Abstracts: Oral Presentations

All oral presentations will take place in the Devon Room

History

(2:00 p.m.)

Resistance to Authoritarianism in Poland's Recovered Territories, 1945-1950
Author: Brandon Hornlein
Advisor: Dr. Paul Steege

In the wake of World War II, Poland saw a radical restructuring of its borders. Its eastern lands were annexed by the Soviet Union, but in return Poland gained control of Germany's eastern regions, up to the Oder and Neisse rivers. These formerly German areas became known as the "Recovered Territories," and formed the new western border of Poland. There were a number of challenges the emerging communist regime faced in this area: heavy devastation from the war, the active expulsion of the German population, the resettlement of Poles from the east, and the establishment of a new state apparatus in the region. Throughout the rest of Poland at this time, the regime saw resistance from a number of groups, such as the remnants of the Polish Underground. It would seem natural that such resistance would flourish in a region as turbulent as the Recovered Territories. However, research thus far has indicated that resistance in the region in the 1945-1950 period was largely muted in comparison to other regions of Poland. That is not to say that resistance was entirely absent, as it could be found in a number of different forms, including political opposition, strikes, terrorism, and the diplomatic actions of other states. The question lies in explaining why the Recovered Territories saw a lower degree of resistance in comparison to the rest of Poland. Hopefully, further research will produce an answer to that question, or at least provide a clearer image of the Recovered Territories.

History & Humanities

(2:15 p.m.)

From Blackout to Billionaire: The Assimilation of Hip-Hop into the Culture Industry
Author: Ryan Dery
Advisor: Dr. Eugene McCarraher

This project investigates hip-hop's assimilation into the culture industry as defined by Theodor Adorno in "The Dialectic of Enlightenment". The genre of hip-hop originated in the 1970s in the south Bronx neighborhood of New York City. Before being a hugely popular and profitable genre, it was a developed by a niche, interconnected subculture. In order to achieve popular success, hip-hop needed to adapt to capitalist imperatives of the culture industry. An analysis of the history of hip-hop reveals how the genre evolved over time as it became more popular. "The Dialectic of Enlightenment"

provides a theoretical framework that explains what the culture industry is and why it necessitates art to be a certain way. By synthesizing the historical narrative with the theoretical framework, the reasons hip-hop needed to adapt in order to achieve mass popularity are revealed.

Humanities

(2:30 p.m.)

Coalescent Love: A Philosophical and Psychological Exploration of the Phenomenon of Love
Author: Jason Mitala
Advisor: Dr. Paul Camacho

What do we mean by "love?" Historically, this question was answered by philosophers, poets, theologians, and laypeople, but it is only recently that we have begun exploring the question from a scientific perspective. I argue that, to clearly understand love, we must draw from a variety of academic disciplines. My research explores a variety of contemporary and historical views of love and synthesizes these sources in favor of a multidimensional approach to academic inquiry. I trace thinkers such as Plato, Aristotle, Aquinas, Kierkegaard, Josef Pieper, Anders Nygren, and Erich Fromm and put their philosophies in conversation with a modern psychological theory, "Love as Mutual Communal Responsiveness." I propose that paradoxes that occur in both our psychological and philosophical systems (such as the "problem of unselfish altruism") can be answered only via an interdisciplinary conversation. I conclude that concepts such as altruism and self-love can only be studied psychologically insofar as they are understood philosophically and posit that this integration provides us with a more robust understanding of love.

Abstracts: Posters

Astronomy, Astrophysics and Planetary Science

A-01: Evaluation of the Next-Generation Very Large Array Revision D Array Configuration for Stellar Imaging
Author: Petretti, Catherine; Akiyama, Kazunori; Matthews, Lynn
Advisor: Dr. Kazunori Akiyama (Massachusetts Institute of Technology, Haystack Observatory)

The next-generation Very Large Array (ngVLA) is a proposed radio array planned for the 2030s, which will have the capability to resolve the surfaces of nearby stars using milliarcsecond-scale resolution and sensitivity to thermal radio emission. We present stellar imaging with the ngVLA using two image reconstruction methods – CLEAN and regularized maximum likelihood (RML) methods – to evaluate the capabilities of a new update to the configuration, the Revision D (Rev D) Main Array, as compared to the previous Revision C (Rev C) configuration. We find that, for the CLEAN reconstructions, the Rev D configuration improves the synthesized beam, resulting in better reconstructions due to the improved uniformity of coverage and circular symmetry. This result demonstrates that Rev D can enhance imaging capability for non-uniform weighting. However, the synthesized beam in both Rev C and Rev D configurations is highly non-Gaussian for non-uniform weightings, limiting the fidelity of image reconstructions. RML methods result image quality comparable to or better than CLEAN reconstructions in uniform weighting without adopting any uv-weighting for both configurations, showing that RML methods are an attractive choice over CLEAN. This work is financially supported by the ngVLA Community Studies program, coordinated by the National Radio Astronomy Observatory, which is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

A-02: Analyses of the Complex Light Variations of the unstable Red Supergiant VY Canis Majoris: On the nature of the star's "Great Dimming" Episodes.
Author: Nguyen, Thinh; Guinan, Edward
Advisor: Dr. Edward Guinan

VY Canis Majoris (VY CMa) is one of the largest red supergiant stars in the Galaxy and is on the verge of becoming a bright core-collapse supernova. Over the last century, VY CMa has been undergoing episodic large complex light variations whose causes are not adequately known. VY CMa has experienced two "great dimming" episodes during 1920 -1950 and 1989-1993. During these times, the star underwent large (~1-2 mag) quasi-periodic light variations. During the 1920-1950 epoch, in addition to the large quasi-periodic light variations, VY CMa became fainter by ~1.0 mag. The data are obtained from the Harvard photographic plates (published by L. Robinson in 1970) and the AAVSO and cover 1894 to 2021. Using Peranso-3 software, we employ the CLEANest algorithm to detect multi-periodic signals from the time-series light variations. We also utilized the Weighted Wavelet Z-Transform (WWZ) program to study the evolution of the star's light variations and periods over time. During the two active epochs, we find that VY CMa has a mean primary period of ~1580 days along with various transitory shorter periods. From our analysis, we speculate

that pulsations are the underlying mechanism to explain these quasi-periodic luminosity variations. However, these large pulsations may eject large quantities of gas that cools to form dust grains that further dims the star.

A-03: An Analysis of GJ 51: Rotation and Magnetic Activity
Author: Parrinello, Kaitlyn; Engle, Scott
Advisor: Dr. Scott Engle

As M-dwarf stars are the most abundant stars in the universe, there have been an increasing number of large terrestrial size planets discovered orbiting them. We focus on GJ 51, an M5 star, to refine its rotation and magnetic activity characteristics, including flare strengths and rates. GJ 51 is a member of the Hyades Supercluster, which has an age of ~725 Myr, therefore its age does not have to be determined, and has a known rotation period from previous observations from survey telescopes. This study has made use of photometric data from the Robotically Controlled Telescope (RCT) at the Kitt Peak National Observatory in Arizona, and the Transiting Exoplanet Survey Satellite (TESS), which is operated by NASA. The results from this study also serve as a comparison to the behaviors of other M-dwarf stars and help illustrate the impacts they can have on the potential habitability of any hosted planets.

A-04: Investigating the Quasi-Periodic Light Variations of Red Supergiant Stars – Analyzing Time-Series Archival Photometry and Carrying out Period Searches
Author: Sheridan, Christopher
Advisor: Dr. Edward Guinan

Red supergiant (RSG) stars are evolved, luminous, moderately massive stars nearing the end of their lives. RSGs are the common progenitors of Type II core-collapse supernovae. As a result, RSGs are keys to astrophysics because during both their supergiant phase and during death they process and eject heavier elements into the interstellar medium as well as heating it. These stars are known for slow semi-regular light variations, generally attributed to pulsations, with semi-regular variability likely caused by large convection cells and large spots. RSGs generally vary with two dominant periods, typically a short period of a few hundred days, and long period up to several years. This semi-regularity permits measurement and analysis of their periods of these light variations, as well as how these periods change over time. Such an analysis was performed of 21 RSGs, using the Peranso-3 period program suite. The period analyses were performed on observations frequently dating back over a century, obtained via the American Association of Variable Star Observers (AAVSO). The CLEANest software was used to initially calculate the periods. We also utilized the Weighted Wavelet Z-Transform (WWZ) program to study the evolution of the light variations and periods over time. The calculated dominant periods were compared with the stars' physical properties to investigate relationships. The initial results will be presented and discussed. This research is supported by a VURF grant which we gratefully acknowledge.

A-05: Stars on the Verge: Period Analysis of the Red Supergiant μ Cephei
Author: Larsen, Conor; Guinan, Edward
Advisor: Dr. Edward Guinan

μ Cephei (μ Cep) is a 4th magnitude, semi-regular red supergiant of spectral type M21a. It is one of the largest known stars, sizing up at about 970 times the radius of the sun. At a distance of 900 -

1080 pc and a mass between 15 – 20 M ⊙, μ Cep is a nearby type-II supernova progenitor. Studies of red supergiant type-II supernova progenitors are important as they reveal vital information about the physical processes before stellar death. Analysis of over 175 years of photometry obtained from the AAVSO database was conducted. This analysis was completed in the period analysis software Peranso where a light curve, power spectrum and WWZ plot were created. These plots reveal the dominant periods present over the dataset. μ Cep is a multi-period, semi-regular variable star and throughout the 175 years of observations, the periodicities have undergone many changes. Multiple period features, such as period merging, period splitting and period decays, were discovered across the dataset. The dominant periods and period features, including a large period decrease in the short period over the past 80 years, are presented. The physical nature of the long periods for red supergiants is an open question. Only the red supergiant Betelgeuse has long term radial velocity measurements to confirm its long period as a pulsation mechanism. Along with presenting the period analysis, the potential physical nature of the long periods of μ Cep are discussed.

A-06: Testing the Growth of Vegetables in Lunar Mare and Highland Simulant Soils: In Preparation for Bases on the Moon before going to the Mars

Author: Nofi, Hayley; Guinan, Edward
Advisor: Dr. Edward Guinan

The announcement of NASA's Artemis Moon mission deadline of 2024 makes Earth independence a clear priority for the future of humanity. Soon, humankind will no longer be limited to a single planet which can be achieved through the establishment of permanent human bases on the Moon and Mars. These colonies will have to be self-sustaining due to the great expense of transporting soil from Earth. The Artemis "Base Camp" is planned to be near the Moon's South Pole that features craters (e.g., Shackleton Crater) that are unique in that the near-constant sunlight does not reach their interiors permitting the build of ice. As a result, LED growth lamps will be necessary to grow plants during the mission. As part of the Villanova Undergraduate Research Fellowship (VURF), a pilot study was conducted to determine how Slobolt lettuce (Lactuca sativa) grows in different synthetic soils under only LED light sources. The LED light sources used were full-spectrum to replicate sunlight. The soils used included the Lunar Mare Simulant and the LHS-1D Lunar Highland Dust Simulant from Exolith Lab (https://exolithsimulants.com). The Lunar Mare Simulant's chemistry closely matches the type of rock at the South Pole of the Moon. The LHS-1D Lunar Highland Dust Simulant was tested in case an alternative landing site of the lunar highlands is chosen. Martian regolith was also tested with the MMS-2 Enhanced Mars Simulant from The Martian Garden (https://www.themartiangarden.com). A secondary component of this project was to test how the type of soils seedlings were germinated in affects the growth in hydroponics systems after the seedlings have been transplanted. The results of this pilot project will be presented and discussed along with plans for follow-up studies.

A-07: Finding and Following Exoplanets

Author: Moposita, Kevin; Engle, Scott
Advisor: Dr. Scott Engle

Exoplanets are defined as planets that orbit stars other than our Sun and are one of many current hot topics within astronomy. Since their discovery, various methods have been utilized to record

their observations. Of all, the transit method has brought much success and is the process implemented in this project. The transit method involves observation during periods of time in which a star's brightness is dimmed due to an exoplanet eclipse (transit). This process has been utilized to further confirm stellar and planetary parameters, in addition to revealing exoplanets themselves. As a part of this project TIC 116264089, a confirmed exoplanet, was the primary focus. Recent data from the Kepler Telescope was downloaded and reduced, along with data from the Robotically-Controlled Telescope (RCT) at Kitt Peak National Observatory. These data were modeled to determine the transit midpoint time and the uncertainty of each observed transit, and the transit timings were then searched for variations. The results of this study will be presented and compared to those found for other transiting exoplanets.

A-08: The Origin of High Field Magnetic White Dwarf Stars
Author: Brown, Shannon
Advisor: Dr. Edward Sion

The origin of strong field magnetic white dwarfs (B > one MegaGauss) are poorly understood. To identify the cause of them, we compiled data for both magnetic and non-magnetic white dwarfs. Using the data, we created an H-R Diagram to visualize the relationship between the effective temperatures and absolute magnitudes of magnetic white dwarfs (MWDs) in comparison to non-magnetic white dwarfs (NMWDs). The diagram shows that most MWDs lie below the main belt of DA white dwarfs, which would occur if the MWDs are more massive than the mean mass of DA stars (0.6 solar masses). Moreover, we see hot, strong field MWDs above the effective temperature of core crystallization, but a majority of strong field magnetic white dwarfs are below crystallization temperature. It appears approximately 1/3 of the 48 strong field magnetic white dwarfs lie below the distribution of 3500 non-magnetic DA white dwarfs, whose mean mass is 0.6 solar masses. Thus, 1/3 of the strong field magnetic white dwarfs are massive degenerate stars that lie on the constant radius cooling tracks at higher white dwarf mass. We suspect a large percentage of these 16 high mass strong field degenerates are the result of mergers during the common envelope phase of evolution which avoided merger, while 1/3 of the high mass, high magnetic field white dwarfs are the result of stellar mergers during the common envelope spiraling-in process of main sequence dwarfs, merging with a white dwarf core of a red giant.

Biochemistry

A-09: Oxidative Stress Suppresses Nrf2 Protein Synthesis through Global Protein Synthesis Inhibition
Author: LaMorte, Joseph; Pensabene, Kaitlin; Allender, Amanda; Eggler, Aimee
Advisor: Dr. Aimee Eggler

Oxidative and electrophilic stresses are common aggressors in chronic diseases ranging from arthritis to cancer to neurodegenerative disease. The transcription factor Nrf2 is an essential mediator of the cell's cytoprotective response to these stressors. Nrf2 is constantly synthesized, ubiquitinated, and degraded with a short half-life of 20 minutes that maintains low basal Nrf2 protein levels. Electrophiles and oxidative stress cause Nrf2 to accumulate and subsequently to

activate cytoprotective genes by modifying cysteines of the Keap1 protein, the repressor that targets Nrf2 for ubiquitination. We previously found that paradoxically, reactive oxygen species (ROS) stimulate the production of cytoprotective proteins, but inhibit Nrf2 protein synthesis, revealing a "Dr. Jekyll and Mr. Hyde" effect of ROS on Nrf2 accumulation. We tested the hypothesis that oxidative conditions that activate the Nrf2 pathway simultaneously inhibit global protein synthesis, thereby suppressing Nrf2 protein synthesis. We investigated both ROS generated by redox cycling of the oxidizable phenol, di-tert-butylhydroquinone (dtBHQ), and direct addition of H2O2 to HaCaT keratinocyte cells. We found that 100 μM to 400 μM H2O2 and 50 μM dtBHQ inhibit both Nrf2 protein synthesis and global protein synthesis. Addition of antioxidants, such as the manganese porphyrin MnTMPyP, rescued both Nrf2-specific and global protein synthesis. Therefore, antioxidants such as MnTMPyP that mitigate the suppressive effects of ROS on global protein synthesis during Nrf2 activation could enhance the Nrf2/cytoprotective response under conditions of electrophilic and oxidative stress.

A-10: Glycine linker placement affects unfolding ability of 26S proteasome
Author: Kisker, Faith; Kraut, Daniel
Advisor: Dr. Daniel Kraut

Proteins can be targeted to the 26S proteasome for degradation by ubiquitination. Polyubiquitin chains are attached to lysine residues of the target protein. Once a protein is ubiquitinated and bound to the proteasome, motor proteins in the 19S regulatory particle latch onto an unstructured region of the protein and translocate it into the 20S core particle for proteolysis. In the Kraut lab, we study the unfolding ability of the proteasome using the N-Neh2-Barnase-linker-DHFR-C substrate with a Neh2-derived degron as a model substrate. Low complexity sequences have been shown, in past research, to stall degradation by the proteasome. In my research, I have inserted amino acid chains with glycine linkers at different locations between the barnase and DHFR regions to study if the location of the glycine linker affects the unfolding ability of the proteasome. Although I have cloned all of these model substrates, expression has been challenging as there have been issues with being able to maintain the stability of the protein long enough for it to be expressed and purified in a significant enough amount. I attempted to clone, express, and purify the proteins with a destabilized barnase with the L89G mutation and was successful in only three of the four sequences attempted. I am currently re-cloning all four proteins with a more stable barnase that does not have the L89G mutation to increase expression levels, and will attempt to purify the proteins using new methods. The hope is to pursue degradation studies with these substrates in the future.

A-11: Characterization of β-Hydroxybutyrate Dehydrogenase from Two Pathogens
Author: Capalbo, Kathryn; Palenchar, Jennifer; Beadle, Azzeiza
Advisor: Dr. Jennifer Palenchar

Our work furthers the characterization of beta hydroxybutyrate dehydrogenase (HBDH) from two different pathogenic organisms. HBDH catalyzes the reversible, NAD(H)-dependent conversion of hydroxybutyrate to acetoacetate. The bacteria *Burkholderia cenocepacia* (Bc) causes infection in patients with cystic fibrosis. BcHBDH was crystalized by the Seattle Structural Genomics Center for Infectious Disease (SSGCID), PDB ID 4TRR. We obtained the construct encoding His10-BcHBDH from SSGCID, overexpressed the protein in *E. coli*, purified the his-tagged protein to

approximate homogeneity, and completed the kinetic characterization. BcHBDH kinetic parameters will be presented. Trypanosomes, unicellular eukaryotic parasites, cause various diseases globally. *Trypanosoma brucei* has acquired an HBDH from bacteria through horizontal gene transfer. HBDH function in *Trypanosoma brucei* is unknown. The enzyme also utilizes a cofactor different than most other HBDHs reported. Towards determining function, we have constructed an RNAi cell line in which HBDH is depleted. Treatment of cells +/- HBDH with oxidative stress molecules will be presented. Finally, we are working on generating a cell line with a tagged-HBDH to be used to identify HBDH-interacting proteins. Progress on a construct to identify TbHBDH-interacting proteins will be presented.

A-12: Expression and Characterization of Wildtype and Mutant Cyclooxygenase from *Gracilaria vermiculophylla*

Author: Hrnjic, Salko
Advisor: Dr. Barry Selinsky

The red algae *Gracilaria vermiculophylla*, has been shown to express cyclooxygenase (COX), a dual function enzyme that converts arachidonic acid to prostaglandins (Varvas et al). The reaction is believed to begin by the formation of a tyrosyl radical (Y327 in Gracilaria), which abstracts a proton from the arachidonic acid substrate. A second tyrosine (Y281) contributes to the formation of the radical at Y327. To confirm the role of Y327 and Y281 in the *Gracilaria* COX reaction, tyrosine were mutated to phenylalanines and their impact on enzyme activity was assessed. Mutated proteins were expressed in bacterial cells and purified to homogeneity. After purification, dioxygenase activity was measured using an Instech monitoring system that measures oxygen addition to a lipid substrate. Hydroperoxide formation was assessed spectrophotometrically, and peroxidase activity was measured using a colorimetric assay. The Y327F mutation eliminated enzyme activity, while the Y281F mutation greatly reduced measured activity. This experiment highlights the structural importance of the Y327 and Y281 tyrosine residues in enzymatic activity, and indicates that Y327 likely has greater impact than Y281. Further research could be done on other sites within *Gracilaria* to correlate structural differences and enzymatic function.

A-13: Effect of Lysine Quantity on Unfolding Ability of the 26S Proteasome

Author: Cotteta, Sarah; Kraut, Daniel
Advisor: Dr. Daniel Kraut

The 26S Proteasome, composed of a 19S regulatory particle and a 20S core particle, is a protein-degrading complex in the cell that has both regulatory and housekeeping functions. Varying types of poly-ubiquitin tags are attached to lysine residues in an unstructured region of the target substrate (the degron) by E1, E2, and E3 enzymes, and the 19S regulatory particle recognizes these ubiquitin tags. Once the 19S recognizes the target substrate, the ubiquitin tag is removed and the substrate is unfolded. The substrate is then translocated to the 20S core particle to be cleaved into short peptides. In my project, I set out to determine if the number of lysines in the target substrate, and consequently the amount of ubiquitin tags, affects the extent of its degradation. This summer, I cloned DNA encoding a single-lysine-containing substrate and a four-lysine-containing substrate. I have conducted initial degradation assays to measure the unfolding ability of the proteasome with

each substrate. Although more experiments must be completed, initial results suggest that having more lysines in the substrate's degron leads to more efficient degradation by the proteasome.

A-14: Identifying genes with constitutively noisy gene expression in yeast organisms
Author: DeStefanis, Thomas
Advisor: Dr. Peter Palenchar

Organisms have intrinsic stochastic differences that can cause gene expression levels to vary between identical cells grown under the same conditions. Small extrinsic differences in environmental conditions can also result in phenotypic differences between isogenic cells. We sought to leverage published S. cerevisiae expression data to identify genes with constitutively high variability in their expression. The post-processing methods used to extract expression data can also result in technical variation which had to be distinguished from meaningful biological results. Analyses were conducted on Affymetrix microarrays and RNA-seq expression data comprised of 240 unique growth conditions. We found that genes involved in ribosome biogenesis have evolved to have highly variable expression in S. cerevisiae.

Biology

A-15: Developing Flow Cytometry-Based Assays to Quantify Anti-Tumor Killer T Cell Activity in Ly-6A-/- Mice
Author: Magahis, Angela
Advisor: Dr. Anil Bamezai

Adaptive immune responses are specific to a pathogen or some type of foreign substance and act more efficiently. One type includes $CD8^+$ killer T cells, which hunt down and kill tumor cells by differentiating into cytotoxic T lymphocytes (CTLs) and moving on to a new target. Immune checkpoint inhibitors (ICIs), such as PD-1 and CTLA-4, on these "serial killer" cells can suppress the immune response. Previous studies found that Ly6A could be a potential ICI, so a Ly6A gene knockout ($Ly6A^{-/-}$) will result in an increase of CTL production and efficiently kill B16 melanoma cells. In order to test and quantify the CTL kill efficiency on the B16 melanoma cells in $Ly6A^{-/-}$, $PD\text{-}1^{-/-}$, and wildtype mice, the target cells must be labeled. During the summer, with the guidance from my mentor, Dr. Anil Bamezai, I carried out multiple pilot experiments with a green-fluorescent dye, Calcein AM, which is permeant to live cells, and a far-red emitting nucleic acid stain, Helix NP NIR, which reports dead cells, in order to identify the best dye concentration for B16 fluorescent staining. With these experimental findings, I am able to test the CTL activity of T-cells isolated from draining lymph nodes in $Ly6A^{-/-}$, $PD\text{-}1^{-/-}$, and wildtype mice in *ex vivo* experiments.

A-16: Engineering controlled pdu MCP expression across different bacteria
Author: Wilson, Anna
Advisor: Dr. James Wilson

Bacterial microcompartments are protein-shell organelles that contain enzymes and proteins and some of these proteins metabolize 1,2 propanediol (1,2PD). When 1,2 PD is metabolized, toxic intermediates are created which are then housed in the microcompartment to not damage the bacterial cell. Microcompartments are of particular interest because they can be used for biotechnological applications for target protein isolation as well as nanotherapeutics. My project focused on studying the pdu gene system from *Salmonella Typhimurium* which encodes a microcompartment. 1,2 PD naturally induces the pdu gene system and I proposed a cell construct to use a heterologous chemical inducer to externally turn on/off the pdu system without the natural inducer, 1,2 PD. This was done by inserting two plasmids into bacteria, a pBAD18 + pocR plasmid and a R995+pduΔpocR plasmid. pocR is a DNA binding transcriptional regulator that regulates the pdu system. The pBAD18 + pocR plasmid expresses pocR only in the presence of arabinose. The R995+pduΔpocR plasmid is the cloned *S. Typhimuirum* pdu system with the pocR gene removed. These two plasmids were inserted into other Gram-negative bacteria to test if we can externally control the expression of the pdu system. We were able to insert the plasmids into other bacteria, such as *Salmonella bongori* and *E. coli* strains. The strains with the new construct were streaked on 1,2 PD MacConkey plates with or without arabinose to show qualitatively that the construct works by showing 1,2 PD utilization. We also conducted growth curve experiments to quantitatively show that the construct works. Our results showed that the construct worked, but had leaky expression so that it would turn on even without arabinose present. To fix this leaky issue, we inserted weaker Shine-Dalgarno and start codon sequences so that the system would not turn on as readily and only turn on with arabinose present.

A-17: Comparisons of Clinical and Non-Clinical Yeast Pathogens
Author: Pasles, Anthony
Advisor: Dr. Dana Opulente

The opportunistic pathogenic yeast *Candida tropicalis* poses a serious threat, as it is one of the five yeast species responsible for 95% of candidiasis infections, an often-fatal infection that occurs frequently in ICU patients. Recently, *C. tropicalis* has been discovered in non-clinical settings. I quantified the phenotypic growth of the non-clinical versus the clinical strains of *C. tropicalis*, investigating factors including sugar use and drug resistance. Also, I compared the genomic similarities and differences for carbon utilization genes in the non-clinical isolates. We found variation in both carbon metabolism and a resistance to antifungals for both phenotypes and genes.

A-18: Effects of anthropogenic noise on chickadee vocal communication
Author: Garriga, Carlos; Coppinger, Dr. Brittany; Curry, Dr. Robert
Advisor: Dr. Robert Curry

Vocal communication plays a major role in the life of Carolina chickadees (CACH), black-capped chickadees (BCCH), and their hybrids, which use their chick-a-dee call—specifically the D note of this call—for social cohesion. Expansion of urbanization has increased noise levels in their habitats. To combat increases in anthropogenic noise, CACHs and BCCHs may shift the frequency range in which they produce their calls. To test this, we recorded calls produced by CACH, BCCH, and their hybrids at 50 different nests across two different sites in eastern Pennsylvania during the breeding season. We considered proximity to roads, highways, and train-tracks as a proxy for loudness of

anthropogenic noise and measured the minimum and maximum frequency of 10 D notes produced in 10 random calls per recording. Preliminary results indicate that the maximum and minimum frequency of "D" notes produced at CACH nests did not change drastically between loud and quiet nests, whereas maximum and minimum frequency of D notes differed between loud and quiet sites at Hawk Mountain, where the chickadee population is mixed. These results suggest that hybrid populations of CACH and BCCH may be more impacted by anthropogenic noise. Further analyses will determine if hybrid birds select their breeding sites in relation to road noise based on the frequency range of their D notes, or if birds alter their D note frequency range based on their immediate soundscape.

A-19: The effect of using a small molecule inhibitor of Brd2, a critical gene regulator, on the developing excretory system in zebrafish.
Author: Canally, Caroline
Advisor: Dr. Angela DiBenedetto

Brd2 is a transcriptional co-regulator and a member of the highly conserved bromodomain-extra terminal domain (BET) family. Brd2 acts as a histone-oriented recruiter protein, aiding in the assembly of complexes associated with chromatin modification and thus controlling access of DNA to transcription. Brd2 helps regulate fundamental processes such as cell death, differentiation, and proliferation, and is implicated in several human diseases including blood cancers. The DiBenedetto lab investigates the role of Brd2 in the development of multiple organ systems in zebrafish. Using morpholino oligonucleotides (MOs), which are DNA-like molecules that base pair with mRNAs of a target gene to prevent translation, the lab has shown Brd2 is necessary for proper pronephric kidney formation, among other organs. While MOs are useful for analyzing the effect of early deficiencies on phenotype, they are unable to track the ongoing role of Brd2 in the development of later structures in organ systems such as these. To assess this, we will use a small molecule inhibitor of Brd2, BIC1, which may be administered ectopically. BIC1 prevents the binding of Brd2 to acetylated histones, thus inhibiting its scaffolding action. By exposing embryos of different ages to different concentrations of BIC for various durations, we seek to define the critical window in which Brd2 activity is needed for the proper formation of the pronephric kidney. A better understanding of Brd2's role in development may lead to novel therapeutics for the treatments of human diseases that affect this organ system, among others.

A-20: Investigating the effectiveness of a dual immune checkpoint blockade using an Ly-6A and PD-1 double knockout (DKO) mouse melanoma tumor transplantation in vivo model
Author: Tillinghast, Christina
Advisor: Dr. Anil Bamezai

PD-1 is a well-documented immune checkpoint inhibitor (ICI) that has become a target of cancer immunotherapy due to its role in initiating immune suppression upon binding its ligand, PD-L1, on cell surfaces. Although PD-1-specific immunotherapies have found success in promoting a more active antitumor immune response in cancer patients, success is limited, often to patients with hot tumors, which have higher expression of tumor-associated antigens. Combinatorial approaches are emerging as potential keys to enhancing patient outcomes. The goal of this experiment is to investigate the effectiveness of a dual checkpoint blockade achieved by targeting two costimulatory

immune suppressors: PD-1 and Ly-6A. Adopting a murine tumor model for induced melanoma, breeding was designed to yield double knockout (DKO) mice for PD-1 and Ly-6A in the F2 generation produced by a backcross between the F1 offspring of single knockout (SKO) parents for each ICI and the original parents. The alternative hypothesis holds that there will be significant differences between tumor growth and survival rates between DKO mice injected with B16 cancer cells and those of SKO and wild type mice. While waiting for the F2 offspring to be born, blood sampling and lymphocyte purification methods were refined to determine the genotype status for PD-1 and Ly-6A. Due to challenges in collecting blood samples via tail vein, genotypes will be determined after the mice are sacrificed at the appropriate end point. Initial FACS analysis suggests that Ly-6A -/- mice may have higher expression of PD-1, and this observation remains to be further investigated.

B-21: Dissecting the requirements for cis elements in the thiamine regulated promoter ScPDC5

Author: Dottor, Cory
Advisor: Dr. Dennis Wykoff

C. glabrata promoters that are regulated by thiamine starvation (THI promoters) require the transcription factor CgPdc2 and the transcriptional regulator CgThi3. We have identified two different cis DNA elements that are required for upregulation of THI promoters – one element present in the recently evolved CgPMU3 promoter, and another element present in all other THI promoters. The dissection of cis requirements has been difficult, and consequently, we are studying a simpler THI promoter. The ScPDC5 promoter is thiamine regulated in both *S. cerevisiae* and *C. glabrata*, but does not require THI3 for upregulation. We have performed truncation and scanning deletion analysis on the ScPDC5 promoter and uncovered two regions that appear to be important for regulation. Interestingly, there are two 23 bp sequences in these regions that match one another (20/22 bp match), and they also include 2 palindromic sequences (TACGTA). We anticipate that CgPdc2 binds these sequences.

B-22: Specifying the window of Brd2 gene activity controlling spinal interneuron patterning in Zebrafish embryos

Author: Briggs, Ian
Advisor: Dr. Angela DiBenedetto

Brd2 is part of the bromodomain-extra terminal (BET) transcriptional co-regulator family and functions as a significant histone-directed recruitment scaffold protein in chromatin modification complexes that regulate transcription. Brd2 is highly conserved and has orthologs in Drosophila, Zebrafish, Mice, and Humans and has previously been shown to regulate the fundamental processes of segmentation, cell proliferation, and cell death. Brd2 has also been implicated in several human diseases including blood cancers and juvenile myoclonic epilepsy. The DiBenedetto lab has used morpholino oligonucleotide (MO) injections to create deficiencies of Brd2 in order to investigate the role Brd2 has in the development of multiple organ systems. Phenotypic analysis of deficient embryos found that Brd2 is critical for proper cell morphology, patterning, and differentiation of the central nervous system (CNS). While useful, the use of MO knockdowns limits the exploration of Brd2's function to early development only which is problematic in exploring the late-stage role of

Brd2 in an organ system like the CNS which develops after the late-stage segmentation period at 10-24 hours post-fertilization. To assess Brd2's ongoing role, we will use a cell-permeable small molecule inhibitor BIC1 which is applied ectopically at varying time points and concentrations during Zebrafish embryonic development to explore the continuous role Brd2 has in CNS development and more specifically symmetric interneuron patterning. A better understanding of Brd2's role in embryonic development may lead to novel therapeutics for the treatment of neurodegenerative and other neurological diseases in humans.

B-23: Song discrimination and male aggressive behavior within a songbird hybrid zone
Author: Day, Lily
Advisor: Dr. Robert Curry

Two closely related songbirds, Black-capped (BCCH) and Carolina chickadees (CACH), hybridize along a northward-shifting zone that crosses Pennsylvania. Song playback experiments (SPEs) can help reveal the role of song in male-male interactions within a hybrid zone by simulating intruding males during breeding season. I observed behavioral responses of male chickadees to BCCH and CACH songs, incorporating model chickadees to elicit a focused response, through 97 SPEs across 36 nests at Hawk Mountain Sanctuary. I am quantifying song discrimination and repertoires through the rate, quantity, and song type of vocal responses to each stimulus, and male aggressive behavior through spatial responses, including distance of the subject male from the speakers and attacks on the models. The Curry Lab uses DNA extracted from blood samples to find ancestry genotypes (BCCH, CACH, or hybrid). Preliminary results indicate that male vocal responses do not necessarily correspond with genotypes. Despite many birds being hybrids with >50% CACH alleles, most birds sang only BCCH or hybrid songs. Birds at only 3 nests sang CACH song, while other males with nearly 100% CACH ancestry sang almost exclusively BCCH song. Responses, both vocal and spatial, also vary little between stimulus types—birds that only sang BCCH song engaged in countersinging with the CACH stimulus, and vice versa. These results indicate that because males can recognize and sing songs that do not match their genotype, learning plays a role in which songs are in a males' repertoire. Failing to "honestly" signal about genetic identity may complicate dynamics of hybridization: individuals may be unable to determine species identity through song.

B-24: Mouse Ly-6A Protein as a Potential Immune Checkpoint, and Pan-Cancer Analysis of Human Ly-6 Gene Family Expression using TCGA
Author: Rathbun, Luke
Advisor: Dr. Anil Bamezai

Immune checkpoints expressed on the surface of T cells have become popular therapeutic targets in cancer patients. Use of monoclonal antibodies to block these checkpoints from interacting with their ligands on the surface of cancer cells has shown to result in increased levels of T cell activation and increased killing of tumors. New immunotherapies that target immune checkpoints like PD-1 and CTLA-4 have shown to be effective treatment methods. However, these immunotherapies do not work for all cancer patients due to differences in tumor composition, and like all cancer drugs, mechanisms of resistance exist. This exemplifies the importance of discovering new immune checkpoints that cannot only be used to treat a broader spectrum of cancer patients but can also be used to develop new synergistic combination therapies that overcome mechanisms of resistance. In

B16 melanoma survival studies, Ly-6A knockout mice have shown comparable survival to PD-1 knockout mice. To that end, we have investigated the expression of the human Ly-6 gene family in different cancers using TCGA data. We have observed that increased expression of many Ly-6 members is associated with poor survival in many cancers, especially pancreatic and uterine cancers. These results call for further analysis of the human Ly-6 gene family to uncover the pathways responsible for poor survival in cancer patients with high Ly-6 family expression. Examination of human Ly-6A homologs as potential targets for cancer immunotherapy is critical as well.

B-25: Identification of new molecular players in the nonstop decay pathway of germ cells
Author: Diamandi, Michelle; Brennan, Catherine; Youngman, Elaine
Advisor: Dr. Elaine Youngman

Approximately 30% of inherited genetic diseases involve gene mutations that are subject to degradation by quality control pathways. One such regulatory pathway is the nonstop decay (NSD) pathway, which targets mRNAs that lack a stop codon. In the model roundworm Caenorhabditis elegans (C. elegans), the protein factors pelo-1 and skih-2 regulate nonstop decay and the mut-7 gene is required for production of all endogenous siRNAs. Previous findings that both loss of nonstop decay and loss of endogenous RNAs produce a temperature-dependent fertility phenotype in C. elegans offers genetic evidence for the possibility that nonstop mRNA silencing in germ cells relies on siRNAs in addition to, or perhaps even coupled with, protein factors. We seek to further this genetic observation. To this end, I have performed genetic crosses to place a GFP-nonstop reporter gene in a homozygous mut-7 background. After completing PCR confirmation of the genotype, I will use fluorescence microscopy to directly ask whether the loss of endo-siRNAs impairs the degradation of an NSD reporter gene. In parallel, we seek to identify new protein players in the NSD pathway, and to ask whether temperature-sensitive loss of fertility is generally associated with loss of the nonstop decay pathway. Using homology to NSD genes in yeast and Drosophila, we have identified 4 new candidate genes for involvement in this pathway in C. elegans: lin-1 (C37F5.1), erfa-3 (H19N07.1), abce-1 (Y39E4B.1), and dis-3 (C04G2.6). In preliminary experiments, RNAi knockdown of abce-1 leads to temperature-sensitive reductions in brood size, while knockdown of erfa-3 has severe effects on worm growth. We are particularly interested in the temperature-sensitive sterile phenotype of abce-1 since it phenocopies the mut-7 and pelo-1;skih-2 mutations, implying that nonstop decay may play a particularly important role in the biology of germ cells. Further experiments are underway to confirm these observations.

B-26: Blowin' in The Wind: The Effect of Wind on Ant Behavior, Locomotion, and Adhesion
Author: DeSaye, Mikayla; Stark, Alyssa
Advisor: Dr. Alyssa Stark

Many organisms rely on adhesive structures to maintain contact with substrates in their environment and prevent falling. Ants rely on adhesive tarsal (foot) pads, curved tarsal claws, and a multi-component secretion to cling onto a diverse set of substrates they encounter while foraging. Many environmental (i.e., rain, temperature, wind) factors can impede ants' adhesive performance, which may result in low locomotor performance or abnormal behavior. One environmental factor that has not been well studied is how adhesive performance may be impacted or may mitigate the effects of

wind. The primary goal of my work is to clarify the effect of wind on ant behavior, running speed, adhesive performance, and body height while crouched. The result of our study is that ants tend to crouch and stand still in windy conditions, and that ants are more stable on coarse substrates like sandpaper than smooth glass. Finally, ant adhesion reduces to failure as wind speed increases. These findings help improve our understanding of how common environmental features such as wind impact the behavior, performance, and survivability of small, wingless, cursorial organisms like ants who are critical ecosystem engineers, shaping the global environment.

B-27: Analyzing the effects of mdivi-1 on *Trypanosoma brucei*
Author: Holmes, Nikki; Criswell, Thomas; Malfara, Madeline; Povelones, Megan L.
Advisor: Dr. Megan L. Povelones

Trypanosoma brucei is a flagellated eukaryotic parasite under the class kinetoplastida. Human-infective species cause African trypanosomiasis, commonly known as sleeping sickness, which is transmitted by tsetse flies. *T. brucei* takes two forms that are easily cultured in the laboratory. The parasite exists in procyclic form (PCF) inside the midgut of the tsetse fly and bloodstream form (BSF) inside a mammalian host. *T. brucei* only has one mitochondrion per cell, making it imperative that mitochondrial and cellular division occur together. DLP, or dynamin-like protein, is involved in organelle division in other eukaryotes. Mdivi-1 was previously discovered as an inhibitor of DLP in both yeast and mammalian cells but has yet to be tested in *T. brucei*. These experiments use *T. brucei* PCF expressing a mitochondrial-targeted GFP. To examine the effect of mdivi-1 on cell growth, we conducted a growth curve using different concentrations of mdivi-1. Additionally, we analyzed cell morphology and mitochondria using fluorescence microscopy. DAPI staining was also used to quantitate nuclei and kinetoplasts (mitochondrial DNA) to stage cells in the cell cycle. The use of DAPI alone as a DNA stain was insufficient to accurately determine cell stages, as the DAPI-stained organelles could not be easily distinguished. To resolve this, we investigated a method combining DAPI and PI staining, which bind to DNA sequences differently. We will use an Image-J macro plug-in in future trials to quantitate DNA content and stage cells in the cell cycle, eliminating subjectivity and providing more information about cell morphology for a better analysis.

B-28: A balancing act: gait kinematics of *Camponotus pennsylvanicus* running on narrow substrates
Author: Dolloff, Samantha
Adviser: Dr. Alyssa Stark

Most animals move to gain access to food, shelter, mates, and to escape predators and unfavorable environmental conditions (e.g., heat, wind, competition). However, while moving, environmental conditions often vary, which results in the utilization of various forms of locomotion or movement adjustment, particularly on unconventional terrain. For example, ants are fast runners and have the ability to navigate complex environments. Recent observations in the field suggest that ants alter their typical tripod gait to move through submaximal terrain. The purpose of this experiment is to quantify changes in gait kinematics and speed of *Camponotus pennsylvanicus* while running across dowels that vary in size, replicating semi-natural conditions like vines and twigs. In addition to gait and speed, behavioral changes (i.e., turning around, jumping off, slipping, and falling) was also quantified to determine the role of substrate diameter in behavior while actively foraging. The results

of this study improve our understanding of how ants alter their kinematics and behavior when traversing a suboptimal surface.

B-29: Quantitative D note variation in Carolina chickadees and black-capped chickadees
Author: Salartash, Savrina; Coppinger, Brittany; Curry, Robert
Advisor: Dr. Brittany Coppinger

Chickadees are social songbirds that use the chick-a-dee call, including its "D" note, to communicate predator threat or aggression. In Pennsylvania, two resident species- Carolina chickadees (*Poecile carolinensis*; CACH) and black-capped chickadees (*Poecile atricapillus*; BCCH)- produce "D" notes with qualitatively different structure. Additionally, these species produce hybrid offspring with intermediate behavioral phenotypes. This study aims to quantify D note acoustic structure with respect to species identity (CACH, BCCH, and hybrids). To test the hypothesis that there are quantitative differences between the call of CACH, BCCH, and their hybrids, we recorded chick-a-dee calls from four different testing sites spanning the hybrid zone and then genotyped the birds using 10 species-diagnostic single nucleotide polymorphisms (SNPs) to determine species ancestry of individuals. We used Raven to measure pitch and duration of "D" notes produced, and the time in between subsequent D notes in a call. Analyses completed to date show that CACH "D" notes were shorter, had a higher pitch, and had longer inter-note intervals than BCCH "D" notes. The D notes of hybrid birds have similar pitch and inter-note intervals to CACH "D" notes, while the "D" note duration is more similar to BCCH "D" notes. These results show that "D" note structure varies with species, and that hybrid birds produce "D" notes with intermediate properties from their two parent species, suggesting genetic influences on call development. Future work will determine if receivers attend to these differences in "D" note structure.

B-30: Variation in achromatic plumage brightness within hybridizing chickadees
Author: Zimmer, Zara; Curry, Robert
Adviser: Dr. Brittany Coppinger

Plumage is often highly variable within and among bird species. This variation also exists in achromatic species, which can be seen more substantially in the ultraviolet (UV) range. Sexual dimorphism is one of the reasons for individual variation in both brightness and hue (chroma) in male phenotypes, as brighter and more pigmented hues are favored by females. This is particularly important in the hybridization zone of Black-capped (Poecile atricapillus; BCCH) and Carolina (P. carolinensis; CACH) chickadees where the hybrid index of a bird is thought to affect plumage brightness. To determine if the hybrid index of the chickadee exhibits intermediate and variable plumage brightness, I collected plumage brightness data for 58 birds from three different field sites inhabited by only BCCH, CACH, or their hybrids (HYCH). I measured both the UV (300-400) and visual (400-700 nm) light reflectance of their plumage in six different regions of the body. Using species-level genotyping, I characterized the birds as BCCH, CACH, or HYCH. I am continuing to analyze the data using regressions by comparing the genotype to the plumage brightness data. So far, the results from the hybrid sites are intermediate and varied, which indicates that the hybrid index affects plumage brightness. Further analysis of my results will determine the extent to which plumage brightness varies between BCCH, CACH, and HYCH, as well as if sexual dimorphism plays a role in this variation.

B-31: Testing possible phosphodiesterase inhibitors on Crithidia fasciculata to inhibit in vitro adhesion.

Author: Williams Jr., Andre; Malfara, Madeline; Povelones, Megan
Adviser: Dr. Megan Povelones

Kinetoplastids are a group of parasites that includes several human-infective species. These parasites are transmitted to humans via insect vectors such as sandflies, tsetse flies, and triatomine bugs. While in the insect, the parasites transform from an elongated, swimming form to a rounder, non-motile form that can adhere to tissues in their insect host. *Crithidia fasciculata*, a parasite that infects mosquitoes exclusively, is used as a model for most kinetoplastids because it is easily cultured and can adhere to tissue culture plastic in vitro. Previous research has suggested that cyclic AMP (cAMP) signaling controls this process within the parasites; specifically that a decrease in cAMP triggers differentiation to the adherent state. Using a series of growth and adhesion assays, we tested drugs designed to inhibit cAMP phosphodiesterases (PDEs) in *T. brucei*. These compounds are called NPD-226 and NPD-55, and have been shown to increase intracellular cAMP levels by inhibiting kinetoplastid PDEs. Our results show that treatment of *C. fasciculata* with these compounds does not inhibit parasite growth, but does block adhesion of the parasites to artificial substrates. We suspect that inhibition of PDEs causes an increase in cAMP and that prolonging this signal maintains cells in the swimming state. Future studies will aim to elucidate upstream and downstream targets of this signaling pathway to learn more about how these parasites interact with and colonize their insect hosts.

B-32: Examining the Role of Ly-6A in Regulating Metabolism of Tumor-Infiltrating Lymphocytes

Author: Ngo, Gina; Bamezai, Anil
Advisor: Dr. Anil Bamezai

Immune checkpoint blockades (ICBs) have proven to be clinically successful as a cancer immunotherapy. In order to reinvigorate anti-tumor immune responses, ICB therapy obstructs immune checkpoints, such as PD-1, that inhibit the tumor fighting ability of tumor-infiltrating lymphocytes (TILs). However, many patients fail to respond to ICBs due to the metabolic exhaustion of TILs caused by chronic exposure to tumor antigens. This incapacitates TILs from executing their cytotoxic function of attacking cancer cells. The terminally exhausted subset of CD8+ TILs, which directly kills tumor cells, are unresponsive to ICBs. Interleukin-10 (IL-10), a cytokine that can stimulate anti-tumor immunity in murine tumor models, has the potential to reactivate terminally exhausted CD8+ TILs by restoring T cell metabolism. Since blocking PD-1 has proven to restore glucose uptake in the tumor microenvironment and revitalize CD8+ TILs, my research aims to examine if obstructing Ly-6A—another potential immune checkpoint—could also reduce metabolic exhaustion. Having run fluorescence-activated cell sorting analysis on purified CD45+ TILs from Ly-6A-/-, PD-1-/-, and wildtype mice, I found that Ly-6A-/- and PD-1-/- mice display higher expression of CD8+ TILs compared to the wildtype. I am currently investigating the expression of IL-10 in Ly-6A-/- and PD-1-/- mice to analyze if non-exhausted lymphocytes in immune checkpoint knockout mice secrete more IL-10. My experiments have shown that IL-10 is expressed uniformly on the edges of tumor tissue in wildtype mice but dispersed in Ly-6A-/- and PD-1-/- mice. Specific markers will be utilized in future experiments to assess the metabolic status of mitochondria in both helper CD4+ and cytotoxic CD8+ TILs.

Chemical Engineering

B-33: Supported dispersed nano calcium oxides for reversible CO2 sorption
Author: Thompson, Benjamin; Coe, Charles
Advisor: Dr. Charles Coe, Dr. Michael Smith

It is desirable to reduce the operating temperatures for the reversible sorption of CO2 to enable the sorption enhanced catalysis of the water gas shift reaction to increase hydrogen yield from gasification processes. The current research expanded on the recent discovery that nano dispersed CaO prepared using Atomic Layer Deposition (ALD) offers faster CO2 adsorption/desorption kinetics, which results with an increased working capacity when compared to bulk CaO or the same composition used prepared by incipient wetness (IWI). Bulk calcium carbonates require 750C to regenerate making them unsuitable for isothermal sorption enhanced water gas shift reactions. Producing CaO composite adsorbents on a high surface area magnesium aluminate improves the CO2 working capacity, adsorption kinetics and lowers regeneration temperature of sorption materials. Fabrication of nano domain CaO species below a monolayer significantly decreased the regeneration temperature, as well as increased the atomic efficiency of the active calcium sites to nearly 100%. More interestingly, the samples prepared by ALD show faster kinetics and an increase in adsorption efficiency (normalized uptake) with decreasing temperature, whereas, the opposite trend is observed for IWI. Future studies will determine how coverage influences the reversible sorption and will use in-situ DRIFTS studies to probe the nature of the reversible carbonate species formed to gain further insight into the active site preventing the formation of a bulk calcium carbonate species

B-34: Development of a Lightweight Freeze-Dried Blood Substitute
Author: Sharo, Catherine
Advisor: Dr. Jacob Elmer

There is a perpetual need for blood transfusions on the battlefield, where patients suffer catastrophic blood loss without access to viable human red blood cells (RBCs). Previous attempts to generate RBC substitutes from human and bovine hemoglobin were unsuccessful due to severe side effects. Unlike mammals, the earthworm *L. terrestris* has extracellular hemoglobin known as erythrocruorin (LtEc) with a unique structure that may avoid these issues. However, for LtEc to be maximally useful, it must be ultraportable, which can be achieved via engineering a freeze-drying process. This involved optimizing the cryopreservatives, freezing methods, storage conditions, and resuspension buffers. Once a process was selected, the samples underwent long-term storage to evaluate different storage conditions. This ensured that the optimized process could maximize recovery of LtEc while minimizing oxidation/dissociation. While all samples experienced some oxidation, those with cryopreservatives generally had lower levels of oxidation. At room temperature (RT) and 37°C, the samples in vacuum-sealed bags showed lower levels of oxidation than those in tubes. Higher levels of dissociation were present in the samples kept at 37°C, with lower amounts present in RT and 4°C samples. Going forward, both the resuspension process and additional storage conditions, such as total deoxygenation of lyophilized samples, need to be further analyzed to ensure optimal deployment of LtEc in the field.

B-35: A Computational Approach for Identifying Inhibitors of Protein Targets for Alzheimer's Disease

Author: Krass, Emily; Zhai, Tianhua
Advisor: Dr. Zuyi Huang

Alzheimer's disease (AD) is a neurodegenerative disorder known for causing memory loss and damaging other cognitive functions. In 2015, estimates were that almost 50 million people were affected by the disease, and this number is expected to increase in coming years as average life expectancy increases since the main risk factor for developing AD is age. There are also concerns over the social and economic impact of the disease since the loss of function that affected individuals experience can lead to their dependence on outside care. Current treatments mainly focus on managing symptoms and do not directly target AD pathology, therefore, supporting the need for new approaches and treatments especially as part of ensuring a healthy aging process for humans. This project, specifically, is based on drug repositioning. First, a protein target related to AD pathways was chosen based on previous literature. Then, virtual ligand screening was used to identify potential small-molecule inhibitors for this target from a database of existing drugs. To verify results from virtual ligand screening, identified compounds will then need to undergo in vitro testing.

B-36: Alkali Doped Lithium Orthosilicate Composite Enables Rapid Low-Temperature CO2 Absorption

Author: Thievon, Kolin
Advisor: Dr. Charles Coe, Dr. Michael Smith

It is desirable to lower the temperature for the sorption enhanced water gas shift reactions to increase hydrogen yield from gasification processes. A nanostructured lithium orthosilicate (LOS) composite, made with an aqueous citrate sol-gel, shows rapid reversible CO2 sorption at 650℃. By substitutionally doping with alkali metals, the temperature of this reversible sorption could be lowered to 550℃. The ratio of LiOH to SiO2 was maintained at 4 to 1, which was used to produce the original LOS composite. To maintain this molar ratio, various amounts of sodium (NaOH) and potassium (KOH) were substituted for LOS in the doped composites. Compared to the original LOS composite, the synthesis with 20 mole% NaOH and 80 mole% LiOH provided the best results as the activation energy decreased from 39.2 to 9.7 kcal/mole and the rate constant increased from 0.00260 to 0.00964 sec-1. The conversions and diffusivities are provided by a piece-wise adaption of the Ishida and Wen shrinking core model. This analysis shows that the preferred 20% sodium doped LOS composite maintains its high diffusivity up to 90% conversion even at 550℃. The dopant composites provide not only faster kinetics, but they also maintain a similar 33% working capacity at 650℃ as the original LOS composite. The faster reaction kinetics and diffusivity are critical to producing a composite that can be rapidly cycled for lower temperature CO2 sorption, which in this case was 550℃. Future work is in progress to extend studies to mixed alkali dopant systems as well as the effects of cesium and rubidium substitution.

B-37: Improving Gene Therapy Treatments via Inhibition of IRF1
Author: Dugoni, Margaret; Warga, Eric: Anderson, Jared; Elmer, Jacob
Advisor: Dr. Jacob Elmer

Gene therapy advances have paved the way for treatment of many different diseases from cancer to cardiovascular issues. With all of the benefits, gene therapy does have some limitations, including IRF1. IRF1 induces specific protein coding genes that are responsible for inhibiting delivery, transcription, and translation of transgenes. Preliminary experiments with multiple cell lines reveal that in PC-3 cells and primary T-cells, IRF1 transfection efficiency with Lipofectamine and IRF1 expression have an inverse correlation. The hypothesis that drives this work is that transgene expression will increase if IRF1 is inhibited, preventing other host cell genes from expressing. Methods for inhibiting IRF1 include ongoing Cas9 knockouts, small molecule inhibitors, and short hairpin RNAs. A panel of inhibitors have been tested at a range of concentrations to identify the inhibitor(s) that can provide the highest increase in transgene expression with a minimal decrease in cell viability. Inhibitor 2 has shown preliminary success in 10nM, 100nM, 1uM, and 10uM concentrations by increasing transfection efficiency (i.e., %GFP+ cells) from around 5% without the drug, to around 20% with Inhibitor 2 added. As an additional approach, shRNA plasmids have been designed and produced to inhibit the translation of IRF1 and preliminary trials have been performed.

Chemistry

B-38: Palladium and Nickel complexes of 1,2-bis(diphenylphosphino)triazole as catalysts for Suzuki-type cross-coupling reactions
Author: Graboske, Alexa
Advisor: Dr. W. Scott Kassel

1,2-Bis(diphenylphosphino)triazole (HLT) will be prepared and used as a primary ligand in palladium and nickel metal complexes for use in Suzuki type cross-coupling reactions. Both protonated and deprotonated (LT-) versions of the ligand will be investigated. The triazole complexes will be compared to similar compounds employing chelating diphenylphosphino connectivity. Isolated products will be characterized using 1H and 31P NMR, mass spectrometry. Following their isolation and characterization, the metal complexes will be used in series of cross-coupling reactions to compare their reactivities to known literature examples.

B-39: Liquid Chromatography-Mass Spectrometry Analysis of Environmental Effects on Toads' Self-Defense Toxins Bufadienolides
Author: Wu, Alice; Barny, Lea; Minbiole, Kevin; Monroe, Dillon; Gabor, Caitlyn
Advisor: Dr. Kevin Minbiole

Many amphibian populations experience significant declines due to urbanization and its consequences, such as an increase in invasive species and the altered environments of habitats. The gulf coast toad demonstrates a unique resistance to the effects: consequently, many researchers express interest in their self-defense mechanisms. The study of the production of bufadienolides in conjunction with glucocorticoid (GC) corticosterone levels, which determine a vertebrate's ability to

physiologically cope with urban perturbations, proves to be a growing interest in the field of biological studies and chemical ecology. Bufadienolides are cholesterol-based toxic steroids produced by members of the family Bufonidae and may cause cardiac arrythmia and/or cardiac arrest when ingested. These compounds and their relation to corticosterone may shine light on the protection of the amphibians' biodiversity. Eight bufadienolide compounds were investigated as a reflection of the total bufadienolide content in each sample, and Liquid Chromatography-Mass Spectrometry (LC-MS) methods were used to analyze the amounts through standard curves of one specific compound, bufalin.

B-40: Evaluation of Steric and Enolization Effects on a Uniquely Inert [3.2.1]-Bicyclooctanone

Author: Heltz, Allison; Forelli, Nick
Advisor: Dr. Eduard Casillas

During a synthesis of an ACAT-inhibiting natural product analog, deoxyprehelminthosporol, an unusual lack of electrophilicity of a [3.2.1]-bicyclooctanone was observed. Even upon treatment with methyl lithium, the ketone would remain inert while allowing chemoselective attack on a pendant ethyl ester. The project described here is intended to probe the reactivity of this bicyclic ketone while considering at least two major factors; 1) steric hinderance in the approach of the nucleophile and/or 2) dominant generation and contribution of the enolate resonance form. A series of [3.2.1]-bicyclooctanones that vary in steric constraints are being synthesized. Once prepared, these ketones are alkylated with methyl lithium, then quenched with deuterated methanol. The extent of alkylation vs. deuteration will allow an estimation of the steric and enolization effects. The results assembled thus far will be presented.

C-41: Synergy of Nrf2-Activating Electrophiles in Combination with the Nrf2-Inhibitor KI696: a Model of Mechanistic Basis for Synergy

Author: Allender, Amanda
Advisor: Dr. Aimee Eggler

Oxidative stress, which contributes to many chronic diseases such as diabetes and cancer, can be mitigated through the production of antioxidant proteins, controlled by the Nrf2 transcription factor. Combination drug treatments in disease therapy hold promise for their increased potency and therapeutic window as compared to single drug treatments. In this work, we tested combinations of three clinically relevant Nrf2 activating electrophiles (bardoxolone methyl, Tecfidera, and sulforaphane) with the Nrf2 inhibitor KI696 to see if there was a more than additive effect on ARE expression. Under basal conditions, Nrf2 is bound by Keap1 in the cytoplasm of the cell, and targeted for ubiquitination and degradation. When Keap1 C151 is modified by these electrophiles, Nrf2 escapes repression and localizes to the nucleus to bind to cognate antioxidant response element (ARE) sequences, thereby upregulating expression of antioxidant genes. KI696 binds to the Nrf2-binding site on Keap1, allowing for accumulation of Nrf2 and subsequent ARE-driven expression. Through an ARE-reporter luminescence assay, we show that these three electrophiles each synergistically upregulate ARE-driven expression with KI696 in a statistically significant manner, based on our Dose Equivalence/Zero Interaction (DE/ZI) method (Repash et al., Frontiers in Pharmacology, 2021). The combination of these clinically-relevant electrophiles and KI696 are a model for mechanistic investigations of synergy and identification of targets other than Keap1 cysteines.

C-42: Investigation of Varied Formal Charge on Iron in Metallocene-Based Quaternary Ammonium Compounds.
Author: Peterson, Ashley; Michaud, Marina; Hess, Mia; Amoo, Lauren; Sommers, Kyle
Advisor: Dr. Kevin P. C. Minbiole, Dr. Jared Paul

The increasing usage of antibacterial disinfectants has spurred the proliferation of antibacterial-resistant microbes, causing a drastic increase in cases of infections in human beings. Novel disinfectants must be produced in order to combat bacterial strains that have evolved to resist common household disinfectants. Quaternary ammonium compounds are positively charged amphiphilic disinfectant compounds which adhere to the bacterial membrane using a polar head and insert a nonpolar tail into the phospholipid bilayer to disrupt its structure. It is hypothesized that the minimum inhibitory concentration (MIC) needed to destroy a bacterial cell decreases when there is a greater positive charge on the polar head of the amphiphile. Thus, a less concentrated form of the compound would be needed to disinfect surfaces, and would be less toxic to the user. The unique ability of metal-containing compounds, like ferrocene derivatives, to modify charge would allow for careful inspection of this hypothesis. Accordingly, cyclic voltammetry and bulk electrolysis were performed on a series of ferrocenium quaternary ammonium compounds in varying alkyl chain lengths to explore their efficacy to eradicate resistant strains of MSSA, MRSA, *E. coli*, and *E. facaelis*, pathogens commonly found in households and hospitals.

C-43: Synthesis, Characterization, and Metalation of Three N-Heterocyclic Carbene (NHC) Ligands with Copper
Author: Rongo, Austin; Garcia, Nicole; O'Donnell, Katelynn
Advisor: Dr. Deanna Zubris

Coordination chemistry plays a central role in our daily biological, industrial, and medicinal functions. Organic ligands bond to metal centers to form coordination compounds that can catalyze reactions, transport essential nutrients, and even treat types of cancer. In recent years, catalysis with coordination compounds containing earth-abundant metals has been a fruitful topic in academic and industrial research. Two novel ligands and a previously reported ligand have been synthesized, and their characterization data and metalation attempts with copper are described here.

C-44: Quaternary Phosphonium Compounds – Novel Multicationic Amphiphilic Antiseptics
Author: Amoo, Lauren; Hogue, Cody; Brayton, Samantha; Spahr, Aaron
Advisor: Dr. Kevin Minbiole

Quaternary ammonium compounds (QACs) have been the backbone of antiseptics like Lysol for nearly a century. However, bacteria have begun to develop resistance to these surface disinfectants. To address this threat, our lab has developed over 700 novel QACs bearing multiple cationic moieties; their improved antimicrobial activity is hypothesized to derive from superior binding to the bacterial cell surface, which bears a net negative charge. In recent efforts, we have pivoted to the study of cationic phosphorus-based analogs, known as quaternary phosphonium compounds (QPCs). In this study, we investigate the ramifications of linker rigidity on three series of bis-cationic QPC species, via synthetic efforts and biological evaluation.

C-45: Redox Stability of Promising Solid Oxide Fuel Cell Anode
Author: Giannini, Clif; White, Daniel; Eigenbrodt, Bryan
Advisor: Dr. Bryan Eigenbrodt

Because of their high efficiency, solid oxide fuel cells (SOFCs) are an important tool for mitigating the environmental impact of fossil fuels. Further, if coupled with renewable biofuels, SOFCs can achieve carbon neutrality. Previously, the Eigenbrodt lab has worked with Sr2Fe1.5Mo0.5O6-δ (SFMO), a SOFC anode material. In voltammetry and impedance spectroscopy, SFMO fuel cells outperformed the commercially available nickel/yttria stabilized zirconia (Ni/YSZ) fuel cells. In addition, unlike Ni/YSZ, SFMO tolerates alcohol fuels. Thus, renewable alcohol biofuels can power SFMO cells, resulting in carbon neutral SOFCs. Moreover, an SFMO variant, Sr2Fe1.6Mo0.4O6-δ was recently proven to be the most stable variant under reducing and oxidizing conditions at operating temperatures. This summer, the Eigenbrodt lab incorporated nickel into SFMO to improve its catalytic properties. Nickel was added to the anode in two ways. First, nickel was doped into SFMO's crystal structure, forming Sr2(Fe1.6-xNix)Mo0.4O6-δ(SFNMO). Second, nickel was impregnated into SFMO, which dispersed NiO particles throughout SFMO's microstructure. These two materials were then tested for stability in reducing and oxidizing conditions at operating temperatures. Finally, fuel cells were made using the novel anode materials. Electrochemical analysis of these cells with hydrogen, ethanol, and methanol fuels is underway.

C-46: Effects of Wastewater Nutrients on Lipid Quantification for Biofuel Applications of *Nannochloris eucaryotum*
Author: Clayton, Emily; Bennett, Michael
Advisor: Dr. Bryan Eigenbrodt

Biofuels are one form of alternative energy that have been proposed to replace fossil fuels. The research presented explores the potential of algae as a source of renewable biofuel via conversion of intracellular lipids. This research combines this concept with the capability of algae to clean wastewater; it explores the use of urea, an abundant compound in wastewater, as a nutrient source for the algae *Nannochloris eucaryotum* being grown for biofuel purposes. Several analytical techniques and instruments, such as fluorescence spectroscopy, confocal microscopy, and gas chromatography were utilized to optimize and monitor lipid yield, as well as to compare the efficiency of urea to other nitrogen sources for cell growth. This research aids in the development of renewable fuel sources, improved wastewater treatment, and prevention of eutrophication of the environment when utilized correctly.

C-47: Kinetic Characterization of an Essential Haloacid Dehalogenase Present in the Trypanosome Parasite
Author: Mahoney, Emily
Advisor: Dr. Jennifer Palenchar

Trypanosomes are eukaryotic parasites that can infect a variety of hosts and result in multiple diseases. *Trypanosoma brucei* contains two haloacid dehydrogenase enzymes (HADs), one of which, (HAD1) is essential in their life cycle. Both trypanosome HADs are uncharacterized. Exploring the function of HAD1 may hold therapeutic potential. Recombinant His10-TbHAD1 was

overexpressed in bacteria and purified to approximate homogeneity. Glucose-6-phosphate and AMP were identified as substrates and the kinetic parameters of the enzyme were determined for each. Our work also looks to uncover HAD1 function in the parasites. Towards this goal, an RNAi construct was generated to silence the HAD1 gene and deplete the protein from the parasites. Characterization of this RNAi cell line is underway.

C-48: Synthesis of iron oxide nanoparticles and surface binding of thiol surfactants
Author: Bazurto, Eric
Advisor: Dr. Temershah Ahmadi

Understanding binding strength and geometry of various organic surfactants grafted on iron oxide nanoparticles (IONPs) will help us understand the nature of IONPs surfaces and assist in the design of surfactant molecules that would give them their desired functionality. In this presentation, iron oxide nanoparticles were synthesized and post-synthesis binding of thiols to their surface was investigated. In particular, the binding of 1,9-nonanedithiol to the surface of the IONPs is studied using FTIR and Raman spectroscopy. A discussion of these results is presented in context of grafting of small molecules on colloidal oxide nano-surfaces.

C-49: Investigation of the Effect of the Dsk2 Shuttle Protein on Proteasomal Degradation
Author: Mallon, Erica
Advisor: Dr. Daniel Kraut

The 26S proteasome is a molecular machine found in eukaryotic cells which plays an essential role in regulating cell activities through protein degradation. The proteasome recognizes and degrades proteins that have been ubiquitinated by three enzyme complexes in an intricate system called the ubiquitin-proteasome system (UPS). Certain proteins in the UPS, such as shuttle proteins, help the proteasome carry out its function of protein degradation. The shuttle protein Dsk2 is one of several shuttle proteins that have been found to mediate substrate degradation by helping deliver ubiquitin-tagged substrates to the proteasome for degradation. The importance of Dsk2 and the specific role it plays in proteasomal degradation is still being explored. We investigated how the unfolding ability of the proteasome is affected when Dsk2 is removed and then subsequently added back into the reaction solution. In preliminary experiments, we found that Dsk2 knockout (ΔDsk2) lowered the proteasome's unfolding ability, and we could rescue this defect by adding back purified Dsk2 protein. However, some of these effects appeared to be artifacts due to Dsk2's ability to pull substrates out of solution. After finding conditions that prevented this additional Dsk2 activity, we still found that Dsk2 showed a "rescue effect" and increased the unfolding ability of the ΔDsk2 proteasome by a small but significant amount. However, wild-type and ΔDsk2 proteasomes had similar unfolding abilities, perhaps because WT has sub-stochiometric levels of Dsk2 associated with it. These results indicate that while the Dsk2 protein is not strictly necessary for protein degradation by the proteasome, it can still play a role in enhancing degradation.

C-50: Electrolyte Interfaces: The Effect of Salt Concentration on Electrolyte Structure and Dynamics.

Author: Casingal, Joel
Advisor: Dr. Ryan Jorn

The main focus of this project was to study the surface electrolyte structure and dynamics as a function of changing concentration in the interaction of the interfaces Lithium Fluoride and Graphite with solutions of propylene carbonate (PC) containing varying concentrations of the salt LiPF6. In this work it was found that as the concentration of LiPF6 increased the density of ions at the surface of the interface did not change proportionally to the concentration. Therefore, ion density does not increase linearly with concentration and has saturation type behavior. Furthermore, as bulk concentration increased the contrast between the surface and the bulk are not as pronounced when it comes to coordination. Overall, when it came to electrolyte structure it was found that at lower concentrations the effect of the surface is greater than at higher concentrations. In regard to dynamics the opposite trend was found with greater concentration of salts slowing down dynamics which was expected because the solution becomes more viscous with increasing salt concentrations. When doing similar studies on graphite the literature suggests that with increasing concentration and voltage there is effect on the interface surface structure. At low voltages a layer of PC coats the electrolyte surface with thus far no changes to this surface structure being found in the simulations. However, only trials at lower voltages have been run, with higher voltages trials still being run with the hopes of observing the trend expressed in the literature.

C-51: Novel Derivatization Method for the Determination of Amino Acid Concentrations in Arctic Marine Waters

Author: Mitchell, Katherine; Boschi, Vanessa; Grannas, Amanda
Advisor: Dr. Vanessa Boschi

Arctic warming due to climate change has contributed to a loss of sea ice and an increase in freshwater contribution to the Arctic Ocean ecosystem. As a result, marine biodiversity is changing and affecting surface water chemistry. To determine the effect of ice density on marine biota and thus water chemistry, concentrations of amino acids, an important biomarker, need to be assessed. In waters with high salt content, determination of amino acid concentrations requires derivatization. Traditional derivatization methods using o-phthalaldehyde (OPA) would not allow for the separation and analysis of amino acids from an aqueous saltwater matrix. Therefore, a novel derivatization method was developed to produce amino acids that could be extracted from saltwater solution prior to analysis using liquid chromatography paired with mass spectrometry. This new method features n-butyl chloroformate, which binds to both zwitterionic groups of the amino acid, forming a larger, more nonpolar product which can be extracted in a more organic solvent. Glutamate, leucine, and lysine standards ranging from 10-200 μM, in both salt (0.33 M NaCl) and ultrapure water solutions were used to test the method. After derivatizing and analyzing the standards in triplicate, salt water amino acid standards produced R2 values above 0.95 and had similar detection limits to the freshwater standards. Using this new method, future work will involve the derivatization of amino acids in Arctic marine water samples to determine their concentrations as a function of ice density.

C-52: Identification of Isomeric Forms of 2,2'-bipyrimidine-Bridged Polypyridyl Ruthenium (II) Complexes Utilizing NMR

Author: Moffa, Katherine L.; Boyko, Walter J.; Paul, Jared J.
Advisor: Dr. Jared J. Paul

Bimetallic complexes, in which two metal spheres are joined by a bridging ligand, show much promise in the development of catalysts, as their multiple metal sites increase the available electrons for multi-electron processes. This work reports the synthesis of [(dmbpy)2Ru(bpm)Ru(dmbpy)2]4+ (dmbpy = 4,4'-dimethoxy-2,2'-bipyridine; bpm = 2,2'-bipyrimidine) by the coordination of two equivalents of [Ru(dmbpy)2(Cl)2] to one equivalent of bpm ligand. Subsequent NMR analysis via COSY and supporting homo2Dj experiments allowed for the identification and assignment of the bimetallic complex's two isomeric forms, rac and meso. NMR analysis also found a mononuclear complex [(dmbpy)2Ru(bpm)]2+ present along with the dinuclear complex. Purification efforts by way of size-exclusion chromatography are reported, as well.

C-53: ΔpKa determination of phenol and 4-methoxyphenol by NMR titration

Author: Rouse, Kevin
Advisor: Dr. Jared Paul, Dr. Brian Ohta

The energetics of proton transfer reactions of our ruthenium complexes have been difficult to study in the past due to the similarities in ΔpKa values of the protonatable hydrogens. A method for determining ΔpKa with precision to three decimal places has been developed by Perrin. The method involves an NMR titration where two species in solution, both with one protonatable site, are titrated with small aliquots of acid or base. If distinguishable resonance peaks are able to be seen for each species through the titration, the ΔpKa can be determined. As a proof-of-concept experiment, the method was tested on phenol and 4-methoxyphenol, and the determined ΔpKa was 0.287 +/- 0.003 units with the unsubstituted phenol being more acidic, which follows literature precedence. Using this method on our ruthenium complexes will allow us to observe how small changes in our single-hydroxy-substituted complexes affect ΔpKa. Since we already know the reduction potentials of the protonated and deprotonated forms of our complexes, coupling the pKa values we will obtain from this method will give us great insight into the energetics of ET*, PT* and PCET* reactions.

C-54: Progress Towards the Total Synthesis of Caespitate: An Acylated Phloroglucinol

Author: Jaunich, Kyle; Manion, Dave; Casillas, Eduard
Advisor: Dr. Eduard Casillas

Caespitate is a natural product isolated from Helichrysum Caespititium, a well-known medicinal herb found in South Africa, that has shown activity against Gram-positive bacteria. The synthetic preparation of Caespitate pivots on an allyl stannane/benzyl halide Stille coupling. Two synthetic routes continue to be explored to prepare the latter highly electron-rich phloroglucinol precursor. One approach has synthesized a resorcinol-based benzyl halide that was capable of the desired Stille coupling. Unfortunately, multiple attempts to oxidize the resorcinol product to a phloroglucinol have been unsuccessful. A second approach is to prepare the phloroglucinol-based halide directly, using a neutral Mitsunobu method, that would avoid polymerization noted in earlier efforts. Progress towards this synthesis and its Stille coupling are underway.

C-55: To each their own: Disparate abilities of Nrf2 activators to protect against various electrophilic and oxidative insults

Author: Biesterveld, Laura B.; Eggler, Aimme L.
Advisor: Dr. Aimee L. Eggler

Electrophilic and oxidative stress contribute to major diseases such as cancer and diabetes. Small-molecule activators of the Nrf2 cytoprotective pathway show significant promise for prevention and amelioration of chronic diseases by combating these stressors through upregulation of detoxification and antioxidant enzymes. An understudied area is whether distinct small molecular Nrf2 activators can protect cells from all electrophilic and oxidative stressors, or whether certain molecules are better suited to protect against a particular type of stress. In this study, human keratinocyte HaCaT cells were preincubated for 24 h with one of four Nrf2 activators before different stressors were added for an additional 24 h and cell death was assessed. Three electrophiles were tested: sulforaphane (SFN), the subject of over 70 clinical trials, the multiple sclerosis drug Tecfidera (dimethyl fumarate, DMF), and bardoxolone methyl (BARD), in clinical trials for treatment of chronic kidney diseases and other conditions including COVID-19. SFN, DMF, and BARD target C151 of the Keap1 protein, a negative regulator of Nrf2. Also tested was KI696, an inhibitor of the Keap1-Nrf2 interaction. Three chemically distinct stressors—hydrogen peroxide, menadione (a quinone that rapidly generates ROS through one-electron redox cycling), or chlorambucil (an alkylating chemotherapy agent)—were tested. Stressors were added to the cells at their LC50 concentration after pretreatment with a range of cytoprotective compound concentrations. Unexpectedly, SFN pretreatment showed little to no rescue for all stressors. However, DMF rescued the viability of cells stressed with hydrogen peroxide, menadione, and chlorambucil. BARD showed no rescue for hydrogen peroxide-treated cells. KI696 improved the cell's ability to survive chlorambucil. The ability of a given Nrf2 activator (or lack thereof) to protect against a given stressor points to a need to better understand the cytoprotective environment (specific enzymes upregulated, glutathione levels, etc.) that best protect against specific stressors.

C-56: Interfaces and Electrolytes: Is the Solvation Shell Impacted By Surfaces in Lithium Ion Batteries?

Author: Silen, Leilani
Advisor: Dr. Ryan Jorn

The main focus for this project was to understand how varying solvent compositions impact two major ideas: electrolyte dynamics and structure. We mainly focused on combinations of ethylene carbonate (EC) and propylene carbonate (PC), two critical solvents for lithium ion batteries. We observed their interactions with certain interfaces, which includes graphite, lithium fluoride crystal, and lithium diethylcarbonate. The effect of air interfaces on the dynamics and structure of the electrolyte were also considered. For this work, computational simulations were used to analyze the electrolyte properties. Classical molecular dynamics were performed on Augie, the new computational resource at Villanova. Contrary to previous experiments, there was no preference for EC or PC. The ratios of these solvents in the solvation shell of lithium were the same as those in the bulk composition. The densities of EC and PC followed the same pattern. These results indicate EC preference is not the dominate effect on experimental observations. In future works, we will look at different combinations of cyclic and linear carbonates to see if solvent preference is affected by interfaces.

C-57: Electronic and spectroscopic studies of pH tunable [Ru(bpy)2(L)]2+ and [Ru(phen)2(L)]2+ (bpy = 2,2'-bipyridine; phen = 1,10'-phenanthroline; L = 6,6'-dihydroxy bipyridine or 1,10-phenanthroline-5,6-dione) at varying protonation states

Author: Hess, Mia; Paul, Jared; Palenchar, Jennifer
Advisor: Dr. Jared Paul

After discovery of [Ru(bpy)2(66'(bpy(OH)2)]2+ and the 6,6'-dihydroxy bipyridine ligand photo-dissociative abilities, various hydroxyl- and carboxyl-substituted ligands were studied for their pH tunability. As this ligand dissociates from the metal at low pH and light activation, there are many ways to trace these changes chemically through UV/Vis absorption and emission spectroscopy. Looking at substituted bipyridine and phenanthroline ligands, we report on the synthesis and characterization of [Ru(bpy)2(L)]2+ and [Ru(phen)2(L)]2+ (bpy = 2,2□ -bipyridine; phen = 1,10□ -phenanthroline; L = 6,6□ -dihydroxy bipyridine or 1,10-phenanthroline-5,6-dione). In studying new ways to tune the electronic properties of these ruthenium compounds, this could lead to new multi-proton and multi-electron catalysts for reactions of interest. The phen=O (phen=O = 1,10-phenanthroline-5,6-dione) ligand is an electron and proton accepting ligand, leading to a variety of ways to tune the ligand to study the effects on the ruthenium compound. Various electrochemical studies on each compound are reported as a function of pH, showing the impact of the 6,6□ -dihydroxy bipyridine and phen=O ligands on the ruthenium metal complexes.

C-58: Synthesis and characterization of [Ru(bpy)2(dhphen)]2+ (bpy = 2,2'-bipyridine, dhphen = 4,7-dihydroxy-1,10-phenanthroline) and [Ru(bpy)2(dhdmphen)]2+ (bpy = 2,2'-bipyridine, dhdmphen = 4,7-dihydroxy-2,9-dimethyl-phenanthroline)

Author: Kachurak, Olivia
Advisor: Dr. Jared Paul

Intricate changes within polypyridyl ligands in ruthenium coordination complexes can affect the oxidative ability of this class of complexes and its use as a catalyst. By studying different functional groups on the ligands, specifically those that are protonatable/deprotonatable, we can observe how these changes can alter the electronic properties of the complexes. To this end, we have synthesized two ligands: 4,7-dihydroxy-1,10-phenanthroline (dhphen) and 4,7-dihydroxy-2,9-dimethyl-phenanthroline (dhdmphen), and complexed them to ruthenium. Complexation of the hydroxy-substituted-phenanthrolines to [Ru(bpy)2(Cl)2] (bpy = 2,2'-bipyridine) yielded dark red compounds, [Ru(bpy)2(dhphen)]2+ and [Ru(bpy)2(dhdmphen)]2+, as hexafluorophosphate salts. The compounds were identified using infrared spectroscopy, nuclear magnetic resonance spectroscopy, and elemental analysis. Studies were undertaken to look at the UV/Visible and electrochemical properties of these complexes as a function of protonation state. Each compound had MLCT electronic transitions typical of ruthenium polypyridyl complexes that are impacted by protonation state. In addition to potential catalysis, [Ru(bpy)2(dhdmphen)]2+ is also a candidate for the lab's anticancer studies due to the ligand's 2,9-dimethyl substitution which causes instability and light sensitivity.

C-59: Examining the Extent of Metal Contamination on Dairy Farms Using Copper Sulfate Footbaths
Author: Burwell, Samuel
Advisor: Dr. Amanda Grannas, Dr. Vanessa Boschi

Copper sulfate is used in footbaths by the dairy industry to combat hoof lesions such as digital and interdigital dermatitis as well as foot rot. Footbath waste is cleaned out with barn waste and then spread on crop fields for fertilizer. Levels of copper (Cu), chromium (Cr), zinc (Zn), arsenic (As), cadmium (Cd), and lead (Pb) were tested in surface water, field soil, and corn sileage at three dairy farms of varying size in north central Pennsylvania. Cu and Zn concentrations were found to be statistically higher in fields where biosolids from bovine were spread. The corn sileage analyzed had Cu and Zn concentrations at an average of 55 and 333 ppb, both exceeding the recommended toxicity levels in feed for farm animals of 35 and 150 ppb. Manure fields from farms with a differing number of cattle, and thus differing amounts of footbath solution, did not show a difference in the concentration of copper or other metal contaminants. Surface waters had lower heavy metal concentrations than that of the field soil samples. Heavy metal concentrations in surface waters were dependent on the proximity to the contaminated field. These results demonstrate the use of copper sulfate footbaths impact soil quality in fields that are spread with manure captured from the farm.

C-60: Optimization of the Modified Aza-Biginelli Reaction Toward the Synthesis and Biological Evaluation of Antibacterial Functionalized Dihydropyrimidines
Author: Boyer, Zachary; Viollet, Constance; Brosman, Hannah; Kessler, Hannah
Advisor: Dr. Matthew O'Reilly

The continuous acquisition of bacterial resistance to the arsenal of available antibiotics is both concerning and life-threatening. A functionalized dihydropyrimidine (DHP) was previously discovered to have antibacterial activity, and its mechanism differs from common legacy classes of antibiotics, signaling it as a promising lead compound toward a therapeutic capable of combating multidrug resistant bacterial infections. This molecule was reported to exert its mechanism of action by inhibiting bacterial dihydrofolate reductase (DHFR) via a unique uncompetitive mechanism. DHFR can be considered an underexploited antibiotic target, as trimethoprim is the only FDA approved antibiotic targeting DHFR, and it works via a competitive inhibitory mechanism. Development of the DHP compound class could produce a DHFR-targeting antibiotic working via a secondary uncompetitive mechanism. Despite this promise, there has been limited exploration of how the DHP structure relates to its biological activity. Our research explores the steric and electronic requirements for biological activity, examining the structure activity relationships of DHPs. We synthesize analogs of the lead compound via a modified aza-Biginelli reaction, which was systematically improved by altering the temperature, time, solvent, equivalents of reagents, and energy-input methods to provide useful and reproducible yields of DHP derivatives. Further, due to product tautomer ratios complicating characterization, we discovered that variable temperature NMR analysis was necessary for effective characterization of reaction products. Replacement of the guanidine functional group with urea or thiourea required significant modifications to the reaction conditions, and catalysts such as indium (III) chloride, bismuth (III) nitrate, cesium (III) chloride, copper (I) chloride, and boron trifluoride etherate (BF3• OEt2) were examined with various solvents and additives. While BF3 • OEt2 provided reproducible conditions for urea replacement, thiourea incorporation proved challenging and continues to be under development. Research efforts exploring the antibacterial activity against various strains of methicillin resistant *Staphylococcus aureus*

have been promising, and additional studies involving different clinically relevant bacterial strains, biochemical studies, and mammalian toxicity are ongoing.

D-61: Quaternary Phosphonium Compounds – Novel Multicationic Amphiphilic Antiseptics
Author: Amoo, Lauren; Hogue, Cody; Brayton, Samantha; Spahr, Aaron
Advisor: Dr. Kevin Minbiole

Quaternary ammonium compounds (QACs) have been the backbone of antiseptics like Lysol for nearly a century. However, bacteria have begun to develop resistance to these surface disinfectants. To address this threat, our lab has developed over 700 novel QACs bearing multiple cationic moieties; their improved antimicrobial activity is hypothesized to derive from superior binding to the bacterial cell surface, which bears a net negative charge. In recent efforts, we have pivoted to the study of cationic phosphorus-based analogs, known as quaternary phosphonium compounds (QPCs). In this study, we investigate the ramifications of linker rigidity on three series of bis-cationic QPC species, via synthetic efforts and biological evaluation.

D-62: Synthesizing and Complexation of 4,7-Dihydroxyl-2,9-Dimethyl-1,10-Phenanthroline Ligand to Copper
Author: Sokoloski, David
Advisor: Dr. Jared Paul

Ligands that have the ability to exist in multiple protonation states can impact the electronic properties of the complexes to which they are attached. The Paul laboratory has typically focused on hydroxyl-substituted ruthenium complexes, due to the relative ease of synthesis. However, there is a great need to develop complexes with earth abundant first row transition metals, such as copper, which has rich electrochemistry. The 4,7-dihydroxyl-2,9-dimethyl-1,10-phenanthroline (pdhdmphen) ligand was synthesized and characterized using NMR, IR, and UV-Visible spectroscopies. From there, the ligand was attached to a copper metal core to create the copper complex: [Cu(pdhdmphen)2][PF6]2. The synthesized copper (II) complex was also characterized by NMR, IR and UV-Visible spectroscopies. The copper (II) metal complex was found to be pure via NMR and showed to have a potential metal-to-ligand charge transfer around 575nm. Attempts to make the corresponding copper (I) complex were unsuccessful since it is readily oxidized in air.

D-63: Exploration of the Structure Activity Relationships of Functionalized Dihydropyrimidines Toward the Analysis of their Antibacterial Activity
Author: Brosman, Hannah
Advisor: Dr. Matthew O'Reilly

Bacteria are constantly evolving into forms resistant to antibiotic medication, and these infections can be life threatening. A functionalized dihydropyrimidine (DHP) was shown to have antibacterial activity and a unique mechanism of action. This combination gives it promise toward treating infections that are resistant to many FDA approved therapeutics. The DHP lead compound was reported to act through uncompetitive inhibition of dihydrofolate reductase (DHFR). Trimethoprim, the only DHFR-targeting antibiotic approved by the FDA, inhibits its target via a

competitive mechanism of action. Uncompetitive DHFR inhibition is therefore an untapped mechanism of antibacterial activity that we are exploring via the evaluation of the DHP compound class. While the O'Reilly Lab has synthesized a focused library of DHP analogs using an aza-Biginelli reaction, my research explores the biological activity of these compounds, seeking to understand how their structure relates to their biological activity. Using a high-throughput 96-well plate microdilution assay, compounds were screened at various concentrations to examine their ability to inhibit bacterial growth, and activity trends were noted against various strains of clinically relevant bacteria. Toward a more thorough understanding of the compound's mechanism, bacterial DHFR was expressed and purified, allowing for enzyme kinetics assays to demonstrate that the compounds provided modest inhibition of DHFR. Additional hemolysis assays were performed to assess mammalian toxicity, and all compounds were shown to lack nonspecific membrane rupturing activity, signaling they may display selective toxicity toward bacterial cells.

D-64: The synthesis and characterization of substituted tris(pyridyl)phosphine oxides and their k2 ruthenium complexes: towards applications in catalysis.
Author: Allen, Stefanie; Izzo, David; Kassel, Scott
Advisor: Dr. Scott Kassel

Ruthenium polypyridyl complexes are used as catalysts in a variety of reactions including water oxidation. As such, developing methods to prepare a variety of novel ruthenium polypyridyl complexes is needed. In this work, a new method for preparing methyl derivatives of tris(pyridyl)phosphine oxide (OPpy3R) was developed resulting in significantly higher yields than traditional methods. A series of [(k2-OPpy3R)Ru(cymene)Cl]x (where x=PF6- or Cl-) complexes were prepared via a modified literature method leading to higher yields than previously reported. Preparing [(k3-OPpy3R)Ru(bby)Cl]x Ru complexes using the k2-derivatives was attempted both thermally and photochemically. All complexes were characterized by 1H and 31P NMR and UV-Visible spectroscopy. Several complexes were additionally characterized using {1H-15N} HMBC NMR spectroscopy.

Civil & Environmental Engineering

D-65: Media Resiliency within Bioinfiltration Systems for Stormwater Management
Author: Walther, Erik; Sample-Lord, Dr. Kristin; Smith, Dr. Virginia; Hess, Dr. Amanda
Advisors: Dr. Kristin Sample-Lord

Bioinfiltration systems, such as rain gardens, are effective tools for managing stormwater runoff and providing water quality treatment in urban landscapes. The purpose of the media (amended soil) used in the bioinfiltration system is to infiltrate, filtrate, and store water to reduce runoff volumes and improve water quality. However, the media may be susceptible to clogging due to incoming fine sediments and/or lack of adequate maintenance, resulting in decreased performance over time. Like any infrastructure, bioinfiltration systems require proper design, construction and maintenance. Thoughtful selection of media during the design phase that considers the effect of future incoming sediments can reduce subsequent maintenance burden and maximize system longevity. To build a framework for this proactive design and maintenance approach, a bioinfiltration system in

Philadelphia (referred to as SMP A) has been continuously monitored for hydrologic function and changes in the media over a four-year period. SMP A receives runoff from the deck of I-95 and was constructed as part of PennDOT's I-95 Revive Project. A comprehensive field testing program for SMP A was paired with laboratory experiments to quantify: (1) temporal and spatial changes in the SMP A media throughout operation; and (2) thresholds of clogging for the SMP A media. Traditional concepts of graded filter design commonly used for geotechnical infrastructure were adapted to the evaluation of the media for stormwater infiltration performance. Based on the results of the laboratory and field testing, and analysis using graded filter criteria, the media in SMP A is shown to be effectively functioning as a filter - maintaining sedimentation at the surface (i.e., localizing maintenance) while still allowing for adequate flow and volume removal. These results support recommendations to PennDOT for media selection for subsequent SMPs along I-95. The findings from this work will be expanded upon and applied to other sites, using a methodical hydraulic conductivity test program for media selected for other SMPs.

D-66: Equitable Green Stormwater Infrastructure Distribution through Geographic Information Systems

Author: Devlin, Eric; Smith, Dr. Virginia; Kremer, Dr. Peleg; Wadzuk, Dr. Bridget; Mehidi, Abdullah Al; Moore, Laura; Homet, Kate
Advisor: Dr. Virginia Smith

Flooding in urban environments can have numerous impacts including road closures, degradation of infrastructure, destruction of homes and public safety risks. These effects can disrupt daily life and have significant economic drawbacks. The negative impacts of flooding are disproportionately distributed, leaving marginalized populations to bear a more severe burden. Communities most at risk to the stresses of flooding are often economically disadvantaged, making them more less resilient to the impacts of flooding. Stormwater infrastructure is a vital component of flooding management. Stormwater engineering is primarily based on physical parameters such as topography and hydraulic models. However, limiting planning to the physical environment, fails to account for critical parameters such as demographics and circumstances of the communities being served by the infrastructure are not utilized. The needs of individual communities are then overlooked leading to uneven outcomes and ineffective infrastructure in mitigating flooding impacts. The physical and socio-economic variables in communities can be spatially analyzed in geographic information systems, like ArcGIS Pro. This study integrates environmental and social data to their geographically locations to identify flood risk and vulnerability for two neighborhoods in Philadelphia. Spatial data integration facilitates identification of trends and correlations between the disparate data. Ultimately, this will allow for a more holistic analysis of civil infrastructure to optimize flood mitigation design. The spatial data trends illuminate areas are most prone and most vulnerable to flooding to aid in equitable distribution of green stormwater infrastructure.

D-67: Enhancing the Anion-Exchange Capacity of Biochar for Removal of Nitrate from Water

Author: Fitzpatrick, Megan
Advisor: Dr. Wenqing Xu

Nitrate (NO_3^-) naturally presents in groundwater and can be toxic when the concentration is above certain level. EPA sets a maximum contaminant level of nitrate at 10 mg/L (as N) to protect human

health. Current filter material (i.e., activated carbon) for NO3- removal is both costly and inefficient due to its low anionic exchange capacity (AEC). In this study, we will engineer biochar from wastes to enhance its AEC and investigate its feasibility as a point-of-use treatment technology for NO3- removal in groundwater. Specifically, we produced biochar from two waste sources by scalable methods. Biochar produced from water treatment residuals is rich in metals and can thus sequester NO3- from the aqueous phase water by electrostatic interactions. Agricultural wastes (i.e., almond shells and switchgrass) were treated with metal salts to increase the AEC of biochar. The performance of biochar was then evaluated by determining their adsorption kinetics and capacities for NO3-. The efficacy of the AEC-enhanced biochars in removing NO3- will be evaluated by column tests. Environmental justice influences the end goal of this research: implementation of AEC-enhanced biochar as a point-of-use treatment technology in rural areas that rely on groundwater to provide a sustainable and economic alternative to commercial filters.

D-68: Analysis of Dynamic Cone Penetrometer Testing and Shear Wave Velocity Data Collected During Blast Liquefaction Testing
Author: Every, Haile; Hanley, James; Hubler, Jonathan
Advisor: Dr. Jonathan Hubler

Soil liquefaction is a phenomenon that can occur during earthquake events and cause soil to lose strength and stiffness and behave similar to a liquid. This phenomenon can be simulated in a controlled manner using blasting to understand parameters that affect liquefaction response. In this study, blast liquefaction testing was performed in Christchurch, New Zealand in 2019. PANDA dynamic cone penetrometer (DCP) and multi-channel analysis of surface wave (MASW) testing was utilized to evaluate changes in soil resistance and stiffness before and after blast-induced liquefaction. Analysis was performed comparing the relationship between the change in shear wave velocity and DCP resistance before and after the blast. An existing procedure from the literature was used to calculate the predicted soil settlement based on one cone penetration test (CPT) performed prior to the blast. A relationship between DCP and CPT resistance was utilized to predict settlements due to liquefaction using DCP resistance in place of CPT resistance. Additionally, comparisons were made between predicted settlement and measured settlement following the blast using LiDAR at the test site. Results from the predicted settlement utilizing the CPT and DCP resistance values showed good agreement with measured settlement at the site.

D-69: Risk Analysis, Mitigation, and Identification of Contributing Factors for Infrastructure Flooding
Author: Kwak, Nayeon
Advisor: Dr. Andrea Welker, Dr. Seri Park

Transportation infrastructure is critical to the health of our economy, thus cost-effective solutions to identify, analyze and mitigate risk to existing infrastructure are of interest. This research focused on risk analysis on the likelihood of local infrastructure prone to flooding at specific temporal periods, starting with the road traversing Dismal Run. Dismal Run is one of the streams monitored by the Villanova Center for Resilient Water Systems (VCRWS) as part of a larger project investigating the effectiveness of stormwater controls on receiving water bodies. Due to the undersized culvert at Dismal Run, the roadway located over it is prone to flooding, posing a safety risk to drivers and long-term risk to infrastructure. Examples of the risks posed are corrosion, persistent loads, and

freeze-thaw. Since winter 2017 to present, VCRWS has set up a monitoring system recording temperature, conductivity, flow depth and velocity, and weather station data in five-minute intervals, while an autosampler takes composite samples for water quality testing during storm events. A thorough statistical analysis was performed on recorded parameters and obtained external factors (e.g. traffic volume) to find an optimized input set of depth and velocity for the desired output - a cost-effective method to identify flooding threats, as well as a streamlined procedure to analyze proposed risk. Flashiness was also identified as a potential indicator of flooding, by applying a new criterion that accurately depicts flashiness for small streams. This is an ongoing project that is currently expanding to further analyze four different streams with local infrastructure located nearby to apply and enhance the developed procedure to assess flooding.

Computing Sciences

D-70: Incorporating Security into a Load-sharing IoT-based Network
Author: Cunneen, Katie
Advisor: Dr. Ebelechukwu Nwafor, Dr. Michael Robson

IoT devices have started to become more common as the technology grows. People use these devices so much in life that they need these devices to work efficiently. Load sharing has been implemented to increase the efficiency of the IoT networks since people need fast and efficient networks. Whether work or personal, it is important to keep their information a secret. Elliptic Curve Cryptography (ECC) has been used for many projects and is a very secure form of encryption. The goal of this project was to attempt to implement ECC encryption on the load sharing simulation in order to keep people's information safe while not affecting time or space.

D-71: Optimizing a Bioinformatics Data Mining Algorithm for Scalability and Performance
Author: Goeke, Maxwell; Pividori, Milton; Robson, Michael
Advisor: Dr. Michael Robson

Data mining tools have become increasingly valuable across scientific disciplines, including bioinformatics. Clustermatch is a novel clustering method for analyzing heterogeneous biological data, with a unique ability to handle both qualitative and quantitative data without the need for pre-processing. While the clustermatch algorithm demonstrates superior performance in terms of its precision, the original implementation takes more than a week to analyze five thousand genes. In this work, we seek to maximize efficiency by reimplementing the original Python codebase in addition to all dependencies on third-party libraries in the C++ programming language. Our approach was architected with careful data structure design to scale across multiple threads, nodes, and GPU cores. We achieve a nearly 65x performance improvement over the original implementation, thus allowing scientists to perform experiments in a matter of hours instead of weeks. Our work is now available as part of the original source package.

D-72: Graph Clustering on Social Networks using Deep Modularity Networks
Author: Vaughn, Ryan
Advisor: Dr. Ebelechukwu Nwafor

Unsupervised machine learning is important due to its ability to learn from unlabeled data in addition most data is unlabeled in the real world. Specifically, unsupervised graph clustering is useful for many machine learning applications such as anomaly detection, data visualization, and data exploration. Deep Modularity Networks (DMoN) aims to use graph neural networks for unsupervised graph clustering. However, DMoN was never applied to a large, complex social network dataset. The goal of this research is to measure DMoN's ability at detecting social circles in large social networks. Furthermore, this research evaluates DMoN's success on soft clusterings, which was also not investigated by DMoN's developers.

D-73: A Novel GUI Based Mobile AI Assistant using Natural Language Processing
Author: Sharma, Tejas
Advisor: Dr. Xue Qin

The Universal Voice Control System (UVCS) provides an alternative way to verbally control the smartphone by converting the user queries to interactions (i.e., clicking a button). While existing voice assistants such as Alexa, Google Assistant exist, they can only support voice commands with a limited number of predefined functions and on a specific set of apps. To solve this problem, we proposed a universal voice assistant called G-Speak, which deciphers the intended action described by a user's voice command and executes this action on all graphical mobile apps. In this research project, we start with building the fundamental structure of the G-Speak to validate our design ideas. More specifically, we built a mechanism to identify the best action to take based on the analysis of the application's graphical interface and user's voice command. By deciphering the APK of the app and the XML of the current activity, the project used TF-IDF to find which UI element on the screen yielded the highest similarity with the user's command. In addition, we have built an accessibility app on Android to continually run in the background to detect and process voice commands. In the future, the idea of this can be implemented to other mobile operating systems such as iOS.

D-74: An Empirical Study of Testing Practices in Virtual Reality Software
Author: Attisano, Isabella
Advisor: Dr. Xue Qin

Software Testing is a critical step employed in software development to safeguard against problems such as financial losses, security breaches, and performance issues before the software is released to the public. Thus, many research approaches have been developed to improve the accuracy and efficiency of Software Testing. Virtual Reality (VR), a form of software that simulates a 3D world paralleling true reality, has grown popular recently due to its significant impact on the user's senses and physical wellbeing. However, little research has been done in regards to Software Testing of VR projects. Furthermore, VR software is difficult to test as its features differ from normal software. For instance, it not only has a dependence on user interaction but also employs special VR frameworks. This empirical study aimed to conduct a manual analysis to identify the current testing practices of existing VR projects. Specifically, we focused on identifying the unit test cases from

each of the VR projects collected from GitHub. We also endeavored to discover the other types of testing such as system testing, integration testing, and performance testing. In the future, we will use the results of this study to identify the primary limitations of VR testing and suggest comprehensive improvements to increase the effectiveness of VR Software Testing.

D-75: The Digital Divide in Healthcare

Author: Molina Funes, Maria Alejandra
Advisor: Dr. Vijay Gehlot, Dr. Elliot Sloane

The digital divide is the gap between those that have continuous access to the internet and those who do not. This research focuses on the digital divide in respect to telehealth and the factors that contribute to some communities having limited access to the services provided through telehealth. The major contributing factors to the digital divide are socioeconomic status and race & ethnicity. Through studies, it is proven that minorities, specifically Latino and African American communities, are less likely to have access to the internet and are less likely to use telehealth. This is due in part to the fact that minorities are more likely to have a lower income than white communities, therefore, have a lower probability of having access to broadband internet. Another factor would be the education level attained; generally, minorities have a lower education level and have a lower digital literacy than their white counterparts. This leads to a lower access to telehealth services. This was particularly challenging at the beginning of the COVID-19 pandemic, where most health services went online to reduce the spread of the virus. Those without access to the internet and technology devices now found themselves without access to certain health services. Furthermore, the vaccination process was mostly handled online, with the clinics being advertised online and appointments being made through email. Similarly, those who suffer from the digital divide found themselves struggling to find vaccines and book appointments. Although the COVID-19 pandemic exacerbated the issue of the digital divide, it was prevalent before and will continue to plague society after the pandemic, especially because health institutions realize the convenience of telehealth and have now established a well-functioning system to handle telehealth services. After the pandemic, it is expected that the structures put in place to aid with the spread will continue to be in place, which means that the digital divide will prevail and steps need to be taken to diminish the digital divide.

D-76: A Visualization Tool for Asthma Prevalence

Author: Schmidt, Carter
Advisor: Dr. Ebelechukwu Nwafor

In an era of unprecedented progress in various areas such as technology and medicine, it can be difficult to understand the direction we are headed in as a society. Due to the high value of understanding our future, the collection and use of big data has been rapidly increasing. Despite increased medical innovation, one area that has historically remained an issue is the prevalence of asthma. Hundreds of thousands of people are diagnosed with asthma every year, and many are susceptible to severe asthma attacks. Therefore, it is important that we are able to visualize the future of asthma in our country in order to gain information about the growing prevalence of this debilitating condition.

D-77: Addressing Conflicts in Diverse PLC Systems Using Data Provenance

Author: McDermott, Taylor

Advisor: Dr. Thomas Moyer (University of North Carolina at Charlotte, College of Computing and Informatics)

Smart buildings utilize Programmable Logic Controllers (PLCs) to manage automated processes. Cyber attacks may impair the functionality of smart building control systems because they can create conflicts in certain devices. A conflict is a violation of a system's defined safety and security policies. For example, a conflict arises when temperature sensors shared by a thermostat try to adjust the temperature differently. Identified conflict types are expressed as algorithms and written in Python code, enabling the PLC inputs and outputs that data provenance collects to be analyzed. Detected conflicts are mitigated by prioritizing certain actions over others using a set of superiority rules. These concepts and code have been tested using internal testbed data. This research intends to build upon this foundation by applying them to external datasets, specifically those taken from smart home environments and documented by the Center for Advanced Studies in Adaptive Systems (CASAS). Challenges include the specificity of smart building control system infrastructure, namely the diversity in sensors and required functions between different systems. This paper proposes approaching this task by modifying the format of external datasets and the code itself. Accomplishing this objective would show that conflict detection and mitigation capabilities built upon the concepts of defeasible reasoning and data provenance can be expanded to any PLC system, not just a specific lab scenario. The solution will be validated when running the CASAS data on the conflict detection and mitigation code yields expected results, specifically those that address known conflicts with accuracy.

Electrical and Computer Engineering.

D-78: Efficient Guided Fuzz Testing on Brain-inspired Hyperdimensional Computing

Author: Smith, Duncan; Ma, Dongning; Jiao, Xun

Advisor: Dr. Xun Jiao

Hyperdimensional Computing (HDC) is an emerging neuromorphic computing scheme inspired by how the human brain functions. HDC leverages (pseudo-)random hyperdimensional vectors (hypervectors) for machine learning tasks such as speech recognition and image classification. HDC outperforms other machine learning methods through lower computation cost, lower hardware requirements, and stronger support for one/few-shot training. HDTest is a framework that tests the HDC model by using guided differential fuzzing. HDTest generates adversarial samples, which can cause classification errors, by mutating the original samples. Such samples in turn can be used to retrain the HDC model to strengthen it against adversarial attacks. Sample generation is guided by the distance metrics between hypervectors of each class in the associate memory and the sample hypervector. HDTest features 5 mutation methods: gauss, rand, row_rand, col_rand, and shift, which are focused on modifying pixel locations. For my research over the summer, I implemented 4 new mutation methods: contrast, brightness, blur, and invert. These new mutations step further from modifying pixel locations by focusing on directly modifying pixel values instead. In my research, I used MNIST, the handwritten digit classification dataset, to evaluate the efficacy and

performance of the original HDTest mutation methods compared to HDTest with my new implementations.

D-79: Deep Learning Based Signaling Design in MIMO-NOMA with Variable SNRs and Antannae
Author: Kuchler, John; Vaezi, Mojtaba
Advisor: Dr. Mojtaba Vaezi

Using a deep neural network (DNN), secure and reliable communication over two-user multiple input-multiple output non-orthogonal multiple access (MIMO-NOMA) channels can be examined. This neural network uses supervised learning, meaning there is a solution provided to the network that is used to train the network to predict the outcome of inputs not included in the solution. State-of-the-art is designed for a fixed number of antennas for each user. This is not however pragmatic and cell phones can have different number of antennas. To overcome this, our network now incorporates a varying number of receiver antennas. Additionally, the signal to noise ratio (SNR) was also a fixed number but is now randomly generated over a range of -5 to 20 dB. This results in more realistic outcomes for the MIMO-NOMA network without losing much efficiency.

Geography and Environmental Science

D-80: Historical Heavy Metal Concentrations and Land Use in the Rio Loco Watershed, Puerto Rico
Author: Moczulski, Michelle; Goldsmith, Steven; Rodrigues, Lisa; Cleary, Niki; Gandy, Michele; Chase, Tory
Advisor: Dr. Tory Chase, Dr. Steven Goldsmith

Rivers transport sediments and their associated pollutants (i.e. heavy metals) from nearby land to the coast, causing stress to vulnerable coastal ecosystems, such as coral reefs. Yet, the inability to trace sediment contamination to non-point sources within a watershed, spatially and temporally, can hinder the initiation of meaningful conservation measures. In Southwest Puerto Rico, the coral reefs of Guánica Bay have been designated a "management priority area" by the National Oceanic and Atmospheric Association due to the sediment runoff from the adjacent Rio Loco watershed. To date, limited research has focused on fingerprinting the source of soil contamination in relation to historical land use/land cover (LULC) changes and environmental threshold values for aquatic ecosystems. This study examines the changes in this region that occurred over ~80 years. Additionally, the study targets these knowledge gaps by comparing historical LULC changes in the Rio Loco watershed with downcore metal concentrations in two sediment cores from the lower watershed. Historical aerial and topographic photos from 1930 to 2016 were analyzed with ArcGIS to determine changes in National Land Cover Database categories to develop a historical timeline of key watershed events. Exchangeable and acid soluble metal concentrations were determined downcore and individual layers were age-dated using Pb-210. Preliminary LULC analysis shows relative changes in LULC overtime, with an 81% increase in high/medium density development between 1930 to 2016. Key events, like the construction of the Southwest Water Project in 1950 or draining the Guánica Lagoon for agricultural purposes, likely caused more contaminants to enter the watershed. Several downcore metal concentrations (e.g. Pb and Ni) were in excess of applicable

guidelines for impacts to freshwater aquatic ecosystems. Finally, core layers at a depth of 0-8 cm spanned 100 years, suggesting minimal sediment deposition within the lower watershed. The results suggest an increase in sediment erosion within the watershed over time, likely resulting in increased metal contamination reaching the coral reefs of Guánica Bay from terrestrial sediment. Study findings can be used by watershed managers to enact targeted measures for reducing sediment generation in the Rio Loco watershed.

E-81: Particulate Matter Trends in the Philadelphia Region from 1986 to 2020
Author: Carino, Hailey; Walsh, Sydney
Advisor: Dr. Kabindra Shakya

Particulate matter (PM), one of the six criteria pollutants listed by the United States Environmental Protection Agency (EPA), is one of the main concerns for poor air quality and human health. High PM concentrations contribute to long and short term respiratory, cardiovascular, and cardiopulmonary disease mortality rates. PM is composed of several chemical and biological components; carbonaceous components are one of the most important, constituting about 40% of PM.. Carbonaceous components also help to identify PM sources. This study documents PM trends in Philadelphia from the years 1986 to 2020 and carbonaceous PM (organic and elemental carbon) trends from the years 2000 to 2020. This study also analyzes the association of air pollution regulations with the changes in PM concentrations. PM measurements were obtained from the City of Philadelphia's Air Monitoring Network and data analysis and data visualization was done using the program RStudio. We observed PM10 (particles smaller than 10 micrometers in aerodynamic diameter) decreased by 59.4% from 1986 to 2020; PM2.5, (particles smaller than 2.5 micrometers in aerodynamic diameter) decreased by 51% from 1999 to 2020, and PM2.5 at Improve sites decreased by 28.6% from 2000 to 2020. Typically, high PM concentrations occur in the summer months, while lows occur in the spring and fall. The ratio of carbonaceous aerosols to PM appears to be declining in recent years. The Clean Air Act contributed to the creation of many regulatory policies that address unhealthy levels of particulate matter. Many of the resulting vehicle regulations' enforcement dates coincide with major declines in PM from 1996 to 2010.

E-82: Resurrection of the American chestnut: quantifying the efficacy of chaga mycelium in arresting chestnut blight infections
Author: Roberts, Claire
Advisor: Dr. Jennifer Santoro, Dr. Lisa Rodrigues

Cryphonectria parasitica, otherwise known as chestnut blight, is an invasive, parasitic fungus that devastated the American chestnut tree (*Castanea dentata*) in deciduous US forests. Blight infections ultimately kill the tree through the excretion of oxalic acid, which degrades host lignin and cellulose and appear as sunken cankers on the host trunk. Mud packing is a technique used to slow canker development which involves creating a clay like mixture of dirt and water and securing it over a canker. Anecdotal evidence has suggested that incorporating the mycelium of a competing fungus *Inonotus obliquus*, known as chaga, can fully arrest canker development (Stamets, 2005). This project aimed to quantify the effects of chaga mycelium in arresting canker development in blight infected American chestnut trees. To test this evidence, we inoculated 30 *C. dentata* seedlings with a moderately virulent strain of *C. parasitica* at three different locations along the stem. Locations were then treated with traditional mudpack, chaga enhanced mudpack, or no treatment. Individual

cankers were analyzed for oxalic acid concentration and canker growth. We found a significant difference ($p < 0.05$) in vertical canker growth (mm) and oxalate concentration (μL) between control cankers and mud and chaga treated cankers, where mud and chaga treated cankers displayed less growth and smaller quantities of oxalate. The position of cankers on trunks was also found to be a significant ($p < 0.05$) indicator of vertical canker growth, with cankers closest to the base of the trunk showing the least growth. This research shows potential for treating blight infections in American chestnuts, which could lead to greater survival rates of remaining populations.

E-83: Physical and climatic controls on nitrogen export across the Panama Canal Watershed
Author: Dempsey, Kara; Smith, Devin; Goldsmith, Steven; Harmon, Brendan; Harmon, Russell; Espinosa, Jorge
Advisor: Dr. Steven Goldsmith

Previous studies have shown that a disproportionate amount of nitrogen is delivered to the ocean from tropical rivers compared to those in temperate regions. It is difficult to draw proper relationships between the timing of nutrient export with physical and climatic controls because many of these studies generally lack long-term data, and there are multiple methods to calculate long term fluxes and yields. In this study, we used long-term discharge records (1998–2019) and nitrate (NO3) data (2003–2019) records of high temporal frequency from 8 drainage basins of the Greater Panama Canal watershed collected and reported by the Autoridad del Canal de Panamá (ACP). Long-term (1998–2019) NO3 fluxes and yields were calculated using two regression models: (1) a linear regression that uses discharge as an independent variable, and (2) a USGS LOADEST model that uses discharge and time as independent variables. The LOADEST regression was a better estimate of NO3 flux than the linear regressions in all but two basins. Long-term NO3 yields ranged from 0.109-3.482 kg/km2/yr and 0.109-0.339 kg/km2/yr for the LOADEST and linear models, respectively. We also compared 2015 nitrate yields to potential controlling variables including annual rainfall, suspended sediment, and land use/cover. Pearson correlations show nitrate yields have a positive significant relationship with forest cover ($R=0.41$, $R=0.36$) and with suspended sediment yields ($R=0.86$ $R=0.90$) for the LOADEST and linear model, respectively. Our results demonstrate variability in predicted NO3 export based on the regression model employed. Regardless of model choice, correlations between NO3–land cover and NO3–suspended sediment were similar. This study demonstrates that land cover is an important control on nitrate export in the tropics.

E-84: Assessing Indoor Exposure of Nitrogen Oxides in Children in Hispanic Households
Author: Scotto, Kathryn
Advisor: Dr. Kabindra Shakya

Increasing Nitrogen oxides levels inside the households adds to concerns regarding indoor air quality and the health effects. Few studies have investigated the indoor air quality and concentrations of harmful air pollutants in relation to Hispanic children. The main objectives were to assess indoor air quality and the factors affecting indoor air quality among Hispanic children in the greater Philadelphia region. In this study, we investigated the indoor nitrogen oxides concentrations in 24 households with Hispanic children in the greater Philadelphia area from November 2020 to March 2021. A member of each studied household completed a survey containing information on household location, amenities, and daily schedules. Ogawa passive samplers were used to measure nitrogen oxides, and the sampling was conducted from each household for five days. Overall nitrogen oxides concentrations were greater in households with gas stoves (33.45 ± 29.51 ppb of

NO2 and 16.92 ± 21.93 ppb of NO) than in the households with electric stoves (27.04 ± 41.78 ppb of NO2 and 5.82 ± 8.45 ppb of NO). The nitrogen oxides concentrations were higher in the households in close proximity to highways than households that are not. The results of this study will show the state of indoor air quality among the children in minority communities and potential health consequences.

E-85: Association of Air Pollution with Near-Road Zoning Classifications in Philadelphia, PA

Author: Gaughan, Megan; Bohra, Charlotte; Cummings, Lucas
Advisor: Dr. Kabindra Shakya; Dr. Peleg Kremer

Air quality is a growing area of concern globally, as levels of pollution rise and give way to higher risk for adverse respiratory symptoms and illness. Specifically in urban areas, pollutant levels may be cause for concern and may be influenced by various land uses. The zoning classifications in a given area are primary tools of land use planning; therefore, it is necessary that planners understand the environmental and public health implications of their zoning decisions. Determining linkages between zoning and pollutant concentrations could provide necessary understanding of pollutant distribution and their prevalence in respective zoning categories. The primary goal of this research was to assess levels of several air pollutants along Broad Street in Philadelphia and to better understand the contribution of zoning laws to these concentrations to develop guidance for city planners in regard to determining what type of mitigation strategies need to be applied to various types of zoning. Mobile Monitoring was used to measure the concentrations of particulate matter, ozone, black carbon, and nitrogen oxides. Air pollution instruments were strapped to a vehicle roof and used to measure air quality on an approximately 35-mile stretch of Broad Street from Route 276 to the Navy Yard in South Philadelphia. Monitoring occurred during the morning (8am-11am) or the afternoon (12pm-3pm) on several days from June 8 to June 30, 2021. Auto-Oriented Commercial (CA) zones showed the highest concentrations of particulate matter, on average. Similarly, Industrial (I) zones showed higher concentrations of PM1, PM2.5, and PM10, specifically high PM10 concentrations relative to other zoning classifications.

E-86: Comparing Air Quality at Four Different Colleges in the Greater Philadelphia Region

Author: Bohra, Charlotte; Gaughan, Megan; Cummings, Lucas
Advisor: Dr. Peleg Kremer, Dr. Kabindra Shakya

Poor air quality can lead to adverse health effects such as respiratory issues, and worsening air quality can especially be a concern around colleges due to the nature of activities on campuses. College campuses have dense populations of students who typically live, work, study, and eat on campus with many activities and time spent outside, so it is imperative that they can do this without worrying about health concerns from poor air quality. Air quality also tends to be worse in and around cities where development is more intensive and there is an increase in concentrations due to traffic. This study investigates air pollution around four colleges along a suburban to urban gradient in the greater Philadelphia region: Villanova University, Haverford College, Drexel University, and Temple University. To analyze the air quality in the surrounding area of these colleges, we collected data by mobile monitoring by driving along Lancaster Avenue and Broad Street with a vehicle equipped with the air pollution instruments on its roof. We measured particulate matter, ozone, black carbon, and nitrogen oxides from 8:00am –11:00am in the morning to 12:00pm - 3:00pm in

the afternoon. This study showed that, on average, PM2.5 was lowest around Villanova University and progressively got higher as the schools got closer to the city with Temple University having the highest concentration of PM2.5, on average. Being in a more suburban area farther from the urban area of Philadelphia with high traffic, air pollution emission sources may be lower around Villanova University thus resulting in the best air quality of the four colleges.

E-87: Water Quality of the North Branch of the Raritan: Suburban Development, Golf Course, and Road Proximity Pollution Impacts at Schiff Land Preserve and Downstream
Author: DeHaven, Kennedy
Advisor: Dr. Jennifer Santoro

Schiff Natural Land Trust is a land preserve located in Mendham, New Jersey. Tributaries of the North Branch of the Raritan River, a drinking water source for NJ inhabitants, flow through the preserve and the bordering golf course and suburban development, which may impact stream health. This study tested the water quality at 10 different sites in and around Schiff over a five-week period, focusing on unforested and forested areas. Data collected included temperature (°C), dissolved oxygen (mg/L), conductivity (µs/s) stream depth, and flow rate. Additional analyses included nitrate concentration, phosphate concentration, and pH Overall, temperature, conductivity, and nitrate concentrations were all lower in forested areas than in unforested areas. This may be attributed to tree cover providing shade, farther proximity to road, and surrounding vegetation cover. Phosphate concentrations had a higher median concentration in forested areas; this could be due to fertilizer application and runoff from the development and golf course. In all, these variables could have been impacted by land cover and immediate surroundings. The amount of runoff from roads, the golf course, and development could vary based on the streams surrounding land cover/location. Knowing water quality is important as Schiff houses many species of concern who all depend on good water quality for survival. Furthermore, the Raritan River is a drinking source for NJ residents therefore knowing its quality is important for health concerns.

Mathematics

E-88: On the Girth of Assignment Graphs Generated from Digraphs
Author: Glassband, Jared; Koch, Garrison; Lebiere, Sophia; Liu, Xufei; Sabini, Evan
Advisor: Dr. Eugene Fiorini (Rutgers University)

Graph pebbling is a mathematical game played on a graph G with no loops or multiple edges. A standard pebbling move consists of removing two pebbles from a vertex and adding one pebble to an adjacent vertex. An assignment graph is a Hasse diagram derived from each sequence of possible pebbling moves. In this presentation, we focus on digraphs G with no bidirectional edges. We investigate assignment graphs and analyze what properties yield certain girths.

Mechanical Engineering

E-89: Operating Room Noise Monitoring Device
Author: Sees, Allison
Advisor: Dr. Garrett Clayton, Dr. C Nataraj

In this research project, a device was designed and built to measure the noise level in an operating room (OR). This is motivated by the fact that ambient noise during induction or emergence from anesthesia can adversely affect patient outcomes. The device is equipped with a microphone to detect ambient noise levels (in decibels) and a liquid-crystal display (LCD) screen to display the value and its historical maximum and minimum. A rectangular string of LEDs surrounding the screen change colors according to the decibel level to indicate if the current noise level is safe for the patient. The ranges can be adjusted using knobs located on the exterior of the device. The device will be positioned in the operating room by the patient's head by attaching to a surgical cart. It is hoped that this device can be used to limit noise levels in the operating room by providing feedback to the OR team. Implementation in a real OR will begin in the spring in collaboration with the Villanova College of Nursing. Data will be collected and then analyzed to draw conclusions about the device on noise levels in the OR.

E-90: An Inverse Modeling Approach to the Health Management of Rotating Systems
Author: Bowers, Evan
Advisor: Dr. C. Nataraj

Today's world requires constantly improving methods of maintenance and health management. Through condition-based maintenance, or CBM, fault domains are detected online and dealt with accordingly based on the current state of the mechanical system. In our study, the system is a Jeffcott rotor with a transverse surface crack at the midpoint of the shaft. Nonlinear dynamics principles are applied to the system for analysis at healthy and faulty domains. This produces datasets that can be used to predict when the system is healthy or faulty, and to what extent. Machine Learning is applied to the obtained dataset, where it learns to predict the condition of the system based on the states of the system it was trained on. The inverse modeling approach produces highly accurate results that can be used in online diagnostics applications.

E-91: Cost Estimation Tools for Data Center Two-Phase Cooling with Vapor Recompression-based Heat Recovery
Author: Khuc, Mai
Advisor: Dr. Aaron P. Wemhoff

Data centers consume approximately 2% of all U.S. electricity, so efficiency improvements can yield large financial and environmental benefits. One approach to improve energy conservation is to utilize the waste heat from data centers for the heating and cooling of adjacent buildings, which is achieved through a novel system that supplies heating in the winter in the form of hot water, and cooling in the summer using the absorption refrigeration cycle. This study seeks to analyze the economics of this heat recovery system, specifically the capital cost and the payback period for different data center load scenarios, which provides guidance and promotes its implementation in

the data center industry. The heat recovery system is modeled using AspenPlus commercial software, where each equipment component is sized accordingly to the input heat from the data center. The final simulation results are used as inputs for the Aspen Capital Cost Estimator, which calculates the equipment and installed costs for major system components. The Marshall and Swift Equipment Cost Index is utilized to account for the time variation in costs. Results indicate that the payback period decreases as data center size increases as expected, with competitive payback periods achievable for large (10 MW) data centers in regions with high electricity costs such as Europe or Singapore.

E-92: Enhanced Dehumidification System Modeling and Comparison
Author: Housen, Tara; Wemhoff, Aaron
Advisor: Dr. Aaron Wemhoff

The cannabis grow industry consumes an estimated 1% of U.S. electricity, and dehumidification represents one of the major components of facility energy consumption. One of the most common dehumidification systems is heat pump dehumidification, where air is drawn into the evaporator coil of a heat pump that condenses out water, which is then drawn through the condenser coil to reheat the air. Enhanced dehumidification features variations of this concept to improve the dehumidification efficiency, defined as the amount of water removed per electricity input (generally expressed in units: pints per kWh). Open, physics-based models of enhanced dehumidification systems are currently lacking and can be valuable to the cannabis growth industry to meet dehumidification requirements in an energy-efficient manner. The purpose of our project is therefore to develop models that evaluate the performance of various enhanced dehumidification technologies such as wrap-around heat pipes and thermosyphons. Models of enhanced dehumidification systems have been created by integrating fundamental heat transfer relations into the Engineering Equation Solver (EES) tool. At this point in time, a basic heat pump dehumidification model is completed, and a model of an enhanced dehumidification system with a wrap-around heat pipe is in progress. This poster presentation provides details on both models and a preliminary validation of their results.

E-93: Design of an experimental platform for image tracking to study fin kinematics related to social behavior in fish
Author: Escobar Zapata, Luz
Advisor: Dr. Deeksha Seth (Villanova University), Dr. Devaleena Pradhan (Idaho State University)

Bluebanded gobies (*Lythrypnus dalli*) are hermaphroditic fish that establish a linear social hierarchy and use their fins to display dominance and chase each other to displace subordinate individuals. Males are the most dominant members of the social group, are highly territorial around a nest tube, and display parenting behaviors, which involve whole-body co-ordination to produce rapid rubbing and fanning movements inside the nest tube. The complex fin structures, small size of the fins and geometric nuances demand high resolution imaging. Current sets of video data do not provide high-resolution or high-speed videos to quantify behaviors in three dimensions. Summer research focused on what fin movements can be quantified, establishing which metrics should be used to perform the quantification using 2-D analysis, and determining the limitations of our current approach. Videos were analyzed using benchmarking video tracking technologies such as Kinovea. Based on the

preliminary analysis, several metrics for quantification were identified. These metrics can be computed using readily available computational software such as Excel and MATLAB from position and time data that can be measured through high resolution, high speed videos. The research will allow for quantifications of fin movements, and characterization of fin movements and behaviors. This design can be used to capture and quantify other goby movements that have not been quantified yet. Understanding fin movements will allow researchers to understand the motor functions and the evolutionary importance of fin kinematics. Creating the model could give insight into new behaviors fish are displaying due to climate change. Studying the bluebanded goby can also give scientists insight into how our own biological systems develop and function, leading to discoveries that could improve our health.

Medicine

E-94: Sleep Better; Breathe Better
Author: Goa, David; Canter, Kimberly; Strang, Abigail; Chidekel, Aaron
Advisor: Dr. Abigail Strang (Nemours/Alfred I. DuPont Hospital for Children, Pediatric Pulmonology and Sleep Medicine)

To examine the relationships between daytime sleepiness, anxiety, quality of life, technology use, and markers of asthma control in 100 children ages 8-17 with asthma using a survey-based study at Nemours/A.I. duPont Hospital for Children, Wilmington, DE. Three validated surveys and one investigator-designed survey were used during routine visits in pulmonology clinic. Relevant clinical data were collected from the EMR at the office visit and statistical analysis was performed to evaluate the results. 59% of participants are overweight or obese and require multiple medications (mean 4.2) to control their asthma. 66% report needing more sleep and 50% struggle to get out of bed in the morning. Interestingly, 98% scored in the normal range on the Pediatric Daytime Sleepiness Scale. 32% scored in the abnormal range for health-related quality of life and 25% reported at least some anxiety symptoms. Respiratory symptoms have less of an impact on sleep compared to the prevalent usage of technology (74% use technology within 1 hour of bed, 61% after lights out, and 53% sleep later). There was no difference in lung function between patients with higher levels of anxiety and lower scores on quality-of-life surveys. Participants reported high rates of sleep difficulties, particularly sleep inertia and fatigue, despite not reporting high levels of sleepiness. Since patients report that technology use is more prevalent than respiratory symptoms in disrupting sleep, behavioral interventions may improve sleep in children with asthma. Further analysis may evaluate the role of obesity, socio-economic status, and mental diagnoses on sleep health.

Nursing

E-95: Social Media's Influence on Adolescents' Food Preferences Amid the COVID-19 Pandemic

Author: Kucharczuk, Adam; Oliver, Dr. Tracy; Dowdell
Advisor: Dr. Tracy Oliver

Nearly half of adolescents report being online "almost constantly" and this time spent on social media has only increased due to the COVID-19 pandemic. With this additional time spent on social media, adolescents experienced increased exposure to the thousands of food and beverage advertisements. The successful marketing of unhealthy food and beverage products with the incorporation of celebrities and influencers compounded with the increased exposure may contribute to an increased risk of developing unfavorable health outcomes such as obesity, hypertension, and type 2 diabetes. To examine social media's influence on adolescents' food preference during the COVID-19 pandemic and explore their parents' perceptions of this phenomenon. A qualitative research study was conducted using semi-structured focus groups from a suburban school district in northeastern Pennsylvania. Seven dyads of 6th grade students and their parents (n=14) were recruited from the school district to participate in two focus groups, with separate focus groups for students and parents. Focus group transcripts were transcribed, coded, and analyzed using a constant comparison approach. Three themes identified from adolescents were (1) increased SM usage, (2) increased bored eating, and (3) increased recall of memorable aspects of F&B advertisements. Themes identified from parents were: (1) parental observations of adolescents' less healthy eating behaviors, (2) parental control of F&B purchases, and (3) increased engagement in food trends seen on SM. These themes suggest increased SM use influenced adolescents' ability to recall specific F&B brands and potentially increased consumption. Additionally, there appears to be safeguards in place regarding parents' control over the adolescents' F&B purchase requests. These findings suggest the importance for parents and healthcare providers to be aware of increased SM usage and the potential influence F&B advertisements may have on adolescent eating behaviors.

E-96: Voices from Across the Digital Spectrum: Perceptions and Experiences of Persons with Type 2 Diabetes Mellitus During the COVID-19 Pandemic

Author: Jucar, Daryl Angela
Advisor: Dr. Christina Whitehouse

Even in ideal situations, diabetes self-management (DSM) is challenging; during COVID-19, it has become even more so. To mitigate the virus's spread, diabetes care providers have rescheduled healthcare appointments and diabetes self-management education and support (DSME/S) services from in-person to virtual and postponed some preventative health screenings. For persons with type 2 diabetes mellitus (T2D) who can afford digital resources and internet access, eHealth care during COVID-19 is a lifeline. But eHealth fails to benefit persons without virtual access—who also happen to be disproportionately affected by T2D—namely the elderly and the socioeconomically disadvantaged. Compounded with COVID-19, a lack of internet access may, in turn, mean a lack of healthcare access. This exacerbates continuing healthcare disparities. While epidemiological studies reveal information about the scope and reach of COVID-19, they do not help healthcare providers understand its impact on persons from their perspective. Qualitative research that portrays

perceptions and experiences of persons with T2D in a world changed by COVID-19 is essential; this understanding will allow for improved care. The purpose of this study is to describe the behavior of adults using diabetes self-management, both before and during the pandemic, as well as identify challenges to DSM stemming from the pandemic. Research on the prevalence of COVID-19 restrictions related to those with T2D is very limited. With this ongoing study, current disparities contributing to current T2D care can begin to be evaluated during this unique time.

E-97: Factors and Perceptions of Eating Habits by Emergency Department Nurses
Author: Holland, Emily
Advisor: Dr. Elizabeth Dowdell

Emergency department (ED) nurses face unique barriers and work-related stress from exposure to unexpected death, violence, trauma, and patient overcrowding. These factors, plus long shifts and a heavy workload, can lead to significant negative effects on their physical and mental health. Behaviors related to unhealthy eating habits, irregular eating patterns, and emotional eating as a coping strategy may lead to an increase in consumption of foods that are high in fats, salt, and sugar leading to weight gain. To explore the self-reported eating habits of ED nurses and identify the factors preventing them from eating consistent nutritious meals during shifts. A sample of 53 nurses who worked full-time in a Level I trauma center/ED (45 females and 8 males) participated in 24 focus groups in this descriptive qualitative study. The ED nurses shared stories of why they often chose unhealthy snack options, underate, or overate both on the job and at home. Five themes including 1) Lack of time, 2) Lack of space, and 3) Unhealthy work environment emerged from analysis. ED nurses also shared that reward food from management made them feel recognized, leading to more positive feelings about their job. Professional nurses are required to have extensive knowledge of nutrition and healthy eating habits; however, many do not put this education into practice for themselves. Good nutrition will have positive effects on stress management, maintenance of healthy weight levels, and energy levels. Identifying and overcoming the barriers to consistent, nutritional meals at the hospital may help to create healthier, happier, and more efficient ED RNs that will improve patient-staff interactions and outcomes. This study was made possible through the Davis Family Undergraduate Research Fund in the M. Louise Fitzpatrick College of Nursing, Villanova University.

Physics

E-98: Fabrication of 2D van der Waals devices for high frequency measurements
Author: Danial, Ahmad; Akbari-Sharbaf, Arash; Dietrich, Scott
Advisor: Dr. Scott Dietrich

Van der Waals materials can be exfoliated down to a single atomic layer due to their weak inter-plane bonding. At this truly 2D limit, exciting electronic properties emerge that vary drastically from those of its parent crystal. In this work, we fabricated stacks of layered van der Waals materials where a monolayer of graphene is encapsulated between two layers of insulating hexagonal-boron nitride. We also use a layer of graphite placed at the bottom of the stack to dynamically tune the charge carriers in the graphene layer. On the top side of the device, a waveguide is fabricated using nanofabrication techniques. This waveguide is used to couple high-frequency AC electric fields to the graphene layer, which allows us to study the unique quantum phases in graphene at high

magnetic fields and ultra-low temperatures. These phases include the formation of electronic crystals and the fractional quantum Hall effect.

E-99: An Analysis of a Variable Accretion Disk Wind From GRS 1915+105
Author: Jensen, Danny; Neilsen, Joey; Steiner, Jack
Advisor: Dr. Joey Neilsen

The black hole X-ray binary GRS 1915+105 has been the highlight of hundreds of studies since its discovery in 1992. GRS 1915+105 possesses powerful jets, has a high luminosity, and displays erratic variability at varying timescales. As such, GRS 1915+105 has been targeted by various telescopes and spectrometers accounting for thousands of hours of exposure time. Here we report our analysis of two such observations collected using NASA's NICER spectrometer onboard the International Space Station. Using two observations, taken just days apart, we model the X-ray absorption spectra using two different methods of spectral fitting. Gaussian modeling reveals the presence of strong Fe XXV and Fe XXVI absorption lines as well as the characteristic lines of other commonly present ions. We further report the time variability of system parameters utilizing the warm absorbing wind model warmabs. While the present absorption spectra corroborate previous studies, there are notable differences between the two spectra as well as differences within the individual observations that warrant further analysis.

E-100: Development of a Burst Gravitational Wave Detectable Range Visualization
Author: Holcomb, Dominic; Terhune, James (UCLA)
Advisor: Dr. Amber Stuver

The Laser Interferometer Gravitational-wave Observatory (LIGO) measures gravitational waves of astrophysical origin. A common measure of detector performance used by LIGO is the distance to which a standard binary neutron star merger can be detected. While all the detected gravitational waves to date have been of this kind, it is expected that the next class of detected gravitational waves will be from unmodelled or unanticipated sources, also known as "bursts." This research focuses on developing a measure of the detectable distance for a burst gravitational wave that is sensitive to the near-real time data quality of the detector. We have developed software that collects results from the primary burst search algorithm to determine what signal-to-noise ratio is needed to achieve an acceptable false-alarm rate and combines this with the power spectral density of the noise to calculate the detectable distance for a standard burst source. The result can be visualized as a time-frequency representation or an average distance over the sensitive frequency range. Ultimately, this measure will be automatically generated during the next observing run and used to determine the effect of current data quality on the search for burst gravitational waves.

F-101: Investigating the Peculiar Obscured State of Black Hole System GRS 1915+105
Author: Sloane, Stephen; Neilsen, Joseph
Advisor: Dr. Joseph Neilsen

GRS 1915+105 is a black hole X-ray binary system known for its unique synthesis of processes of mass accretion, mass ejection, and radiation. This black hole has experienced considerable dimming and a sharp drop in its flux since mid-2019 observations, along with occasional X-ray flares observed

by the ISS-based telescope NICER. The dimming and flares present in this object's "obscured" state are likely due to partial obscuration of the black hole by a cloud of ionized gas. This cloud may contribute various notable emissions which we observe in the spectrum of an 18-month dataset of several hundred stacked NICER observations to study the emission line spectrum of this obscured state in hopes of understanding it better. Notably, the related spectrum for this dataset portrays several prominent emissions of Fe lines XXIV, XXV, XXVI, as well as Si, S, Ar, and Ca, all for which ionization was studied using the spectral analysis tool XSTAR. In addition to absorption and emission due to the partially obscuring cloud, our model accounts for ISM absorption of X-rays, comptonization, and photoionized element emissions. We consider the implications of our ionization models for the geometry of the obscuring cloud. This work pioneers future understanding of similar black hole systems whose emission behavior cannot be sufficiently explained using traditional models.

F-102: Developing the Control System of a Michelson Interferometer for Fourier Transform Spectroscopy
Author: Garner, Sean
Advisor: Dr. David Chuss

A Michelson Interferometer is a device that splits a beam of light and superimposes the beams of light back onto each other, resulting in an interference pattern of the two beams. By varying the path length of one of the beams that result from the split, and measuring the result after the recombined beam is passed through a sample as the path length is changed, an interferogram can be generated. Using a Fourier Transform, the resultant interferogram can be converted into a spectrum that describes the sample. This information can be used to characterize optical equipment, and it can provide valuable insight into the properties of a given sample by determining its absorption spectrum. However, for this technique to work, the path length of the split beam needs to be precisely adjusted while the beam that has been passed through the sample is rapidly measured. To achieve the necessary precision and computing power for high resolution results, a sophisticated control system is required. This project implements a dual core microcontroller designed for industrial applications, which allows for simultaneous path length control and data collection while the spectrometer is being run. Additionally, testing and measurement of the existing linear motor in the interferometer were done to determine the speed and resolution at which the system could be run, and a pressure limiter was installed to optimize the air bearings that constrain the movable path.

F-103: Automating Veto Algorithms for Application to the Search for Burst Gravitational Waves with LIGO
Author: Davis, Michael; Stuver, Amber
Advisor: Dr. Amber Stuver

The Laser Interferometer Gravitational-Wave Observatory (LIGO) measures astrophysical gravitational waves. During the process of data acquisition, transient noise from environmental and instrumental sources creates glitches in the data. The impact of these glitches on the search for gravitational waves can be mitigated by removing (vetoing) these glitches from the data. Omicron is an algorithm that is currently used to automatically identify data segments likely to be glitches. Two different statistical algorithms evaluate data quality when Omicron glitches originating from different auxiliary channels are vetoed: hierarchical veto (Hveto) and Used Percentage Veto (UPV). This research applies these automated veto tools to evaluate their potential to improve the search for

burst (unmodelled) gravitational waves. We have developed software to collect the daily results of Hveto and UPV and apply those candidate vetoes to the burst search algorithm, Coherent WaveBurst (cWB). The results are evaluated by the Veto Evaluation Tool (VET) to measure a veto's efficiency in removing cWB triggers, deadtime (amount of time removed by the veto), and the ratio of efficiency to deadtime. The higher this ratio, the more effective the veto. This work will be integrated onto the LIGO summary webpages, a data quality utility that is available to the entire LIGO collaboration. Results of this research show that Hveto and UPV provide vetoes that identify unique glitch features, and both have the potential to improve data quality for burst gravitational wave search.

F-104: Electron-Beam Induced Structural Transition in MoS2
Author: Webb, Peter; Ji, Kaixaun; Akbari-Sharbaf, Arash; Dietrich, Scott
Advisor: Dr. Scott Dietrich

MoS_2 is unique in that it can exist in both semiconducting or metallic phases. Naturally MoS_2 exists as a semiconductor in its 2H phase but can undergo a transition into a metallic 1T phase under certain conditions. An electron beam lithography system is used to pattern specific regions of the MoS_2 with various doses. When the 2H phase is exposed to a concentrated beam of electrons, zig-zag chains within the material begin to constrict. Sulfur atoms begin to glide in plane to a point where each Molybdenum atom has 4 Sulfur atoms to form the 1T phase. By measuring the current-volage characteristics of each dose, we are able to determine the point at which the MoS_2 has transitioned. A 1T phase MoS_2 atom will have ohmic behavior and no gate dependence. Exploiting this property opens the possibility of using a single material to create various electronic devises such as electrostatic gates, field-effect transistors, Schottky diodes, and quantum dots/wires.

Physics & Astronomy

F-105: Calibrating DESI Tully-Fisher Measurements with SDSS MaNGA
Author: Chiodo, Grace; Douglass, Kelly; BenZvi, Segev
Advisor: Dr. Kelly Douglass, Dr. Segev BenZvi (University of Rochester)

Measuring the rotation curves (velocity vs. galactocentric radius) of spiral galaxies is a classic technique to estimate the presence of dark matter at galactic scales. In addition, the maximum rotational velocity of a galaxy can be converted into a standardizable distance using the Tully-Fisher relation, making these measurements useful for cosmology. The Dark Energy Spectroscopic Instrument (DESI) has collected over 104 spectra from secondary targets along the major axes of spiral galaxies identified in the Siena Galaxy Atlas. The difference between the redshift measurements at a given galactocentric radius and the redshift of the galactic center yields the rotation velocity of each DESI target. Obtaining repeated rotation velocity values within a galaxy provides multiple points along the galaxy's rotation curve. In this study, we analyzed the effectiveness of the rotation curve measurements by comparing the DESI data to rotation curves from the Mapping Nearby Galaxies at APO (MaNGA). The rotation curve models generated with the MaNGA data provide an independent check of the distribution of the DESI results. We find that the MaNGA rotation curves agree with the DESI rotational velocity measurements.

Psychological & Brain Sciences

F-106: Using road sign interpretation to understand mechanisms of temporally limited perception

Author: Schumacher, Maeve
Advisor: Dr. Joseph Toscano

Road signs are an important component of road safety, but they only achieve this purpose when interpreted quickly and correctly by road users. Comprehending a sign's intended message relies on basic mechanisms of perception, as well as semantic knowledge. However, this process also differs from other perceptual activities because it is temporally limited in nature. Other activities, like reading or looking at a picture, for example, do not require the same temporal constraints as interpreting a road sign. The proposed project will use theories from spoken language processing—another task that reflects a temporally-limited sensory phenomenon comparable to the limitations on sign perception—to better understand what components of signs are most effective at conveying their intended message. The primary objective of the project is to determine how various factors of signs—namely, color, shape, text, and familiarity—impact subjects' semantic interpretation of the sign compared to the intended meaning. The proposed project will achieve this through two experiments that will (1) measure subjects' semantic understanding and familiarity of a set of signs, and (2) compare their interpretation to the signs' intended meanings. This work will be used as a vehicle to understand temporally limited perception more broadly and provide useful data for optimizing road safety and road sign design.

F-107: Assessing Knowledge of Early Childhood Development: The Establishment of a Strengths-Based Questionnaire

Author: Riccelli, Victoria
Advisor: Dr. Janette Herbers

Families with young children account for a high number of people residing in homeless shelters. Experiencing homelessness places children at a higher risk of experiencing developmental delays due to the environment and lack of resources and support. Therefore, shelter staff have the potential to promote positive development, yet they are also lacking the relevant knowledge and available resources. To address this gap in early child development education, pre- and post- test questions were developed in conjunction with six educational modules on topics of child development with attention to contexts of poverty, psychosocial adversity, and homelessness. In order to establish content and construct validity for the questions, my project administered an online survey to the general adult population to assess knowledge of early childhood development using the new content alongside already established measures, such as the KIDI, AAPI, and MCC. From participants' demographic information, I will compare whether educational background, experience with children and/or families, income level, gender, and age are associated with more accurate knowledge of early childhood development. In addition, I will analyze the psychometric properties of the newly constructed questions in order to incorporate them in future social service staff trainings.

F-108: The Impact of the Coronavirus Pandemic on Homeless Shelter Staff

Author: Bajada, Allison
Advisor: Dr. Janette Herbers

The Coronavirus pandemic has introduced unprecedented challenges for shelter staff and has greatly reduced many staff members' ability to effectively meet the needs of individuals residing in shelters. I conducted qualitative content analysis utilizing the novel method of Iterative Thematic Inquiry, hypothesizing that the pandemic has contributed to increased burnout among homeless shelter staff, greatly hindering their capability to serve children and families experiencing homelessness. After thoroughly examining the responses provided to a national survey, I devised 10 categories that I would use for my coding: 1) Housing concerns, 2) Health and Safety concerns, 3) Reduced Service concerns, 4) Social concerns, 5) Communication concerns, 6) Mental Well-being concerns, 7) Funding concerns, 8) Technology concerns, 9) Employment concerns, and 10) Schooling concerns. After examining each response to the question, "Please explain how COVID-19 has affected your ability to meet the needs of children and families", I assigned a "no" or a "yes" for each theme, depending on whether or not the theme was alluded to in the response. The main relationship that I examined – between the number of COVID-19 themes and burnout – resulted in a statistically significant positive correlation $r(61) = .47$, $p < .01$. Further correlational analyses clarified which factors seemed to be the main causes of burnout, as well as how variables like shelter capacity and location impacted which themes shelter staff members indicated in their responses.