scale via SAMP-Dep.
37.	**Jeffy Jeffy** *Quantum Mechanics Optimization of Zinc Metallo-Beta-Lactamase Inhibitor* **Advisor:** Yuk Sham **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota - Twin Cities **Abstract:** Metallo-β-lactamase (MBL) is a zinc-dependent enzyme that inactivates a wide range of β-lactam antibiotics. Currently, there is no FDA-approved inhibitor for overcoming MBL causing drug resistance. The Sham Lab has recently discovered 8-hydroxyquinoline-7-carboxylic acid (8HQC) as a low-cytotoxic, nanomolar MBL inhibitor against NDM-1 and VIM-2. The goal of the project is to apply the quantum mechanics/molecular mechanics (QM/MM) method to explore the effect of aromatic substitutions and electronic polarization on binding affinity. Additionally, in-silico combinatorial library design will afford a high throughput discovery platform to identify and optimize novel 8HQC for overcoming the antibiotic drug resistance effect of MBL.

38.	**Elizabeth Kellstedt** *Synthesis of nanoporous polyethylene membranes using ROMP of cyclooctene* **Advisor:** Marc Hillmyer **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota **Abstract:** Current blood oxygenation methods, like intubation, are dangerous and can leave patients with long term health issues. There has been a recent increase in emergency blood oxygenation due to Covid-19, leaving medical professionals searching for different and less traumatic methods. The goal of this project is to synthesize block copolymer polyethylene membranes that will eventually be involved in the blood oxygenation process. Ring opening metathesis polymerization of cyclooctene is a crucial first step to synthesizing the backbone of the membrane. While solvent issues and temperature and time conditions have produced challenges in this step of synthesis, we have been able to successfully form the polycyclooctene product. Hydrogenation of the polycyclooctene gives strong and flexible polyethylene, which will be used as the material for the membrane. These materials are promising for membrane synthesis, and will hopefully be used in the blood oxygenation process in the future.
39.	**Sarah Khaskel** *Facilitating Gene Editing in M. extorquens Utilizing CRISPR* **Advisor:** Jannell Bazurto **Sponsoring Program**: UROP **Home Institution:** University of Minnesota: Twin Cities **Abstract:** The CRISPR-Cas9 system is a technology that has quickly become invaluable in the field of genetics due to its accuracy and efficiency of genomic editing. In fact, CRISPR has the potential to become a beneficial tool that would streamline and significantly shorten the length of time it would take to develop mutant strains of Methylobacterium extorquens, traditionally derived via a time-consuming process of bacterial conjugation. This project focused on developing a mutant strain of M. extorquens through CRISPR. Using vectors that encode the Tn7 transposon as a backbone, a derivative vector was engineered that contained the Cas9 protein, sgRNA, and the tetracycline resistance gene. Once a genetic transfer was done, viable bacteria were selected for by plating them on tetracycline and selecting colonies that were able to survive. Subsequent fluorescence quantifications indicated that there was no lessening of colony fluorescence once Cas9 was induced in the M. extorquens, suggesting that Cas9 interference did not work. Further testing using varying promoters in other locations of the genome, as well as figuring out if Cas9 is even being expressed within the target DNA, are strong future directions to consider.
40.	**Vera Koltun** *a-Amino Functionalization of Heteroaryl Methylamines Using Palladium/Copper Dual Catalysis* **Advisor:** Nick Race **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** Department of Chemistry **Abstract:** Aliphatic amines are commonly seen in drugs as well as natural product motifs. These applications inspire interest in the synthesis of a-functionalized amines. We envisioned that pyridine-based Schiff bases could be utilized to achieve this goal. Here, the two nitrogen atoms coordinate to the copper, forming a copper complex that contains an acidic a-amino hydrogen, which is then deprotonated to form the corresponding anion (Scheme 1). While this type of chemistry has been conducted with amino acid-derived starting materials1,2, the use of a pyridine derived starting material has not yet been reported. Over the course of the summer, our focus thus far has been on the synthesis of one of the starting materials used: an allylic carbonate which is a π-allyl precursor (Scheme 2). Thus far, the 4-fluoro, 4-chloro, 4-methoxy, 4-bromo, and 4-methyl substituted aldehydes have been brought through the multistep synthesis via a Wittig reaction, followed by a DIBAL reduction, and a Boc protection reaction. Plans for the future include the synthesis of further allylic carbonate substrates, as well as synthesizing the imine starting material for the target synthesis.
41.	**Jonathan Landeros** *A Scientific Instrument That Will Be Used To Analyze Metal Acetylacetonate (acac) Precursors* **Advisor:** Bharat Jalan **Sponsoring Program**: MRSEC **Home Institution:** University of texas at El Paso **Abstract:** We want to achieve stoichiometric control within Molecular Beam Epitaxy (MBE) by using metalorganics that can self-regulate stochiometric ratios due to their vapor pressures. This will get us into the growth window, which will allow us to make high quality epitaxy perovskite structure films. The purpose of this project is to assemble a scientific instrument that will allow for metalorganics to be analyzed by quantifying the evaporated atoms and their impurities. Once assembled, we will compare cobalt acetylacetonate [$Co(acac)_3$] to ruthenium acetylacetonate [$Ru(acac)_3$]. $Ru(acac)_3$ has successfully been used to open the growth window in previous experiments and within other systems. The hypothesis surrounding the comparison of these two metalorganics is that cobalt $(acac)_3$ will contain similar characteristics as ruthenium$(acac)_3$ and could be used to create a stoichiometric ratio of a perovskite structure.

42.	**Sang Le** *Design and synthesis of selective bifunctional nucleoside-based TET enzyme inhibitors as epigenetic modulators* **Advisor:** Natalia Tretyakova **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota - Twin Cities **Abstract:** Epigenetic modulation is governed by equilibrium between DNA methylation and demethylation which regulates gene expression, genome stability, and genomic imprinting. Local regulation of these methylating marks primarily occur on the CpG sites of gene promoter regions in which cytosine is converted to 5-methylcytosine via DNA methyltransferase, while a family of ten-eleven translocation dioxygenases maintain local demethylation per an Fe(II)/alpha-ketoglutarate-dependent oxidation cascade on the C-5 position of cytosine. However, disruption of this epigenetic equilibrium from underexpression or overexpression of TET has been found in various diseases, such as cancer and chronic lymphocytic leukemia. Using a bifunctional probe design, we designed and are currently synthesizing a set of specific bifunctional nucleoside-based TET inhibitors that mimic both the cytosine substrate and alpha-ketoglutarate cofactor. In silico docking studies revealed that docking scaffolds containing uridine as the substrate mimic covalently linked to a linear hydroxamic acid as the cofactor mimic have inhibitory potential against TET. Current synthetic approaches of AB-48 and similar analogs ultimately lead to the covalent linkage of the substrate and cofactor warheads via the Sonogashira cross-coupling reaction. Finally, similar amide-containing compounds have been synthesized and were tested in vitro which were determined to have approximate IC50 values of ~30 μM.
43.	**Cecilia Ledezma** *Multislice Image Simulations for Analysis of Experimental Transmission Electron Microscope Images for perovskite oxides* **Advisor:** Andre Mkhoyan **Sponsoring Program**: MRSEC **Home Institution:** University of Texas Rio Grande Valley **Abstract:** PYCCO perovskite oxide films grown on different substrates have been studied over the past for their application in electronic devices. Creating a need to study these materials at the atomic scale. Characterization at this length-scale can be achieved using an STEM which allows a resolution of 0.7Å sufficient to see the atoms of the materials. To study the thin PYCCO films in the electron microscope, the samples are prepared by the Focused Ion Beam technique, to obtain a cross-section of 50 nm film then will be observed in the STEM. The major focus of this experiment will be to match the experimental results by carrying out image simulations and image analysis. These image simulations will be done using Multislice and carry out quantum mechanical calculations. The modes of operation are:conventional TEM mode to simulate focal series to match experimental focal series to identify the best focus condition. And simulate (HAADF)-STEM images to match experimental data. Then compare, to study image interpretation in both modes and experiments.Simulations are relevant to getting the best imaging of the crystals, it allows for an idea of what the image should look like and adapt the focus to get an image close to the simulation.
44.	**Valeria Leon** *Effects of Silica Nanorods on Rheology of Poly(N-isopropyl acrylamide)* **Advisor:** Michelle Calabrese **Sponsoring Program**: MRSEC **Home Institution:** University of Texas Rio Grande Valley **Abstract:** Silica nanoparticles have been found to improve the macroscopic characteristics of polymer solutions significantly. My project aims to investigate phase separation following the addition of silica nanorods to an aqueous polymer solution at various temperatures. I will begin by synthesizing nanoparticles, as per my mentor's instructions. The nanorods will then be dissolved in a mixture of polymers and water. Then, using a turbidity tester, I will track light transmission through the samples as a function of temperature, looking for when the solutions phase separate and how this temperature changes when nanoparticles are added. I will also use a rheometer to look at how flow properties like viscosity and dynamic moduli change with temperature by using oscillatory temperature ramps and frequency and amplitude sweeps. Finally, using a magneto-rheometer to apply a magnetic field during these tests will reveal how these systems are affected by magnetic field.

45. **Rhia Malhotra**
Efforts Towards Ionic-Liquid-Gating of Iron Selenide and Plastically Deformed Strontium Titanate
Advisor: Martin Greven
Sponsoring Program: MRSEC
Home Institution: Cornell University
Abstract: It has recently been demonstrated that the electronic properties of quantum materials can be manipulated with plastic deformation[1]. Plastically deformed strontium titanate $SrTiO_3$ (STO) single crystals exhibit superconductivity markedly above the superconducting transition temperature (T_c) of undeformed STO. It is well-established that ionic-liquid-gating of quantum materials can also alter their electronic properties. Pristine STO acts as an insulator (resistance on order of 10^6 Ω). However, pristine STO is observed to be metallic (resistance on order of less than 10^3 Ω) when a gate voltage of +3 V is applied. Our goal is to apply both plastic deformation and ionic gating in combination to materials to observe any potentially exotic electronic properties. The two materials to be explored are STO and iron selenide [Fe(Se,S)]. To determine changes in T_c of the altered materials, we will probe them with an AC magnetic field and measure their first and third harmonic magnetic response. The first harmonic magnetic response decreases sharply on cooling below T_c. Thus, we can use it to determine T_c. The third harmonic magnetic response becomes nonzero when superconducting puddles begin to form in the material, before the entire substance becomes superconductive. Thus, we can use it to determine the onset of superconducting correlations.

46. **Ian Manning**
Plasma enabled conversion of waste polyolefins as a novel recycling technique
Advisor: Peter Bruggeman
Sponsoring Program: ME
Home Institution: Allegheny College
Abstract: Increasing manufacture and use of single-use plastics coupled with inadequate recycling methods have led to the widespread problem of non-biodegradable plastics contaminating ecosystems. Past research has investigated pyrolysis as a method for converting such plastics to fuels, but the high temperature (500-700°C) at which this reaction occurs makes it an energy intensive process. In this study a novel technique of non-equilibrium plasmas operated at atmospheric pressure, applied directly to molten polyolefin samples was tested for efficacy as a recycling technique. A dielectric barrier discharge (DBD) was generated in a sealed reactor under an argon-hydrogen, reducing atmosphere. Previous studies have investigated using plasma effluent for polymer decomposition, but in this study plasma was applied directly onto the polymer surface to enable direct treatment with larger fluxes of plasma-generated reactive species, such as electrons, ions, and radicals. The significantly lower temperatures (~200°C) at which these experiments were conducted leave a potential for energy savings when compared with pyrolysis. Mass change and size exclusion chromatography were used to investigate and characterize the rates of polymer conversion. Significant conversion to lighter hydrocarbons would suggest effectiveness as a method for disposing of waste plastics.

47. **Ian McNicholes**
Carbon Capture using Bipolar Membrane Electrodialysis
Advisor: Sam Toan
Sponsoring Program: UROP
Home Institution: Swenson College of Science and Engineering
Abstract: For over 20,000 years, the concentration of carbon dioxide in the atmosphere remained steady at around 280 ppm; global carbon cycling was in balance and undisrupted. Since 1750, atmospheric concentrations of CO2 have increased from 280 ppm to about 420 ppm. Since the industrial revolution, energy consumption has rapidly increased and is dependent on fossil fuel combustion, causing increased CO2 emissions. A global achievement of net neutral energy production by 2050 will not solve the problem of climate change. It has been predicted that achieving global net zero anthropogenic carbon emissions by 2050, 2100 or 2200 would leave atmospheric CO2 concentrations of 450+ ppm, 650+ ppm or 1000+ ppm, respectively. To prevent runaway greenhouse effects, ocean acidification and further mass extinctions, we must find a way to quickly decrease the current concentration of CO2 in the atmosphere. I believe that effective carbon capture is an essential technology to preventing rapid climate change. My research involves adding electro-catalysts to a bipolar membrane electrodialysis cell to test its effects on the systems electrical efficiency. By creating an economically feasible method of carbon capture, we can begin reducing current atmospheric concentrations of carbon dioxide in order to mitigate climate change.

48. **Claire Mihalko**
Optimization of ZnO Floating Gate Transistors for Small Molecule Sensing Applications
Advisor: Daniel Frisbie
Sponsoring Program: MRSEC
Home Institution: Rose-Hulman Institute of Technology
Abstract: Electrochemical biosensors are of interest to replace instrumentation for sensitive detection of small molecule hazards. The floating gate, electrolyte-gated transistor (FGT) is an electrochemical sensing platform that shows promise due to its low-voltage operation and high capacitances. High sensitivity can be achieved by tailoring the device architecture, materials, and use of a resistor-loaded inverter. Large and charged molecules, like DNA, have been successfully detected with an FGT, but small molecule detection has yet to be demonstrated. To achieve sensitivity toward small molecules while ensuring the device upholds analytical figures of merit, the semiconductor of the FGT will be switched from a printed, organic semiconductor to a vapor-phase deposited metal oxide, ZnO. Transistor fabrication with ZnO entails use of atomic layer deposition for ZnO deposition, photolithography for electrode patterning, and aerosol jet printing for electrolyte deposition. With this, tens of devices can be fabricated with minimal variability in semiconductor properties, yet other variables, such as electrolyte thickness, electrode sizing, and relative humidity can prevent high reproducibility and stability over time. Such variables were investigated by recording transfer curves and the displacement current to determine how they affect key transistor characteristics, including the trip voltage, specific capacitance, and mobility for ZnO.

49. **Yukino Nakamura**
Optimization of etoposide treatment in mouse embryonic fibroblast (MEF) cells for development of a cellular senescence model
Advisor: Edgar Arriaga
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Cellular senescence is characterized by an irreversible arrest of cell division caused by DNA damage and is known to be implicated in ageing and age-related diseases. A standardized model for in vitro induction, identification, and quantification of senescent cells is difficult to establish due to different cell types expressing different senescence biomarkers at different levels. Here, I am working on optimizing a model for senescence in mouse embryonic fibroblast (MEF) cells through subjecting cells to various concentrations of and incubation times with etoposide, an anti-cancer drug that functions to break double-stranded DNA and cause senescence. Senescent cells were detected with β-galactosidase staining assay, which is considered the gold standard for identifying senescence-associated β-galactosidase (SA-β-gal) activity, a hallmark of senescence. The lowest concentration of etoposide, 1μM, showed blue stained cells (SA-β-gal positive cells), and there did not seem to be a special advantage in using 10, 25, or 50 μM etoposide. An additional assay using 1μM etoposide revealed increasing senescence with 24-, 48-, and 72-hour incubation times respectively, though the highest total senescent cells observed was 17 percent. Further experimentation with etoposide concentration and incubation times is necessary, along with supplementary methods of detecting senescent cells, for better optimization.

50. **Daniel Pan**
Phase Studies of Sea Spray Aerosol Droplets Using Microfluidic and Optical Techniques
Advisor: Cari Dutcher
Sponsoring Program: MRSEC
Home Institution: University of California, Santa Barbara
Abstract:
Sea spray aerosol (SSA) droplets are an abundant aerosol species known to affect Earth's climate through radiative forcing and cloud nucleation. However, current climate models cannot fully account for the radiative forcing associated with aerosols, due to high uncertainty stemming partially from the lack of characterization of chemical and phase behaviors of salt and organic matter in aging SSAs. Here, we incorporate microfluidic and drop-on-slide techniques for model SSA systems, with a focus on evolution through time, to gain insights into the phase transitions and crystal morphologies of SSAs. Through quasi-equilibrium pervaporation, we observe a single efflorescence transition in our model systems. When observing the final crystal morphology, the addition of fatty acids creates an optically opaque, disrupted crystal, while the addition of glucose leads to an amorphous solid. Effloresced SSA droplets are scanned three-dimensionally using Raman spectroscopy to determine the assembly of fatty acids, glucose, and salts. We see an enrichment of fatty acids on the surface of effloresced SSA droplets, as suggested by computational modeling. Our conclusions from single particle experiments on the fundamental properties and assembly of SSA droplets are used to evaluate the UCSD Amaro group computational SSA model conclusions.

51.	**Andrea Perez** *Accesing Complex Nanoscale Packing with ABA' Triblock Copolymers* **Advisor:** Tim Lodge **Sponsoring Program**: MRSEC **Home Institution:** New Mexico State University **Abstract:** Formed by combining chemically distinct polymer blocks, block copolymers are used across several industries owing to their ability to self-assemble at the nanoscale. Of particular interest in recent years has been the discovery that these ostensibly simple materials can order into micelles arranged on large, complex Frank–Kasper (FK) lattices. Frank–Kasper (FK) phase formation in diblock copolymer melts is largely based on three parameters: block volume fraction, molecular weight, and conformational asymmetry. Less explored, however, is how their formation can be driven in triblock copolymers. This research studies this question with a particular focus on ABA' triblock copolymers with variable core (A) block lengths. We hypothesize that an asymmetry in the core block lengths will open up a FK phase window. Polymers will be synthesized by ruthenium-mediated ring-opening metathesis polymerization (ROMP). Volume fraction and core block length asymmetry will be varied to yield symmetric and asymmetric triblock copolymers. Polymers will then be characterized by proton nuclear magnetic resonance spectroscopy (1H NMR) and size exclusion chromatography (SEC). Following, small-angle X-ray scattering (SAXS) will be used to assess polymer nanostructure. Order–disorder and order–order transitions will then be determined using rheology.
52.	**Michaela Polley** *Recycling Photopolymerizable 3D Printing Resin* **Advisor:** Chris Ellison **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** Carleton College **Abstract:** 3D Printing has in recent years taken on a greater role in the medical, automotive, and other industries. One popular form of 3D printing is vat photopolymerization, which uses a laser to cure a vat of liquid resin one layer at a time and allows for very intricate parts. Since this is a cross-linked, thermoset material, traditionally it has not been recyclable. We developed a procedure for incorporating used material back into the pure resin to increase sustainability. Using FormLabs Clear and Elastic resins as a model system, we were able to reach and exceed 10 weight percent of recycled content incorporation without loss of mechanical properties by adding a radical scavenger during milling.
53.	**Ethan Poppen** *Investigation of a Non-Toxic Bismuth Catalyst for Ring-Opening Transesterification Polymerization* **Advisor:** Jane Wissinger **Sponsoring Program**: Center for Sustainable Polymers **Home Institution:** Augsburg University **Abstract:** Polymers are an important topic that must continue to be covered thoroughly in undergraduate curriculum, as the demand for sustainable alternatives to common plastics grows. To meet this demand students must be provided opportunities to work with sustainable polymers in undergraduate labs. Our work focuses on designing a teaching lab where students use renewable feedstocks and a non-toxic catalyst to synthesize sustainable triblock polymers and explore their varying physical properties. The triblock synthesized in this teaching lab is poly(δ-decalactone) end blocked with poly(L-lactide). The mechanism in the formation of the triblock polymer involves ring opening transesterification polymerization with a lactone monomer. Previous work with this type of polymerization used tin catalysts, which educators are hesitant to use. We are employing non-toxic bismuth catalysts as an alternative to make this teaching lab procedure greener. A series of triblocks were made with several different bismuth catalysts, and the catalyst's ability to lead to high end-block formation was compared to the tin catalyst. It was found that bismuth acetate was a promising catalyst for the ring-opening transesterification in the reaction. Further work is being done to alter the reaction conditions to improve incorporation of lactide into the triblock.
54.	**Songyan Qi** *nCas9 mediated CRISPR editing by SDSA and ssDI* **Advisor:** Eric Hendrickson **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota **Abstract:** Synthesis-Dependent Strand Annealing (SDSA) and Single-Strand DNA incorporation (ssDI) are two subpathways of the CRISPR-nCas9 mediated gene editing system that both require homology dependent recombination (HDR). SDSA and ssDI utilize nCas9 and sgRNA to introduce single-stranded nicks at the target locus and use single-stranded oligonucleotide donors to facilitate the chromosomal modifications. Compared with the double-stranded break mediated HDR, single-stranded nick mediated HDR is less robust. The goal of this research is to identify factors that can affect the nick mediated CRISPR editing pathway and improve the editing efficiency. By using a whole-genome CRISPR library screen, SETDB1, ATF7IP and SLFN11 have been identified as being potential negative regulators of ssDI. To validate those three candidate genes and see whether they can truly impact ssDI, we will query the ssDI activity of reporter cell lines in which these candidate genes have been either knocked out or are wild-type. We will compare the ssDI-mediated gene editing efficiency in both cell lines to validate these potential candidate genes.

55.	**Lilly Schroer** *Nanoindentation Study of Next Generation Damage-tolerant Materials for Nuclear Reactor Applications* **Advisor:** Nathan Mara **Sponsoring Program**: MRSEC **Home Institution:** Georgia Institute of Technology **Abstract:** Nanoindentation is being used to measure the mechanical properties and creep deformation mechanisms in engineering alloys to predict behavior at extreme conditions found in nuclear reactors. Conventional creep tests pose a challenge because they require large samples and are long. Nanoindentation is a small-scale mechanical testing method that offers an alternative with small samples and quick testing times. The goal of this project is to further develop nanoindentation techniques to analyze creep. Austenitic stainless steel (SS347 alloy) is being studied as a model system for proving testing protocols and studying the effect of microstructure because it's a single-phase (FCC). Room temperature testing protocols were developed using a Berkovich indenter, and the nanomechanical behavior of the SS347 alloy was measured for the first time. Young's modulus was observed between 190-200 GPa, and hardness between 1.6-1.8 Gpa, decreasing with strain rate, showing an average strain rate sensitivity of 0.017. Using electron backscatter diffraction (EBSD), we used an orientation map to indent single grains to analyze how microstructural inhomogeneities effect hardness and observed anisotropic behavior. Future work will develop high temperature nanoindentation protocols. Finally, nanoindentation and bulk creep test results will be linked to develop a model to predict properties of engineering alloys.
56.	**Subhra Sen** *Atomization of viscous liquids* **Advisor:** Vinod Srinivasan **Sponsoring Program**: ME **Home Institution:** The City College of New York **Abstract:** Biofuel is made of agriculture and forest residue. The GHG emissions rate of biofuel is about a quarter of fossil fuels. However, some characteristics including low heating value, moderate oxygen content, and high viscosity have made biofuels incompatible in the conventional combustion design. To make biofuel functional in real applications, the atomization process becomes critical to ensure production of fine droplets comparable to those produced by fossil fuels. The goal of the research is to characterize the performance of a nozzle that has a weak dependence on viscosity for Newtonian fluids. The goal also comprises to understand the impact on droplet sizes with the change of several experimental parameters including pressure, air flow rate, liquid flow rate and fluid droplets. In the lab, spray is produced using a counterflow nozzle. Two experiments were done with water and with a 1% aquas CMC solution. Then, using a camera, pictures of the sprays are taken. Based on the result it can be stated that, by changing the pressure, mass flow and volume flow rate, it is possible to get the same range of droplets for different liquids.
57.	**Margaret Shepherd** *SHIELD Galaxies with Offset Neutral Gas Distributions* **Advisor:** Evan Skillman **Sponsoring Program**: Physics REU **Home Institution:** Macalester College **Abstract:** This study uses data from the Arecibo Legacy Fast ALFA (ALFALFA) survey, an extragalactic HI census, from which 82 galaxies were selected to make up the Survey of HI in Extremely Low-mass Dwarfs (SHIELD). We present the results of this study, which characterizes the properties of dwarf galaxies demonstrating offsets between their neutral gas (HI) and stellar distributions and uses images from the VLA, the Spitzer Space Telescope, and the DESI Legacy Imaging Survey. While it is clear that some galaxies have a visible but unexplained offset between the HI and stellar components, we found no strong correlations between the offset and other galaxy properties. We also completed a visual classification, where the categories of "offset", "possible offset", and "non-offset" were created, into which seven, 11, and 64 galaxies were placed, respectively. Further analysis revealed that the "offset" or "possible offset" galaxies are more likely than "non-offset" galaxies to have non-detections in their Ha star formation rates (a measure of recent star formation). This analysis can expand our knowledge of internal star formation processes and galaxy evolution mechanisms in dwarf galaxies, with the goal of realigning observations of dwarf galaxies with simulations using current predictions of cold dark matter.

58.	**Javier Soliz-Martinez** *Evaluating How the Backbone Affects the Properties of Bottlebrush Polymers* **Advisor:** Mahesh Mahanthappa **Sponsoring Program**: MRSEC **Home Institution:** University of Texas Rio Grande Valley **Abstract:** Polymers are fascinating for being easily manipulated into different architectures and patterns which affect their physical properties, demonstrating their versatility through their wide range of applications. The project I'm working on focuses on synthesizing densely grafted core-shell bottlebrush (csBB) polymers that order themselves into lamellar structures with finite domain spacings. The side chains are grafted together by the Oxanorbornene backbone to form a bottlebrush like pattern, hence the name. Microchips and various electrical components have small groove-like patterns that serve as the device's storage. Engineers are reaching the physical limits of manufacturing these components, as rising technologies are barely scratching the surface of 10-nm sized objects. Chemists, on the other hand, work with template synthesis which can be used to create molecular templates and thus smaller patterns. A high repulsion between chains (?) is needed to reach a maximum architecture capacity and a small degree of polymerization (N), which means shorter arms. The lamellae structure formed by bottlebrushes can potentially form sub 14-nm domain spacings which would increase the current storage density by approximately eight times.
59.	**Noah Stanis** *Pacing increases reproducibility of calcium transient analysis in human induced pluripotent stem cell derived engineered heart tissue* **Advisor:** Brenda Ogle **Sponsoring Program**: UROP **Home Institution:** University of Minnesota **Abstract:** Calcium transient analysis acts as a marker for maturation of human induced pluripotent stem cell derived cardiomyocytes (hiPSC-CM). Calcium handling can be visualized through the calcium transient of beating cardiomyocytes. Analyzing maturation is essential to confirm the adult phenotype has been obtained. Engineered heart tissues (EHT) are 3D tissue models allowing for greater interaction between the extracellular matrix and cardiomyocytes as compared to 2D models. They also allow for culturing of cardiomyocytes under passive mechanical loading i.e. the 3D issues are mounded between two PDMS posts. We are using calcium transient analysis to assess the maturation of these EHTs. It has been seen that electric pacing of these cells with platinum electrodes synchronizes beating patterns and calcium transient signals. Paced and non-paced EHTs under identical conditions were compared based on their upstroke velocity, downstroke velocity, time to peak, average max, inter-spike interval, and coefficient of variance. Measurements taken under pacing conditions had a more uniform inter-spike interval confirming synchronization occurred. The standard error of these measurements was compared between the two conditions. It was found that pacing gave a higher reproducibility of measurements denoted by the lower standard error.
60.	**Sophie Stevens** *The Implementation of the Muon g-2 Experimental Measurement Within the Snowmass pMSSM Scan* **Advisor:** Nadja Strobbe **Sponsoring Program**: Physics REU **Home Institution:** St. Olaf College **Abstract:** The phenomenological minimally super symmetric addition to the standard model (pMSSM) is a theoretical framework to describe new physics. The MSSM predicts a supersymmetric partner with the same quantum numbers but a spin difference of _ to each particle in the standard model. It attempts to explain gaps in the standard model such as dark matter, the higgs boson mass, and the muon g-2 discrepancy. The pMSSM narrows 124 free parameters to 19 based on well-motivated assumptions. In preparation for the 2021 Snowmass convention physicists have been working to explore this parameter space computationally. One group has made significant progress writing a Markov chain Monte Carlo with logarithmic stepping for this purpose. In this project a, the difference between the theoretically calculated muon anomalous magnetic moment (a=g-22) and the latest experimental value from Fermilab, was added into the pMSSM MCMC as a likelihood contributor. The McMC was then run over 1000 steps with and without this contribution, with the same starting values for the 19 parameters. Several scans with different starting parameters were then added together to get a more comprehensive set. Distributions of free parameters were compared and analyzed to investigate the impact of the g-2 parameter.

61. **Carter Swift**
Interaction of Topological Defects in 2D Nematic Liquid Crystals
Advisor: Jorge Vinals
Sponsoring Program: Physics REU
Home Institution: Macalester College
Abstract: Topological defects in a nematic liquid crystal are deformations in the director field which cannot relax away due to being topologically distinct from the defect-free configuration. The particular form of these deformations is that which minimizes the Frank free energy, and is known both for the case when the Frank elastic constants are all equal and the case when the constants for splay and bend deformations are not equal, provided that only one defect is present. Knowledge of the director field when two defects are present allows us to calculate the interaction energy associated with the defects, and thus calculate the forces they exert on each other. However, in this situation, the resulting field is a simple superposition of the single-defect fields only in the equal-constant (isotropically elastic) case and is not known in the anisotropically elastic case, so there only exists a well-known analytic expression for the interaction energy in the isotropically elastic case. In this project, the anisotropically elastic case was examined through numerical and analytic methods in order to describe the interaction of the two defects in this more general case.

62. **Abigail Tadlock**
Wire Responses in the Short Baseline Near Detector
Advisor: Andrew Furmanski
Sponsoring Program: Physics REU
Home Institution: Mount Holyoke College
Abstract: The Short Base Near Detector (SBND) is a liquid argon neutrino detector being built at FERMILAB to study neutrino interactions and oscillations. Using LArSoft (Liquid Argon Software) and the SBN software package neutrino events can be simulated and examined. The goal of this project was to simulate muons passing through the detector and examine the induced charge on the wire planes inside the detector by muons generated by neutrino events. Because charge only collects on the final of three wire planes, the integral of the charge induced on each of the first two planes should be zero. In preparation for the first collected data, I studied how to verify that the wires respond correctly. This included examining the effects of muons traveling parallel to the wires, developing a method to filter incorrect responses, and examining the predictions of a cosmic particle simulation.

63. **Jarod Tang**
Integrating green chemistry into a renewable PLA Vitrimer teaching lab experiment
Advisor: Jane Wissinger
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: In an ongoing effort to integrate sustainable polymer chemistry into teaching lab experiments, we report a new and engaging teaching lab experiment centered on synthesizing a polylactide-based vitrimer. Vitrimers are a class of covalent adaptable network (CAN) that undergoes dynamic crosslink exchange under elevated temperature. Vitrimers have advantageous properties of both thermosets and thermoplastics. Vitrimers are cross-linked like thermosets, but flow at elevated temperatures like thermoplastics. Design of the experiment was based on a recent Center for Sustainable Polymer publication but modified to incorporate an alternative greener catalyst and use of safer solvents suitable for a teaching lab. A one-pot two-step synthesis was developed using ring-opening transesterification polymerization (ROTEP) of L-lactide and pentaerythritol with bismuth (III) acetate catalyst. The resulting hydroxyl-terminated star-shaped poly(L-lactide) (HTSPLA), was then cross-linked using methylene diphenyl diisocyanate (MDI). Students then perform mechanical and self-healing tests of the cross-linked polymer to study the reprocessable characteristics of a vitrimer. This experiment not only exposes students to green chemistry and cutting-edge polymer science but it also addresses sustainability goals.

64. **Cassandra Vargas**
Mixing dynamics of bilgewater emulsions in Taylor Couette flows
Advisor: Cari Dutcher
Sponsoring Program: MRSEC
Home Institution: University of California, Riverside
Abstract: Taylor-Couette flows between two concentric, rotating cylinders, is ideal for studying the mixing dynamics and stability of emulsions due to the availability of wide variation of hydrodynamic flow states. The control of oil discharge concentration at sea from the marine vessels require a better understanding of the stability and formation of Navy standard bilge mix emulsion. In this study, a pre-prepared (IKA: T-25 digital Ultra-Turrax) concentrated oil-water emulsion is directly injected into the annulus of the Taylor-Couette cell containing surfactant-water solution at varied flow conditions to determine the intermixing rate or dispersion rate of the emulsion. The optical properties of the Tayler-Couette cell enables us to visually study the mixing and spread of the emulsion in the solution. The dispersion coefficient shows an approximate linear response to increasing inner cylinder speed of Taylor-Couette cell. Collected samples at different occurring mixing TC cell stages, laser diffraction particle analyzer and use of optical microscopy help characterize droplet size distribution for those mixing stages. The measurements indicate the droplet breakup or shear induced coalescence in terms of droplet size distribution. These measurements of droplet size distribution determine the conditions for formation of stable bilge emulsions.

65.	**Julie Villamil** *Investigation of Anisotropic, Nodal, and Topological Material Properties in 2D Superconductors* **Advisor:** Vlad Pribiag **Sponsoring Program**: MRSEC **Home Institution:** Florida International University **Abstract:** Superconductivity of 2D materials, specifically transition metal dichalcogenides (TMDs) are of current interest due to their unique symmetry properties. This study focuses on the development of 2D superconducting devices and the investigation of the properties of NbSe2. Computer-aided design (CAD) software will be used to design multi-layer devices, which will be assembled with a combination of dry transfer techniques and nanofabrication. Beginning with the exfoliation of outer device layers such as graphene and hexagonal boron nitride (hBN), thin layers of these materials will be obtained and characterized. This is conducted using a simplified practice of continuous mechanical exfoliation to obtain few-layer flakes of each material. Characterization of these metal flakes will be conducted using atomic force microscopy. In addition, heavy emphasis in this study is placed on the dimensionality and topology of the metal flakes and their effect on device superconductivity. Electrical transport measurements will be obtained at low-temperature, and the data analysis will be conducted in MATLAB. Due to results from previous testing on NbSe2, it is expected that it will demonstrate layer-dependent anisotropic symmetric superconductivity when under the effect of a rotated magnetic field.
66.	**Yanbo Wang** *On the Fronts of the Cubic Allen-Cahn Equation* **Advisor:** Arnd Scheel **Sponsoring Program**: UROP **Home Institution:** School of Mathematics, College of Science and Engineering, University of Minnesota. **Abstract:** We study wave speeds of different types of critical fronts for the cubic Allen-Cahn type equation u_t=u_xx+f(u)+μ, where f(u)=u-u^3 and depict the bifurcation diagram with the speeds of the fronts c with respect to the driving strength μ. Together with the previous studies of existence and stability of such critical fronts, we identify pulled, pushed, and bi-stable fronts for μ-[-2/(3-3),2/(3-3)], reproducing results from Stegemerten, Gurvich and Thiele's paper. In this specific test example, all speeds are given through algebraic expression. We develop numerical continuation algorithms that are widely generalizable to compute the front speeds from boundary-value problems in finite domains x-(-L,0). We demonstrate that the algorithm used in Stegemerten, Gurvich and Thiele's paper converges slowly O(1/L^2) and develop refined algorithms that converge exponentially O(e^(-ηL)) and identify the pushed-pulled transition with very high accuracy. Throughout, special care has to be given to round-off and underflow errors due to the exponentially small effects in the leading edge of the front.
67.	**Lentrell Webb** *Examination of Proline-Rich Antimicrobial Peptides* **Advisor:** Ben Hackel **Sponsoring Program**: MRSEC **Home Institution:** Dillard University **Abstract:** With antibacterial resistance on a rise, healthcare systems around the world are seeking alternatives to fighting bacterial infections. Various organisms produce antimicrobial peptides (AMPs) as a defense against invading pathogens. In the family of AMPs are a group of proline-rich AMPs (PrAMPs)- which inhibit ribosome function, stopping protein synthesis essential for survival. The previous library testing completed on the PrAMP oncocin in Escherichia coli expresses that PrAMPs are a viable option for treatment. The effectiveness of PrAMPs Apidaecin 1b, Arasin 1, Heliocin, Metalnikowin 1, Pyrrhocoricin, and Tur 1a on E. coli has been tested. Each PrAMP is placed into a DNA plasmid and transformed into bacteria. Isopropyl β- d-1-thiogalactopyranoside (IPTG) is used as an inducer that will express the given PrAMP within the bacterial cells. Bacteria that show a decline in growth convey that the PrAMP is effective against E. coli. Conversely, bacteria that show an increase or no change in growth rate convey that the given PrAMP is not effective. All six of the PrAMPs have shown to be effective against E. coli.

68.	**Fabian Williams** *Plasmonic Photocatalyzed Reaction Outcomes of Differing Excitation Methods Using Surface Enhanced Raman Spectroscopies* **Advisor:** Renee Frontiera **Sponsoring Program**: MRSEC **Home Institution:** University of Minnesota - Twin Cities **Abstract:** Surface enhanced Raman Spectroscopy (SERS) is well-known for enhancing weak Raman signals via intense electromagnetic fields on plasmonic materials. SERS is used to determine chemical identities through vibrational modes present in analytes. Its sensitivity to chemical environments also makes it a reliable tool for monitoring plasmon-driven reactions. These reactions have potential to create efficient, inexpensive, and low-hazard reaction pathways. Previous studies have been conducted to determine the dependence of SERS on substrates, size of nanoparticles, and other parameters. However, the manipulation of reaction efficiency of plasmon-mediated processes is yet to be understood. This experiment, I carried out the dimerization of 4-nitrobenzenethiol (4-NBT) to 4,4-dimercaptoazobenzene (DMAB): a well studied reaction known to be driven by plasmonic effects. For this experiment, ultrafast and continuous-wave (CW) radiation will be used to drive the dimerization of 4-NBT to DMAB. This will potentially provide insight into controlling plasmonic reactions, as the CW and pulsed excitations may impact the reaction differently. By observing the reaction kinetics of the excitation methods, a difference may be revealed. Whichever method drives the system to higher yield would be the dominant excitation method. Exploring the effects of different excitation methods could allow experiments regarding chemical reactions to be conducted efficiently.
69	**Anjali Dziarski** *Mu2e Tracker Construction: Developing Ideas and Prototypes for Mu2e-II* **Advisor:** Ken Heller **Sponsoring Program**: Physics REU **Home Institution:** Indiana University **Abstract:** Mu2e is a high-energy physics collaboration that's searching for the rare muon to electron conversion. The University of Minnesota's job is to build the electron tracker. The tracker consists of 216 panels and each is made with 96 thin, metalized straws. For the second iteration of the experiment, Mu2e-II, the straws need to be half as thick. To deal with the unique challenges these thin straws present, we tested various prototype straws. We analyzed the density, leak rate, and thickness of these straws to determine the pros and cons of different designs. The Aluminum Only Overlap straws performed better in leak testing but are denser. The Aluminum Only straws performed badly on leak testing but are thinner. In addition, the Overlap straws have a flap where the seam is. This seam is concerning to the team because it could disrupt the electric field inside the straw.

Teacher Poster Presentations
Listed Alphabetically by Presenting Author

70.	**Michael Hamann, Elizabeth Myers** *Illuminating Luminescent Solar Concentrators* **Advisor:** Vivian Ferry **Sponsoring Program**: MRSEC **Home Institution:** Waconia High School, St. Paul Central High School **Abstract:** The green energy revolution has begun and solar cells on homes, businesses and schools are becoming a common sight. Traditional solar cells obstruct light and require a large surface area. Luminescent Solar Concentrators (LSC) combine the function of a solar cell with the practicality of a window. We developed a high school appropriate project involving Luminescent Solar Concentrators that will engage the students in exploring the properties of LSC while learning about the concepts of light and optics. We utilized non-toxic organic dyes to create LSC paints that can be applied to a waveguide. The type of LSC paint and number of layers can be tested under a variety of light sources while intensity of luminescence is measured using the light sensor on an Ipad.

71.	**Cassandra Lydon, Olivia DeSutter** *Green Applications of Seaweed: Edible/Degradable Calcium Alginate Capsules* **Advisor:** Jane Wissinger **Sponsoring Program**: MRSEC **Home Institution:** White Bear Lake High School, FAIR School Minneapolis **Abstract:** Edible, biodegradable calcium alginate capsules are synthesized using safe, readily available materials, sodium alginate, a derivative of seaweed, and calcium lactate. The capsule outer membranes are a result of ionic interactions between specific carboxylate groups from different alginate strands and the divalent calcium cations between them, thus forming cross-linked polymers. When the carboxylate groups on the alginate strands are protonated, crosslinking is inhibited, preventing formation of the capsules. In the first part of this experiment, various concentrations of citric acid are used to lower the pH of the sodium alginate solution and the effect of calcium alginate capsule formation is observed. As pH decreases the capsules are less firm, oblate, or do not form at all. In the second part of this experiment, cranberry juice, apple juice, and lemon juice, rather than water, are used in the synthesis of the calcium alginate capsules. The impact of the concentration and natural acidity of the juice on capsule formation is studied. Learning outcomes include simple bonding, acid/base chemistry, polymer structures, and green chemistry concepts. Students consider the environmental challenges of traditional plastics and how innovative products, like NotPLA, are attempting to provide solutions.
72.	**Eva Nelson, Claire Hypolite** *An Example of Phenomenon-Based Learning Through the Exploration of Protein Prenylation in Algae* **Advisor:** Mark Distafano **Sponsoring Program**: MRSEC **Home Institution:** Thomas Edison High School **Abstract:** The 2019 Minnesota State Science Standards are shifting focus from content-driven learning to the use of scientific practices to explore and understand new phenomena. This project will use protein prenylation in algae as an anchoring phenomenon in both biology and chemistry courses to support a collaborative multi-year project. Students in chemistry will learn the synthesis of a fluorescent prenylation probe through a click reaction. Students in biology will use a synthesized probe to prenylate proteins in algal cells and visualize the resulting product using gel electrophoresis and staining.
73.	**Mark Szybnski** *Analyzing Iron Oxides: Seeing the Unseen* **Advisor:** Lee Penn **Sponsoring Program**: MRSEC **Home Institution:** Mankato West High School **Abstract:** Science requires observation. In chemistry, observations of change in color, mass, and heat can be exciting, but they can further provide clues as to what is occurring deeper within the particles and atoms. Crystals of iron oxides (iron rusts) made under various conditions (pH, time, temperatures, ion presences) can provide an opportunity for student analysis and provide clues into their formation and structure. Using steel wool, students will be challenged to make rust. While the rust formed is visible, identifying the types of rust requires analysis--as there are sixteen iron oxides and iron oxyhydroxides. At a high school level, this analysis can include a visible identification, a streak test, and a check with a magnet. However, a deeper analysis can include a check with an RGB color picker (using a computer or mobile phone app) or, with a university connection, powder XRD (X-ray diffraction). Student learning outcomes will include material synthesis and applying various methods for analysis. The analysis provides opportunities for students to open the door to deeper skills and technologies and allows them to see the unseen. Student-produced iron oxide samples can be compared to standardized samples created and characterized at the University of Minnesota.