Inquiry at UST:
A Poster Session with the Results of Faculty/Student Collaboration at the University of St. Thomas

ABSTRACTS

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Introduction

The abstracts published here summarize some of the most compelling research and creative inquiry carried out in recent months across many disciplines by undergraduate students at the University of St. Thomas. In all cases, the student researchers have worked in close collaboration with faculty mentors who have contributed their time and talent to help our students dig more deeply into topics of the students’ choosing and design.

Funded by the University of St. Thomas through undergraduate research programs administered by the Grants and Research Office, this poster session allows some of our most dedicated scholars an opportunity to share their work with larger audiences and receive the critical scrutiny of their peers, professors, and the general public.

We hope that you enjoy this event and invite you to engage our scholars in ways that will both challenge them and encourage them to continue their journey of the mind.

David Steele, Ph.D.
Director, Grants & Research Office

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Coordinator, Inquiry at UST

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Kevin Theissen, Ph.D., Geology
Kathleen Winters, Ph.D., Political Science
October 2016

As president of the University of St. Thomas, I am both pleased and proud to introduce the 28th poster session devoted to the collaborative projects of our students and faculty, sponsored by the Grants and Research Office.

One of the most effective ways for students to learn is through collaborative inquiry, in which students and faculty work together on research with real-world consequences. Active learning of this kind solidly demonstrates our mission as a Catholic university grounded in the liberal arts tradition. We strive to provide a high degree of personal attention in a challenging campus environment that is engaged with the complexities of our urban community and the world beyond.

Collaborative inquiry offers our students the opportunity to learn from their professors' approaches to research questions in a variety of disciplines. It also gives our faculty an excellent opportunity to work one-on-one with their students as they together develop new ways of examining research problems. Collaborative inquiry enables our students and faculty to experience their disciplines in action, deepening students' academic experience while simultaneously increasing career competency.

I heartily endorse this effort, and I hope you enjoy this presentation so aptly demonstrating the importance of collaborative inquiry at St. Thomas.

Sincerely,

Julie H. Sullivan, Ph.D.
President
The Green Research at St. Thomas badge, sponsored by the Office of Sustainability Initiatives, identifies research projects that exemplify the St. Thomas’ strategic priority:

To effectively engage students in advancing the common good, we will build upon our strengths in ethics, sustainability, social justice, service learning, globalization and social entrepreneurship with diverse local and global communities. Specifically, St. Thomas will cultivate an ethic of the care for God’s creation through curricular and co-curricular activities aimed at environmental stewardship and sustainability.
Jenna Abrahamson
CENOZOIC EVOLUTION OF THE SOUTHWESTERN NORWEGIAN ‘PASSIVE’ MARGIN
Faculty mentor: Dr. Jeni McDermott

The landscape of southwestern Norway is an area undeniably shaped by geological forces. Well known for its stately fjords and steep mountain escarpments, the formation of this topographically diverse area has been established by researchers as a product of both glacial and tectonic forces. Our research within this area is focused primarily on the development and evolution of a passive margin, otherwise known as a continental margin that is no longer tectonically active. Studies within this area have suggested this Norwegian margin transitioned from active rift to passive rift more than 50 million years ago, yet the southwestern margin of Norway is characterized by high-relief, mountainous topography that is typical of topography displayed in areas of active tectonic movement. These conflicting aspects have caused a lot of disagreement among researchers and have brought up the question of whether or not tectonic activity is still playing an active role in transforming the landscape today.

My research involves analyzing fluvial systems using programs such as ArcGIS and Matlab in order to determine whether glacial or tectonic activity is responsible for forming the knickpoints found within these systems. In addition to this, I will be processing samples using (U-Th)/He apatite and zircon thermochronology and 10 Be comogenic nuclide dating in order to obtain proxies for depth as well as erosion rates within the area of study. Results from these processes will hopefully help us to either confirm or disprove the hypothesis of active faulting within the region. Furthermore, this research has both scientific and societal significance because of the passive margin’s potential links to geological hazards such as earthquakes and landslides as well as its possible connection to the formation of hydrocarbon basins capable of producing oil.

Elliott Allen
USING LOW-TEMPERATURE THERMOCHRONOLOGY AND FLUVIAL PROFILES TO TEST FOR FAULT REACTIVATION IN SOUTHWESTERN NORWAY
Faculty mentor: Dr. Jeni McDermott

Passive margins, sites of prior rifts that are now inactive and away from plate boundaries, are home to much of the world’s petroleum resources. Specifically, passive margins that have experienced recent reactivation are valuable to petroleum research, as they may have deposits that are nearer to Earth’s surface. These rejuvenated ancient margins are often characterized by high relief and elevation despite the long temporal gap between now and the time when these sites were being actively uplifted. In order to maximize the efficiency of the petroleum industry’s search for fossil fuels, it is imperative that more be learned about the mechanisms that drive passive margins. Southwestern Norway’s passive margin is home to a unique 2km high escarpment often referred to as The Great Escarpment. This landform is atypical of ancient margins in both relief and topography, and, therefore, warrants analysis. The Møre-Trøndelag Fault Complex (MTFC) is a large section of land southwest of Trondheim that contains parts of The Great Escarpment and provides a valuable opportunity to further analyze the intricacies of the Norwegian margin’s history. The MTFC is home to many major faults that may contain information regarding the timing of uplift in the area. The data for this project is being obtained through low-temperature thermochronologic analysis of samples taken from the footwall and hanging wall of two faults in the MTFC. By examining the age of these samples, it is possible to constrain the timing of faulting in the area and determine whether Southwestern Norway is currently experiencing active faulting.
Dacotah Anderson and Georgianne Younger
THE EFFECT OF FADROZOLE ON EUROPEAN STARLING MALE DOMINANCE (*Sturnus vulgaris*)
Faculty mentor: Dr. Sarah Heimovics

The role that androgens such as Testosterone (T) and its subsequent metabolite, 17-Estradiol (E$_2$), have on breeding season aggression is well established. Through genomic and non-genomic mechanisms, research has suggested that E$_2$ can influence the physiology and sexually motivated behavior of various male species. To focus on the direct influence of E$_2$ on sexually motivated and aggressive behavior, however, the use of non-steroidal inhibiting drugs has been utilized. The effects of the drug fadrozole hydrochloride (FAD), which works through the inhibition of the aromatase enzyme, has been successfully implemented and analyzed. The European starling (EUST) is known to use song as a territorial defense mechanism, as well as a precursor in copulation when presented a female. Here, with the establishment of a male-pair bonding scheme to force the presence of a dominance hierarchy, we directly test the acute and chronic effects of FAD on the dominant male. The quantification of circulating levels of T and E$_2$ in the blood plasma in both control and FAD bird(s) will also be analyzed. After preliminary analysis, the total orientation time of the dominant male birds appeared to increase after the chronic administration of FAD relative to the baseline testing days. However, only trends were detected in other scored behavior. These data suggest that the chronic administration of FAD could have increased the levels of circulating androgen in the bloodstream, thus increasing the sexually motivated behavior. Further statistical and behavioral analysis includes, but is not limited to, a principle components analysis (PCA) and a closer look at the various types of orientation (i.e. proximate, sexually motivated orientation vs. total orientation time).

Meghan Anthony, Natalie Vandeweghe, Erik Santa and Maria Ishmael
ESTIMATING PROBABILITY OF A CYBER-SECURITY BREACH
Faculty mentor: Dr. Arkady Shemyakin
Industry collaborator: Gary Stanull, Optum Health

Information technology is the engine that drives the U.S. economy, giving it a competitive advantage in global markets by providing better services and facilitating greater productivity. This great value means that information systems are subject to a variety of threats, from malicious hackers to an employee simply losing a flash drive. Unfortunately, the threat landscape is constantly changing. To determine the risk these threats pose we need to evaluate the likelihood of their success in exploiting known and unknown vulnerabilities. This involves an accurate assessment of both impact and probability of breaches.

The purpose of this paper is to define a predictive model, based on known system attributes, for assessing risk associated with information systems. The goal is to provide decision-makers with the best possible information about the probability of a security breach so they can make informed decisions on how to best address the risk.

Joe Arend
ASTROCHEMICAL ROVIBRATIONAL SPECTRA CALCULATIONS
Faculty mentor: Dr. Joshua Layfield

The identification of compounds in space requires the use of both rotational and vibrational spectroscopy. However, the instability of the compounds found in such a different environment makes them virtually impossible to study in a lab. In order to calculate the rovibrational frequencies of larger molecules for astrochemical purposes, a new computational method that doesn’t sacrifice accuracy of results for computational time is required. For this purpose, this research was directed toward adjusting the parameters of a semi-empirical method so that electronic structure calculations match the results of high-level CCSD(T)/aug-cc-PV5Z calculations. This resulted in electronic structure calculations that had
an RMSD of $5.826 \times 10^{-4}$ Kcal/mol, 4 orders of magnitude more accurate than original semi-empirical calculations. This was achieved by the addition of other functionalities, such as the direct weighting of geometric measurements and force constants into the program that minimized the RMSD, along with finding the minimum in the parameter space for those optimized inputs.

Sarah Beck  
**ASSESSING EFFECTIVENESS OF A TECHNIQUE IN REMOVAL OF POLYCYCLIC MUSKS FROM WASTEWATER**  
Faculty mentor: Dr. Kris Wammer

In recent decades, polycyclic musks (PCMs) have become an essential component of many household materials such as detergents and personal care products. Due to their ability to fix certain fragrances by means of slowing the release of volatiles, they have become widely produced compounds. Unfortunately, new studies have shown that these chemicals are becoming more present in natural Minnesota water sources. Furthermore, other studies have seen that certain polycyclic musks display toxic potential toward aquatic life. These two factors combined make this a topic of high interest to conduct additional research. It is proposed that the systems implemented in wastewater treatment plants (WWTPs) are not adequate enough to completely remove PCMs from wastewater before releasing it back into rivers and lakes. In this research, we will eventually primarily focus on UV light disinfection methods using the two most used PCMs - galaxolide and tonalide. Using a 254 nm germicidal UV-C lamp, our goal will be to replicate the type of light PCMs would encounter in a WWTP and determine the ideal intensity required to sufficiently eliminate such PCMs from the water. Our initial work this summer, however, focused on simulated sunlight using a Suntest CPS+ to replicate the type of light present in the environment. Throughout the summer, we monitored how quickly our PCMs degraded in certain light intensities as well as observed the different photoproducts that grew in throughout photolysis. At the conclusion of the summer, it was determined that both PCMs produce several different photoproducts under simulated sunlight. Also, it was found that tonalide degrades much more readily than galaxolide. In the future, we hope to replicate these experiments with the UV light photoreactor as well as perform various toxicity assays on both photolyzed and unphotolyzed samples.

Kristen Berger  
**SYNTHESIS AND CHARACTERIZATION OF 9-BENZYLACRIDINE DERIVATIVES**  
Faculty mentor: Dr. Eric H. Fort

A new approach to synthesizing 9-benzylacridine derivatives is described. The purpose of this research is to classify new 9-benzylacridine derivatives and optimize the work-up. To proceed for this reaction, varying methods of experiment conditions are tested to explore purity and gain some mechanistic insights. The resulting 9-benzylacridine derivatives are characterized. These findings are relevant as acridines have many potential uses, from antibiotics to organic light emitting diodes. This research has the potential to create a more fluid synthesis of acridines for the future.

Lindsey Bollig  
**DETERMINING EFFECTS OF ANISOTROPY AND ORIENTATION ON THE MAGNETIZATION AND MAGNETIC MOMENT OF 3D PRINTED SAMPLES**  
Faculty mentor: Dr. Brittany Nelson-Cheeseman

Additive manufacturing (AM), commonly referred to as 3D printing, refers to the process of building a part up, layer by layer, with a material. As opposed to traditional manufacturing methods, AM allows for
the manufacture of complex geometries without being limited by the abilities of tools or molds. One of the more common types of 3D printing is FDM. This process involves heating a material (mostly commonly a thermoplastic filament) in a nozzle and continuously extruding the molten material onto a print bed to create a layer. When one layer of the part is complete, the printer head moves a fraction of a millimeter up so a subsequent layer can be extruded and deposited. This process is repeated until each layer of the part has been extruded.

Using a simple FDM machine (3D printer), magnetic samples were prepared by extruding a composite filament comprised of a polylactic acid polymer with 40 wt.% iron. Different printer settings, such as fill factor, number of outer layers, and orientation of the inner fill, were used to create the samples. The 3D printed samples were evaluated via VSM. Hysteresis loops from each sample where obtained from the VSM and were used to determine if the different printer settings had an effect on the sample's magnetic response in a magnetic field. Although it was determined that the fill factor had the greatest and more prominent effect on the cube’s magnetic response, other settings were also found to have some effect. Determining the effects of each of the printer settings will help better understand how a magnetic component, such as a transformer, could be 3D printed using a thermoplastic 3D printer.

Ashley Brundrett

RECONSTRUCTING THE PALEOECOLOGY AND PALEOClimATOLOGY OF LOWER PAHRANAGAT LAKE TO UNDERSTAND MICROBIALITE FORMATION IN THE LAKE MEAD, NV REGION

Faculty mentor: Dr. Kevin Theissen

Our research focuses on the Lower Pahranagat Lake (LPAH) and the paleoecology and paleoclimatology of the area to better our understanding of microbialite formation. LPAH is an alkaline lake located in south-central Nevada. Microbialites have been found surrounding LPAH in past research, and we are looking for microbialite features in sediment cores. Our end goal is to compare the microbialite features in LPAH to those of an ancient analogue called the Horse Spring Formation in the Lake Mead region, and determine under what conditions microbialites form. We took a 12 meter core from LPAH, and we have been doing analyses on the core looking at composition at both the micro and macro scale. We have been using a new freezing technique using liquid nitrogen to make thin sections from wet sediment, allowing us to look at the fine fabrics of the sediment without disturbance. We are looking for signs of microbialites in our thin sections, particularly fabrics similar to those seen in ancient microbialites. Initial core descriptions showed the presence of gyrogonites extensively in the first 11 meters of core, as well as the plants the come from, charophytes, in various sections throughout the core. In continuing our research, we will be doing SEM/EDS analyses on multiple samples from the core to look for microbial fabrics as well as XRD to get a better sense of elemental and mineral composition. We plan to return to LPAH in November to retrieve another longer core.

Paul Buchmann

PUSHING THE LIMITS OF THE CHAOTIC PENDULUM: MAGNET EDITION

Faculty mentor: Dr. Marty Johnston

There are some macroscopic things in nature that seem to defy conventional methods of analysis - they appear to be random instead of governed by set laws of nature. These systems are not random, but rather chaotic. A simple system commonly used to study chaos is the driven pendulum.

I experimentally pushed the chaotic pendulum one step further by adding magnetic interactions at various angular locations around the pendulum. The addition of these magnets changed the shape of the potential, which corresponded to a change in behavior of the pendulum and so also the attractors produced by these potentials. The strength of the torque, which drives the system was also varied systematically.
These two experimental changes provided a way to look at the chaotic pendulum that had not been done before.

On the theoretical side, I improved the model for dipole-dipole interactions, which improved the accuracy of the simulated bifurcation diagrams for the single magnetic interaction pendulum. This was done using Mathematica with the same code that had produced the previous bifurcation diagrams. I was also able to simulate the attractors as well as the bifurcation diagrams of the single dipole-dipole interaction using Python.

I will continue working on simulating the multi-dipole system as well as finding the correlation dimension of the attractors, both in Python.

Anna Buelt

**LSM9DS1 ACCELEROMETER CALIBRATION**

Faculty mentor: Dr. Jalkio

An accelerometer is used in all types of devices, from smartphones to cars to lab equipment. An accelerometer measures acceleration vectors. In order to properly use any sensor, it must first be calibrated. The LSM9DS1 accelerometer measures acceleration vectors in terms of gravity for the x-, y-, and z-axes. The sensor’s uncalibrated x-, y-, and z-axes are not necessarily perpendicular to each other, and the sensor’s uncalibrated perception of 1g is often inaccurate. A simple calibration method to correct these inaccuracies is to take twenty-four different uncalibrated readings from the sensor where the accurate acceleration is known. Using the uncalibrated acceleration readings alongside the actual accelerations, calibration variables can then be calculated. Future measurements can use these variables for calibration.

Mackenzie Burke

**ASSESSING A NOVEL, FINANCIALLY SUSTAINABLE FARMERS MARKET MODEL FOR LOWER-INCOME URBAN NEIGHBORHOODS**

Faculty mentor: Dr. Adam Kay

Many low-income neighborhoods in North Minneapolis identify as food insecure. Oftentimes, attempts to make fresh produce more accessible and affordable in low-income urban neighborhoods are short lived because they rely on grants government agencies. A sustainable approach to addressing food insecurity is needed within the scope of public health as well as for greater society.

This research project explored a model for creating financially viable farm stands in lower-income urban neighborhoods. The study also explored whether sidewalk farm stands in lower-income urban neighborhoods provide benefits to corner stores that partner in hosting the stands.

Eight corner stores in North Minneapolis who have pre-existing relationships with community partner, BrightSide Produce, participated. Five corner stores hosted weekly farm stands while three corner stores served as control stores. Each week, one local youth and one university student volunteer hosted a farm stand outside of a corner store for three hours. The stand offered a diverse mix of conventional and local produce.

Remaining produce was sold in $10 shares to local neighborhoods. Each week, members picked up their produce bags at a central location. This guaranteed all produce was sold and youth hosts were able to receive a fair wage for their work at the stands.
Liam J. Coulter

IMAGE DEBLURRING AND CENTERFINDING FOR OPTICAL NAVIGATION
Faculty mentor: Dr. Thomas Höft

This project focuses on image deblurring and centerfinding for astronomical optical navigation. Optical navigation (OPNAV) has been in use in multiple spacecraft for many years, and is an important component of spacecraft navigation. However, OPNAV deals with images that are blurry and contain noise, so image processing is an integral part of OPNAV. This project seeks to solve traditional OPNAV problems with a new approach: deblurring using inverse matrix linear algebra, paired with centerfinding techniques. To accomplish this we use filtering, regularization and sparse inversion methods. A discussion of both visual results and quantitative results is given, and of which methods perform best in each category. Then, possible conclusions, as well as future directions are discussed.

Zachary H. Czerniak

SOLID-STATE CHEMISTRY OF NITRILE OXIDES
Faculty mentor: Dr. William H. Ojala

Nitrile oxides are compounds of formula R-C≡N+-O- that have proved useful in synthesis for many years. Those that are unhindered dimerize in solution to yield three possible products, depending on the reaction conditions: a furoxan, a dioxadiazine, or a 1,2,4-oxadiazole-N-oxide. In contrast, those that are hindered are reported to isomerize to the corresponding isocyanates, compounds of formula R-C=N=O. We are examining the solid-state chemistry of benzonitrile oxides of both types, those that should be capable of solid-state dimerization and those that may undergo solid-state rearrangement. We have begun the preparation of the nitrile oxide formed by the treatment of 9-anthraldehyde with hydroxylamine hydrochloride in the presence of base, reaction of the resulting oxime with N-chlorosuccinimide, and treatment of the resulting hydroxamic acid chloride with aqueous sodium hydroxide. Our goal is to study the solid-state chemistry of this nitrile oxide and to determine its molecular packing arrangement by means of single-crystal X-ray diffraction. This study is intended to determine whether the anthracene moiety is either sufficiently small to allow solid-state dimerization of the nitrile oxide to one of the three possible solution dimers or sufficiently large to allow solid-state isomerization of the nitrile oxide to the corresponding isocyanate.

Samuel Duncanson and Gabrielle Houle

DRASTIC SEDIMENTATION CHANGES IN MN WATERSHED POST-EUROPEAN SETTLEMENT
Faculty mentor: Dr. Kevin Theissen

The Comfort Lake-Forest Lake Watershed District encompasses lakes located in both Chisago and Washington County, MN. Several of these lakes were deemed impaired, in part due to higher than recommended phosphorus levels. Three of these impaired bodies: Shields, Comfort, and Moody lakes, are being considered for remediation and long-term management. Before such steps are taken, however, an understanding of the lakes historical conditions needs to considered. Overlapping sediment cores were collected in February 2016 from each lake. The cores underwent several geochemical analyses, including loss on ignition (LOI), magnetic susceptibility, x-ray fluorescence (XRF), and 210-Pb age dating.

Results will focus on LOI and XRF data from the 274cm Shields Lake core. Shields Lake is particularly impaired, with monitored total phosphorus concentrations around 336 μg/l.

LOI results from Shields Lake show an increase from 48% to 73% (dry weight) in deposited organic material occurring around 142cm sediment depth. Shields XRF results show a significant rise then fall in
concentrations of Fe and Mn occurring between 156-200cm. In the same interval, K and Ti concentrations rise.

These results reflect environmental changes that have occurred around Shields Lake within the 274cm sediment interval. LOI data indicates either an increase in the amount of biologic material being deposited into the lake and/or decreases in the amount of land-based material depositing. Although interpretations of XRF data on Mn and Fe are influenced by multiple factors such as redox conditions and weathering + erosion, their spikes in concentration are more likely increases in the latter, or a possible different sediment source. The rise in K and Ti concentration after their brief decline is also suggestive of an increase in terrestrial material, triggered from a possible erosional increase near the lake.

These changes in the lake sediment are likely related to land-use changes caused by European settlement.

Patrick Fisher
THE METAPHYSICAL IMPLICATIONS OF MATHEMATICAL EXPLANATION IN SCIENCE
Faculty mentor: Dr. Thomas Feeney

Where does mathematics come from? What is mathematics really about? Is mathematics something we discover, or something we invent? Historical figures such as Plato and Aristotle as well as more contemporary authors have attempted to answer these questions, and my project brings these views to bear on a specific way in which mathematics is applied: mathematical explanation. Mathematics seems to have this peculiar property of being distinctively explanatory of certain physical phenomena. I consider two cases studies of this phenomenon, that of the bee’s hexagonal honeycomb and the cicada’s prime life-cycle. For both of these animals, the ideal property reached through evolution can, in fact, be mathematically calculated! Geometrically, hexagons have been proven to maximize the perimeter to area ratio (thus being the most efficient shape to use less wax to store more honey) and algebraically, it is easy to prove that prime numbers minimize intersection with other numbers (thus being the most effective way to avoid intersection with the life-cycles of predators). So-called Platonists, who are on the ‘discovery’ side of the discovery/invention debate, have seen this phenomenon as strengthening their view, while ‘nominalists’, those on the ‘invention’ side, have attempted to show how these examples can be made sense of without objectively existing mathematical objects. I argue, however, that neither view can adequately explain mathematical explanation. The nominalist is unable to accommodate the necessity of mathematical claims (since they posit no mathematical objects to ground such claims), and the Platonist is unable to explain the bridging of such necessity to the physical world (since their mathematical objects are non-physical, separate abstract objects). An Aristotelian philosophy of mathematics, however, positing mathematical objects that are both universal and physical, and thus claiming that discovery and invention are simultaneous, is able to explain mathematical explanation.

Anna Folska
ANALYZING THE DIFFERENT MEMBRANE INTERACTIONS OF CELL-PENETRATING PEPTIDES
Faculty mentor: Dr. Lisa Prevette

Cell penetrating peptides (CPPs) efficiently enter cells while transporting proteins, drugs and other cargos. Pep-1, a 21-residue amphiphilic CPP, traffics cargo to the nucleus once inside. It is known for its fast and strong membrane interaction, superior delivery rates and low toxicity. Pep-1 is thought to directly penetrate cell membranes instead of using an endocytosis pathway, which could lead to higher internalization rates and efficiency of attached drugs due to not having to escape endosomes. Tat (transactivating transcription factor) peptide is an 11-residue CPP that has been widely used to deliver covalently and noncovalently attached cargo to multiple cell lines and in vivo. It has been shown to enter
cells via energy-dependent endocytosis. Tat peptide is non-structured, with 8/11 residues being arginine or lysine, providing dense positive charge.

The interaction between these CPPs and lipid membranes is being studied using isothermal titration calorimetry (ITC). Results showed that Tat binds negative lipid (POPG) membranes but not neutral (POPC) ones, suggesting an electrostatic mechanism. This conclusion was confirmed by altering the salt concentration in the buffer solution, where a decrease in affinity was observed. Pep-1, however, was shown to bind both POPC and POPG, suggesting hydrophobic forces may play a role. With these results, the nature of binding between these CPPs and model membranes can be determined, which hopefully sheds light on the different cell uptake mechanisms.

Will Frost
HOW TO MAKE A TORNADO: SASAKI'S ENTROPIC BALANCE TORNADOGENESIS
Faculty mentor: Dr. Doug Dokken

I researched Dr. Y.K. Sasaki's entropic balance theory this summer. The theory was developed to make numerical modeling of tornadic supercells easier, which would allow higher-resolution models with greater predictive power. It does so in two ways: providing a new way to examine tornadic behavior, and providing new metrics for supercell development. Additionally, the mathematics and physics used by Sasaki suggest the existence of a mathematical attractor behind tornadogenesis. My paper primarily examined the math and physics behind that attractor, justifying its existence, then expanded it by analyzing the Smale-Williams Attractor as the next stage in finding the shape of that attractor.

Hannah Ganzel
BINDING AFFINITY OF PAH-COATED AU NANOPARTICLES TO GRAM POSITIVE BACTERIAL CELL WALLS
Faculty mentor: Dr. Lisa E. Prevette

With their potential in drug delivery, imaging, and sensing, engineered nanoparticles are a fast-growing and beneficial novel technology. Their surfaces are often functionalized for stability and/or enhanced cell interactions, but the effects of these different coatings on the environmental impact of the nanoparticles are largely unknown. Polyallylamine (PAH)-coated Au nanoparticles are known to be toxic to gram-positive bacteria, likely by attaching to the cell wall at one of three locations; the lipid bilayer, the peptidoglycan layer, or the lipoteichoic acids. A study was done in order to determine where on the gram positive cell surface PAH-coated Au nanoparticles (PAH-AuNPs) bind. Due to strong electrostatic interactions between the positively charged PAH polymer and the negatively charged lipoteichoic acids, it was hypothesized that the PAH coating on the nanoparticles would cause them to bind to this site with the highest affinity. Binding studies were performed using isothermal titration calorimetry (ITC). The results showed no binding of PAH to model lipid bilayers or peptidoglycan, and no binding of PAH-AuNPs to model lipid bilayers or lipoteichoic acids. Peptidoglycan pull down assays show binding of PAH to peptidoglycan so further studies on this interaction are needed for confirmation. Binding of PAH to lipoteichoic acid was observed, as expected, demonstrating the importance of charge in the cell surface interaction with bacteria.
Zachary George

STABLE ISOTOPES REVEAL NICHE SEPARATION AMONG THREE PISCIVORES IN A NORTHERN MESOTROPHIC LAKE

Faculty mentor: Dr. Kyle Zimmer

The piscivorous Muskellunge (Esox masquinongy), Northern Pike (Esox lucius), and Walleye (Sander vitreus) have strong influences on trophic structure and energy flow in North American lakes. All three species are popular gamefish with both recreational and economic value, often coexisting in individual lakes either naturally or through stocking efforts. Given the high degree of piscivory in all three species, there is high potential for interspecific competition and niche overlap. However, despite their ecological and economic importance, the degree of niche overlap among these three species is poorly known. We assessed niche overlap by measuring the stable isotopes $^{13}$C and $^{15}$N in Walleye, Muskellunge, Northern Pike, and their potential prey fish in Elk Lake, Minnesota. Results indicated three general groups of prey fish based on $\delta^{15}$N and $\delta^{13}$C levels. Cisco (Coregonus artedi) had high $\delta^{15}$N and low $\delta^{13}$C due to its deep-water, pelagic niche. Mixed-diet fish had high $\delta^{15}$N due to higher levels of piscivory and also high $\delta^{13}$C due to its more littoral niche. Planktivorous had low $\delta^{15}$N from feeding on aquatic invertebrates and high $\delta^{13}$C due to their littoral niche. The three piscivore species we evaluated appeared to have significantly different diets and niches, each focusing to a greater extent on one of the three groups of prey fish. Overall, Muskellunge had significantly lower $\delta^{13}$C than both Northern Pike and Walleye, while Northern Pike had significantly lower $\delta^{15}$N compared to Muskellunge and Walleye. This indicates Muskellunge prey more heavily on pelagic Cisco and Walleye feed more heavily on mixed-diet fish, while Northern Pike feed on a mix of mixed-diet and planktivorous fish. Our results indicate the response of Walleye, Northern Pike, and Muskellunge to changes in prey fish abundance will depend on the specific species of prey fish in lakes. Of particular concern is the reliance of Muskellunge on Cisco, as Cisco populations are threatened by eutrophication and climate change. Our results indicate Muskellunge would be impacted most by reduced abundance of Cisco, potentially forcing Muskellunge to alter their niche and compete more directly with either Walleye or Northern Pike.

Madison Gonsior

THE SECRETED PROTEIN SLIT IS REQUIRED FOR PROPER LCH5 CHORDOTONAL NEURON MORPHOLOGY AND MIGRATION IN THE DROSOPHILA PNS

Faculty mentor: Dr. Afshan Ismat

Cells migrate along pathways to their target during embryogenesis, responding to different repulsive and attractive cues in their environment. The slit-robo signaling pathway is a repulsive cue that repels axons away from the midline of the central nervous system (CNS) via Robo, a transmembrane protein, and Slit, a secreted protein in the extracellular matrix (ECM). In normal development, the lateral chordotonal neurons (lch5) repel away from the midline of the CNS while migrating laterally during stages 15-17. The absence of slit showed a change in the migration patterns. The lch5 neurons migrated more dorsally and were not aligned properly. The morphology of the lch5 neurons was also altered when slit was absent. The neurons tended to: not be shaped in a teardrop shape, not interacting with each other properly, and their dendrites were pointing in various directions. The migration patterns of sensory neurons can be in part due to proteins and substrates present in the ECM, around the cell membrane or other cues in the environment causing a defect in the slit mutant embryos.
Will Goodwin
DO GRATIFIED PEOPLE MAKE BETTER ECONOMIC DECISIONS? THE RELATIONSHIP BETWEEN GRATITUDE AND ECONOMIC CHOICE
Faculty mentor: Dr. Greg Robinson-Riegler

DeSteno, Li, Dickens, and Lerner (2014) found that priming feelings of gratitude enhances the ability to wait longer for a larger payoff, a reduction in so-called economic impatience or temporal discounting. Gratitude differs from other positive emotions and human traits such as happiness, in that it is socially oriented in nature. Happiness shows no connection to higher patience, showing that simply the positive valence of an emotion doesn’t affect patience (DeSteno et al., 2014). We investigated whether the relationship between gratitude and patience extends to trait gratitude. Participants completed questionnaires assessing subjective happiness, trait gratitude, and temporal discounting. We found a relationship between gratitude and patience, but it was limited to only one dimension of gratitude (sense of abundance) and the relationship was limited to men. We found no relationship between happiness and patience. Our findings replicate previous findings of relationship between gratitude and patience, and add gender as an important individual difference to consider.

Steven Guillemette
FREE WILL AS PARSIMONIOUS AGENT CAUSATION
Faculty mentor: Dr. Timothy Pawl

Free will and moral responsibility share an intricate relationship. Whether we deem an agent as morally praiseworthy or morally blameworthy depends, in part, on whether or not the act was “performed freely”. However, numerous difficulties emerge when one tries to articulate what “performed freely” entails: one must not only provide an account of free will with reference to its nature, he or she must also take into consideration its compatibility, or lack thereof, with existing and/or potential features of the world. Ultimately, this paper attempts to do just that, to provide an account of free will that is both coherent and naturalistic. Consequently, I argue that such an account be contrived under the umbrella of agent-causal libertarianism using the mechanics of quiescence.

Madeline K. Hankard
DIRECT PHOTOLYSIS AND PRODUCT TO PARENT REVERSION OF THE STEROID DIENOGEST
Faculty Mentor: Dr. Kristine H. Wammer

Dienogest is a progestin that is used in combination with other molecules for hormonal contraception (sold under trade name Natazia ®) and by itself to treat endometriosis. Dienogest, like many other pharmaceuticals, is not fully metabolized in the body, is excreted, and ends up in freshwater environments. When dienogest reaches the environment, it is exposed to sunlight and photodegrades into photoproducts. Interestingly, during dark conditions, the photoproducts revert back to the parent molecule. We have found that dienogest degrades slower in acidic conditions than basic conditions. Regeneration is near instantaneous in acidic conditions, but dienogest regenerates to the greatest extent in pH 5. Based on NMR data that comes from collaborators at the University of Iowa, it is suspected that two photoproducts have an aromatic A ring and are therefore likely biologically active. To confirm and quantify biologic activity, we are collaborating with the Martinovic lab of the University of St. Thomas Biology department to run estrogen assays. A preliminary assay shows measurable estrogenic activity for both dienogest and photoproducts, but further assays are necessary.
Nick Hayes
EXPLORATION OF MENTHOL AS A RENEWABLE FEEDSTOCK FOR POLYMER SYNTHESIS
Faculty mentor: Dr. Eric H. Fort

Society today has a huge dependency on plastic; we use it every day in bottles, bags, and various other forms. The majority of plastics that are produced each year come from petroleum. The problem is that someday there will not be any petroleum left, and we will still need plastic. The goal of our research is to find a renewable source to make plastic. Specifically, we want to find out if Menthol (derived from mint leaves) can be used to create a stable plastic. The first step of our research is converting Menthol into a new target molecule. This molecule is much more likely to polymerize and form plastic. Once this step is completed, we will add a catalyst in order to expedite the new molecule to form plastic. The more we understand about how plastics are made using plant derived feedstocks, the closer we will be to finding a renewable source to make plastic.

Rachael Heier
INITIAL EFFECTS OF ASSISTED COLONIZATION ON THE SURVIVAL AND GROWTH OF OAK SEEDLINGS IN A RESTORED FOREST ECOSYSTEM (SOUTH WASHINGTON OAKS PROJECT)
Faulty mentor: Dr. Simon K Emms

Increasing carbon emissions and other pollution have caused climate change to become an ever growing threat to this world and those that inhabit it. The changing climate could pose a substantial risk to biodiversity, as environmental effects cause native species that were once fit for an environment to be no longer suited for it. Any species that can't adapt quickly to the changing environments, mainly those unable to swiftly migrate or with long generation spans that prevent rapid adaptation, are at risk of extinction as the world grows warmer. Integrated conservation efforts have started to develop to help mitigate these issues, one of these new techniques being assisted colonization. In the fall of 2015, approximately 900 oak seedlings of two different ecotypes, either native to a Twin Cities location or from a location in Iowa, were planted at the South Washington Oaks Project in Woodbury and Cottage Grove, MN. In this long-term study, the two ecotypes will be compared in order to judge the effectiveness of assisted colonization as a conservation strategy for the restoration of a forest ecosystem. This past summer of 2016, we took measurements of the first year of growth in the seedlings, including plant fate, survival, and physical aspects such as stem diameter, old, new and total growth heights, number of live stems, number of leaves, and average leaf area. Here we compare and analyze the data from the initial year of the project and use it to determine a baseline for the future data collected that will allow for a conclusion on whether or not assisted colonization can be a viable option for future restoration projects.

Carlee Heiling
QUANTIFYING CULTIVATABLE ANTIBIOTIC-RESISTANT BACTERIA IN MINNESOTA DRINKING WATER
Faculty mentor: Dr. Kristine Wammer

In recent years, there has been a growing concern regarding the capability of bacteria to become resistant to antibiotics, and the environment is one possible route for propagation of this resistance. In this study, our particular focus was potential impacts associated with drinking water. The specific goal of this study was to determine the levels of antibiotic resistance in St. Paul and Minneapolis tap water. About 1500 L of tap water was filtered through a AsahiKASEI hemodialyzer membrane and the bacteria were subsequently backflushed from the membrane. The bacteria were grown on R2A or iso-sensistest broth (ISB) media amended with high and low concentrations of five different antibiotics and incubated at room temperature. The cultivatable antibiotic-resistant bacteria from these tap water samples were
then observed and compared to the antibiotic resistance genes quantified from earlier samples. The Minneapolis sample had more bacteria that exhibited more antibiotic-resistance-like behavior than St. Paul’s for all but one antibiotic, which correlates well with the genetic data previously collected. However, only one sample from each site has been collected and successfully analyzed thus far, so more samples and data are needed to confirm the results.

Emily Heimerman, Quinn Blattner, Mara Cavanaugh, Courtney Eickhoff and Margaret R. Misey
ARCHAEOLOGY OF A ROMAN VILLA ON SVETI KLEMENT, CROATIA
Faculty mentor: Dr. Ivančica Schrunk

This summer we worked on an archaeological dig site named Soline on the southern side of Sveti Klement, a Croatian island in the Adriatic Sea. During this dig, we found: mosaic tesserae, pottery, glass, metal and bone fragments and three Roman coins. The finds range from the era between 200 B.C. – 500 A.D. The site was a Roman villa, that is a rural estate, built along the bay. The size and location of the structures indicate a complex of several buildings that were used for agricultural production and residential function. This was the tenth year of the collaborative Croatian-American. This season a team of German archaeologists assisted with drone aerial photography and electrical resistivity survey of underground structures. The location of the trenches dug this year was decided using information from geophysical survey and excavation, gathered during previous years. Roman walls began appearing about 0.5 meters below the surface. The goal of our search this year was to continue exploring the production sector of the villa. We discovered a round stone foundation, perhaps used for a wine or oil press. It was located next to a basin with waterproof mortar floor. All of the findings from the dig were transported from Sv. Klement to the Hvar Heritage Museum and have been undergoing further examination.

The information we continue to uncover over these ten summers along with artifacts gathered this year will be one more step in the journey to uncover the Roman history that Soline holds. This dig not only furthered our own personal education, but also unearthed and provided insight into the way of life on this island.

Luc Henke
UTILIZING THE PALEO DIET TO PROMOTE MELATONIN PRODUCTION AS A NATURAL TREATMENT FOR DEPRESSION
Faculty mentor: Dr. Jerry Husak

This study identifies how the Paleo diet influences an individuals melatonin levels. Individuals suffering from mental disorders, such as depression, often exhibit irregular melatonin profiles. A diet high in protein, which includes elevated levels of the amino acid Tryptophan, has the potential to elevate melatonin levels. Therefore, we hypothesized that individuals placed on a Paleo diet for a 6-week period would display melatonin profiles that resemble “healthy” levels compared to a control group who eats a Western style diet. The results of the study showed a 8.969pg/mL increase in salivary melatonin in those individuals consuming a Paleo style diet. Peak salivary melatonin levels in Paleo dieters reached 30.111 pg/mL, compared to the initial 21.142 reported in the Pre screening samples. Therefore we can conclude that while consuming a Paleo diet can have health benefits such as improved sleeping patterns and increased melatonin levels, solely consuming Paleo food choices is not sufficient treatment for those suffering from low melatonin levels or mental illnesses such as depression.
UNDERSTANDING CARBON EMISSIONS FROM PRAIRIE POTHOLE REGION WETLANDS

Faculty mentor: Dr. Leah Domine

This project was aimed to gain understanding in methane flux on wetlands in the Prairie Pothole Region. Wetlands are a large source of methane to the atmosphere, and evidence from this investigation yields important data on the flux magnitudes and the source of carbon, which is largely unknown in this region. The project was formulated to have several components – to quantify methane efflux from three wetlands within the Prairie Pothole Region, analyze the variability of methane flux from each, and determine the source of carbon being respired by the system. Floating chambers were utilized over four field deployments throughout the summer to estimate methane efflux at multiple locations from the lakes. A rarefaction analysis will be done to determine the number of sites on a wetland needed to be sampled in order to obtain an accurate methane efflux estimation, and the identification of the carbon source will be done through Accelerator Mass Spectrometry (AMS). The algae-dominated lake had the highest magnitudes of methane fluxes, while the submerged plant-dominated lake was significantly less, and the microalgae-dominated lake was the lowest. The range of average methane flux for the summer from the algae-dominated lake was 161-475 mg m⁻² d⁻¹, the submerged plant was 7-109 mg m⁻² d⁻¹, and the macroalgae was 3-103 mg m⁻² d⁻¹. Overall, the mid-summer sampling dates had the largest magnitudes of fluxes than the later sampling dates, which was true for all three different wetlands. The rarefaction analysis would allow a number of sites required to be monitored to be determined, which would improve sampling efficiency and maximize time. The radiocarbon analysis identifies the age of the carbon, meaning it has the potential to identify a new source of carbon – if old carbon is identified, it is likely that a terrestrial source of carbon is augmenting the system.

RECONSTRUCTING THE DEPOSITIONAL HISTORY AND PALEOCLIMATE OF LOWER PAHRANAGAT LAKE IN THE LAKE MEAD REGION OF NEVADA

Faculty mentor: Dr. Kevin Theissen

The Lower Pahranagat Lake (LPAH) is a shallow alkaline lake located in the Pahranagat National Wildlife Refuge in southeastern Nevada. LPAH is significant to paleoclimate research of the Great Basin region because it is a natural and long-lived lake, which is rare for the region that spans several arid southwestern states. Previous core collection by UST faculty and students involved a sediment record going back 2400 years (Theissen et al., 2013). However, cores collected by Peter Wigand (1997) in 1988 and 1993 have established that the sediment record extends at least 5600 years. Wigand's research focused entirely on plant pollen and plant microfossils over the last 3800 years, so not much is known about the geochemical characteristics of the core sediments. These sediments provide a check on previous work and additional information on past climate and hydrological change in the Great Basin. Thanks to the construction of a new coring system, in March 2016 we were able to core more than three times as deep as we previously had in LPAH, allowing us to look at multiple climate proxies that will likely represent the full lake record. Over the summer of 2016 I described and characterized the core sediments and ran an elemental analysis of core sediments to identify carbon, nitrogen, and calcium carbonate contents of the core. I am currently in the process of preparing samples to collect isotopic data on carbon and oxygen from carbonates. This fall we will continue analyzing the core using radio-carbon age dating to determine the age of different core sections. In addition, I will use x-ray diffraction (XRD) and scanning electron microscopy (SEM) to determine the mineralogy of the cores. This will allow us to identify the water chemistry of the lake at the time of sediment deposition, identifying changes in hydrology.
Kiersten M. Idzorek
TOWARD SOLID-STATE REACTIONS BETWEEN NITRILE OXIDES AND NITRILES
Faculty mentor: Dr. William H. Ojala

Nitrile oxides are useful in the synthesis of heterocyclic compounds by means of 1,3-dipolar cycloaddition reactions; for example, reaction of a nitrile oxide with a nitrile in solution leads to the formation of 1,2,4-oxadiazoles. We are examining the possibility that nitrile oxides might be capable of co-crystallization with nitriles and that subsequent solid-state cycloaddition might yield a heterocyclic product different from that obtained upon reaction in solution (1,2,5-oxadiazole vs. 1,2,4-oxadiazole). Success of this approach requires a nitrile oxide sufficiently reactive to undergo cycloaddition with a nitrile but not so reactive that it reacts with either the nitrile or with itself (by dimerization) before the incorporation of both components into the crystal. Success also requires an overall similarity in molecular space-filling requirements between the components to allow formation of mixed crystals (solid solutions). Our observation that several nitrogen-containing heterocycles assume crystal structures isomorphous with their corresponding N-oxides suggests that nitriles may be capable of co-crystallization with their corresponding nitrile oxides. Having determined the crystal structure of the relatively hindered 2,6-dichlorobenzonitrile oxide in previous work, we have begun co-crystallization studies using 2,6-dichlorobenzonitrile oxide and 2,6-dichlorobenzonitrile and describe our initial results here. We have also by single-crystal X-ray diffraction determined the crystal structure of one of the three dimers potentially obtained upon dimerization of 2,6-dichlorobenzonitrile oxide either in solution or in the solid state, the bis(2,6-dichlorophenyl)oxadiazole-N-oxide. The crystal structure is disordered, with molecules located upon crystallographic twofold axes even though the molecules lack twofold symmetry. Future work includes developing a satisfactory model for crystallographic refinement of this disorder and determining the crystal structure of the bis(2,6-dichlorophenyl)dioxadiazine, the one dimer in the 2,6-dichlorophenyl series yet to be examined crystallographically.

Francesca M. Ippoliti
SYNTHESIS AND CHARACTERIZATION OF THREE OLEOYL PEG ORTHOESTER MICELLES FOR DRUG DELIVERY
Faculty mentor: Dr. Lisa E. Prevette

There are many considerations for the effective delivery of pharmaceuticals within the body, such as solubility, stability during circulation, targeting to specific cells, cellular internalization, intracellular trafficking and proper function once inside. These properties are determined by the chemical structure of the drug molecule. Drug delivery agents can be used to improve upon these properties by packaging the drug, providing reactive sites for targeting ligands and/or interacting with cell surfaces. Often, these delivery agents are micelles that can carry hydrophobic drugs and release their contents in a controlled way. Three new micelle delivery agents were synthesized from polyethylene glycol (PEG) and oleic acid linked through orthoesters. Orthoesters hydrolyze at varying rates in different pH environments and with different structural modifications; therefore, ring size and functional groups were varied. Characterization included determining critical micelle concentrations (CMCs) and orthoester hydrolysis rates using NMR, DLS, and spectrofluorimetry. These orthoester micelles will be further studied for their potential as a delivery agent for the chemotherapeutic doxorubicin to enhance its bioavailability and pharmacokinetics.

Ryan B. Johnson
SOLID-STATE NITRILE OXIDE DIMERIZATION: CRYSTAL STRUCTURE OF 2,3-DICHLOROBENZONITRILE OXIDE
Faculty mentor: Dr. William H. Ojala

Nitrile oxides dimerize in solution to form three possible products: a furoxan, a dioxadiazine, or a 1,2,4-oxadiazole-N-oxide. We are using single-crystal X-ray diffraction to determine whether the
molecular packing arrangement of the parent nitrile oxide determines which product is formed upon solid-state dimerization. We report here the crystal structure of 2,3-dichlorobenzonitrile oxide, formed by dehydrohalogenation of the corresponding hydroxamic acid chloride. This nitrile oxide crystallizes in the monoclinic space group \( P2_1/c \) with four molecules in general positions in the unit cell. Unlike our previously determined 4-chlorobenzonitrile oxide crystal structure, which includes close oxygen···chlorine contacts but no close chlorine···chlorine contacts, the crystal structure of 2,3-dichlorobenzonitrile oxide includes no close oxygen···chlorine contacts but does include chlorine···chlorine approaches at distances just beyond the sum of the chlorine van der Waals radii. A centrosymmetric approach between neighboring fulminate groups (also at distances just beyond the sum of the van der Waals radii) suggests that the “head-to-tail” dioxadiazine or oxadiazole \( N \)-oxide dimers might be favored in a solid-state dimerization, but the large molecular motions possible even in the solid state render this conclusion speculative. Future work will involve the identification of the actual solid-state dimerization product as well as preparation of polymorphic forms of the nitrile oxide to determine any dependence of the product obtained on the crystal structure of the parent nitrile oxide.

Morgan Kaardal

THE GERMAN GUEST WORKER PROGRAM: ITS FAILURES, ITS LESSONS AND ITS IMPACT ON THE NEW GERMAN IMMIGRANTS
Faculty mentor: Dr. Susanne Wagner

This project focuses on the Guest-worker program in Germany in the 1960s and 70s. This research examines the complexity of the early Turkish immigration, the barriers to integration of Turks into Germany, and how this failure has influenced Germany’s attitude toward new migrants, relying primarily upon academic analysis, primary documents, journalism and pop culture representations. An examination of these resources revealed that the German’s popular perception of what constitutes being German contributed to the slow integration of the Turks into the larger German society.

Evan M. Kalb

STUDY OF FLUORESCENT LIGAND INTERACTIONS ON SUPRAMOLECULAR G-DNA
Faculty mentor: Dr. Thomas C. Marsh

DNA is known to follow traditional Watson and Crick base pairing where adenine pairs with thymine and guanine to cytosine to form helical duplex DNA. In addition to this pairing, there exists a structure in which guanine binds to other guanines to form a quartet structure using Hoogsten hydrogen bonding called a G-quadruplex. Guanine-rich sequences of DNA that are able to form these G-quadruplexes have been found in telomere ends and oncogene promoter regions, hinting towards interest in cancer therapeutic strategies. G-quadruplexes can also form supramolecular DNA structures called G-wires that are formed by the spontaneous stacking of G-quadruplexes. There is interest in studying G-wires in cancerous cellular systems using fluorescent ligands to determine uptake, path, and degradation. Before tracking the G-wires, we seek to detail what the effect of fluorescent ligand binding has on the conformation of the G-wire as well as determining how ligand binding may compete with G-quadruplexes as they self-assemble into G-wires. In this study, we found an attenuation effect on higher order G-wire structures as we increased the concentrations of the particular ligand present in the self-assembly and determined the binding capabilities via fluorimetry.
Taryn Kay
HIERARCHIES IN HERDS: MODELING DOMINANCE AND SUBORDINANCE
Faculty mentor: Dr. Paul Ohmann

Within nature, the congregation of animals in the forms of herds, schools, and flocks can be seen across a multitude of different species, demonstrating that certain advantages come from aggregation. This relatively recurrent trait within the animal kingdom leads to the appearance of different patterns. This study attempts to investigate the effect of dominant and subordinate traits and how they directly correlate to repetitive behaviors within a herd of female bovine, through the use of simulations. The simulation itself will attempt to recreate these natural patterns of dominance and subordinance while depending solely on three different activity types: resting, foraging, and traveling. It will be given movement through the use of movement vectors (which take into account instinct, noise, and overall herd movement) and an avoidance factor (which accounts for subordinate animals distancing themselves from dominant individuals). Thus, the simulation will display the characteristics needed to accurately represent an authentic herd, along with allowing a closer look at the driving forces behind the different patterns that emerge in nature due to dominance.

Jillian Kolasinski and Whitney Lloyd
IDENTIFICATION OF NONRIBOSOMAL PEPTIDE SYNTHETASE (NRPS) ENZYMES TO FIND NATURALLY OCCurring PHARmaceuticals
Faculty mentor: Dr. Justin Donato

The widespread use of antibiotics is crucial for the treatment of illnesses however the prolonged use and occasional overuse of these pharmaceuticals has caused a global epidemic due to antibiotic resistance. Antibiotics are efficient at killing certain strains of bacteria, but over time natural selection causes the resistant strains of bacteria to emerge as the dominant variety. With the use of sequence-based metagenomics, a method used to screen the genes of unculturable bacteria, molecules with pharmaceutical importance can be discovered. Many of these molecules are products of the secondary metabolites nonribosomal peptide synthetase (NRPS) enzyme, which uses a non-traditional, modular method to assemble molecules. Products of NRPS enzymes have shown antibiotic, antitumor and immunosuppressant properties. Discovery and identification of NRPS enzymes could lead to the discovery of novel products with pharmaceutical relevance. Isolation of NRPS enzymes was initiated through culture dilutions of metagenomic libraries followed by amplification of conserved DNA domains via polymerase chain reaction (PCR). Gel electrophoresis, restriction digest and sequence confirmation were used to verify the PCR product. One NRPS enzyme from the Cambridge Municipal Wastewater Treatment Plant metagenomic library was confirmed through sequencing. Fifteen potential NRPS enzymes from a Wisconsin Apple Orchard and the Cambridge Wastewater Treatment Plant are awaiting sequence confirmation. Positive amplifications of these enzyme domains indicated successful methods and potential candidate pools for novel NRPS enzymes whose products could be a future pharmaceutical.

Samantha Leibold
ROLE OF ADAMTS-B IN TRACHEAL CELL MIGRATION DURING DEVELOPMENT
Faculty mentor: Dr. Afshan Ismat

The protein AdamTS-B is a known extra cellular protease. This protein is believed to help in cell migration during development. It is found in the trachea, respiratory system in Drosophila, more commonly referred to as the fruit fly. AdamTS-B is closely linked to 6 human proteins. By studying this in flies we can understand more about how human lungs branch and develop during gestation. Studying this protein and how it aids in cell migration could also help us to understand how cancer cells metastasize and spread from one part of the organ to another.
Tyler Lifke
AN EDUCATION IN ADVERSITY: THE IMPORTANCE OF SELF-REGULATORY PROTECTIVE FACTORS IN YOUNG ADULT RESILIENCE
Faculty mentor: Dr. John Buri

As adversity has increased in frequency and intensity in recent decades, resilience, an advantageous adaption to adversity, has gained greater importance. Research into resilience has found that there are three categories of traits that are associated with resilience: (a) demographic factors, (b) risk factors, and (c) protective factors. Of these, protective factors have shown the largest effect sizes on resilience. The present study focused on three potential protective factors: (a) Self-Evaluations, (b) Self-Control, and (c) Perceived Control of Internal States. Each of these yielded strong positive correlations and large effect sizes, but did not show moderating effects on resilience. These three factors explained 60% of the variance in resilience in the 25% highest adversity population. This finding shows strong support of the importance of Self-Evaluations, Self-Control, and Perceived Control of Internal States in resilience and should be considered for intervention-based studies.

Kha Lor
THE PREDICTION OF POSTTRAUMATIC STRESS SYMPTOMS AND QUALITY OF LIFE AMONG VETERANS WHO SERVED IN IRAQ AND AFGHANISTAN
Faculty mentor: Dr. Brian E. Engdahl, Department of Neuroscience, University of Minnesota

The prevalence of posttraumatic stress disorder (PTSD) diagnosis in veterans returning from the wars in Iraq and Afghanistan are high, resulting in a worsening of their quality of life. This study sought to investigate and identify risk and protective factors—pre-deployment, deployment, and post-deployment—of increased PTSD symptom severity (PTSS) and inversely, decreased non-mental health quality of life (QOL) in this population. Specifically, childhood family dynamics, educational level, warzone perceived threat, warzone living conditions, post-deployment social support, and lifetime exposure to potentially traumatic events (PTE) were evaluated as predictors of the outcome variables PTSS and QOL. Two hundred sixty-five veterans completed and returned self-report questionnaires an average of six months post-deployment. A structural equations model (SEM) that specified predictive relationships and interplay among variables was developed with excellent fit characteristics. Warzone perceived threat and living conditions were found to be risk factors for both PTSS and decreased QOL. Lifetime PTE strongly predicted PTSS. Both childhood family dynamics and educational level were directly associated with enhanced QOL, while social support was directly associated with PTSS. The SEM also demonstrated that childhood family dynamics, and warzone perceived threat and living conditions exerted indirect effects upon PTSS mediated by social support. All the examined variables were statistically significant risk or protective factors for one or both of the outcome variables, with warzone perceived threat and living conditions accounting for the greatest variance. Demonstrating the roles of risk and protective factors can help refine treatments, and improved pre-deployment screening can help guide efforts to enhance resilience to traumatic exposure.

Samuel M. Madden
SEARCH FOR A NOVEL SPIROCYLE FROM BIS(TOLAN)AMINE
Faculty mentor: Dr. Eric H. Fort

Spirocycles have been of interest to chemists for more than a century. In 1900, Adolf von Baeyer, a German chemist, who would later receive the Nobel prize for Chemistry in 1905, synthesized a spirocycle. This compound was described as a bicyclic compound with rings connected through a single atom. Due to the tetrahedral nature of the atom connecting the two rings; the two rings are nearly perpendicular to each other. Much attention has been given to the synthesis of spirocycles with chiral carbon centers connecting
Nitrogen containing spirocycles have been shown to play fundamental roles in biological processes and have shown important pharmacologic activity. The research conducted focused on some of the first attempts at the formation of a spirocycle containing a nitrogen tetrahedral center from a compound previous synthesized in lab, Bis(tolan)amine.

Bridget McGivern

INVESTIGATING THE DIVERSITY OF ANTIBIOTIC RESISTANCE GENES IN WASTEWATER BACTERIA EXPOSED TO TRICLOSAN
Faculty mentor: Dr. Justin Donato

Many household products, such as toothpastes and hand soaps, contain the antibacterial agent triclosan. When these products are used, triclosan washes down the drain and ends up in the municipal wastewater treatment system, where activated sludge bacteria are exposed to it. The goal of this project is to assess the impact of exposure to sub-lethal doses of triclosan on the antibiotic resistance profiles of bacteria in a simulated wastewater treatment system. Samples of activated sludge bacteria were obtained from a full-scale treatment facility. Bacterial cultures were prepared from this activated sludge, and grown in triplicate in a synthetic wastewater medium with triclosan concentrations of 0, 1, 5 or 15 µg/L. After seven weeks of growth, fosmid libraries were constructed from each culture. Antibiotic selection was carried out on Luria Bertani agar plates supplemented with antibiotics from the major classes. Unique resistant clones were identified, and their antibiotic resistance profiles were quantified through minimum inhibitory concentration (MIC) assays. At present, 29 resistant clones have been isolated from various libraries. These clones represent resistance to six of the thirteen antibiotics that were tested. Of these clones, two are resistant to multiple antibiotics: one is resistant to different β-lactam antibiotics, while the other is resistant to carbenicillin and rifampicin. Some preliminary sequencing has been done in order to determine the mechanism of resistance possessed by the clones, but more extensive analysis needs to be done before any conclusions can be drawn.

Joseph G. Molohon

EVE AND GENESIS: THE HISTORY AND POWER OF A STORY
Faculty mentor: Dr. Martin Warren

My project is an exploration of Eve's changing role within Genesis and within human history. Our perceptions of Eve and our interpretations of the Bible have changed greatly over the course of their extensive shared history, and the intention of my project is to explore the dynamics of this changing relationship. It is the hypothesis of my project that is the give-and-take of the reader and the writer that primarily affects our interpretation of any given work (with the Bible being a major example), and it cites many works of literature as examples and paragons of this change.

Certain works of literature at certain time periods represent certain perspectives of Eve popular during their era. In the same way that Milton's Paradise Lost represents the misogyny of earlier interpretations of Eve, more contemporary works like The Passion of New Eve by Angela Carter represent the more open-minded, humanistic approach taken towards Eve and the Bible in modern times. My work is concerned not only with proving the existence of these intertextual connections, but also with giving the reader some idea of their power.

The Bible, as a literary work, has gone through many phases and changes. This is both literal; in the sense that the Bible has many editions; and figurative; in the sense that it exists in different forms within our minds as well. In exploring Eve's especially problematic role within the Bible, we can come to a stronger realization of this change and how this change comes about. The end goal is a better understanding of the Bible and the process of its interpretation, as well as a deeper appreciation for the power of any literary work.
Maria K. Neuzil
STRUCTURES AND PROPERTIES OF CRystalline BENzonitrile oxides
Faculty mentor: Dr. William H. Ojala

Nitrile oxides are compounds containing the fulminate group, composed of a carbon atom triple bonded to a nitrogen atom that is single bonded to an oxygen atom. These compounds are useful in solution reactions, particularly in 1,3-dipolar cycloadditions, but their solid-state properties and reactivity have been understudied. We are interested in examining the parent nitrile oxide and its three possible solution-phase dimers — the furoxan, the dioxadiazine, and the 1,2,4-oxadiazole-N-oxide — to see if there is a correlation between the product of the solid-state dimerization and the packing arrangement of the parent nitrile oxide. We have obtained the infrared spectra of a selection of nitrile oxides and their dimers, including 4-nitrobenzonitrile oxide and 2-chlorobenzonitrile oxide, which indicate that we have successfully synthesized these parent nitrile oxides and also potentially a corresponding oxadiazole-N-oxide. To confirm these results, samples have been submitted for analysis by single-crystal X-ray diffractometry. Our ongoing work will include obtaining a complete set of solid-state molecular packing arrangements (crystal structures) for the parent nitrile oxides and their dimers in the 2-nitrobenzonitrile oxide, 3-nitrobenzonitrile oxide, 4-nitrobenzonitrile oxide, and 2-chlorobenzonitrile oxide series.

Whitney Oachs
“WHITE MAN’S FREEWAY”: HIGHWAY CONSTRUCTION AND PROTEST POLITICS DURING 20TH CENTURY TWIN CITIES
Faculty mentor: Dr. David Williard

In summary, what “White Man’s Freeway” attempts to do is link Minneapolis and St. Paul into a national context of highway construction and the displacement of black communities, as well as analyze the protest politics that followed. What were instances of black neighborhoods being targeted by the Minnesota Highway Department? How did residents react to their sudden loss of community? Did the freeways set the stage for a new age of geographic segregation and racial injustice? Have the Twin Cities atoned for their actions? All of these questions are integral to understanding the legacies and consequences of highway development through urban areas of color in Minneapolis and St. Paul in the 20th century.

For example, in St. Paul, the historic black Rondo community was decimated by the construction of interstate 94, which linked downtown Minneapolis to downtown St. Paul. By cutting through the economic district and displacing many family homes, the interstate had disastrous impacts on Rondo residents’ generational wealth, sense of belonging, community culture and socialization. Suddenly, what once was a cohesive community was a plethora of streets and neighbors-past, separated by a vast, roaring highway.

Minneapolis also suffered from the effects of highway construction. Both North Minneapolis and Downtown East were and are neighborhoods made up of primarily people of color, and were in 1935 deemed “slums” “negro sections” and an area of “foreign borns.” The construction of I-94 from Brooklyn Center to Minneapolis went right through North Minneapolis, with interstate 35W doing the same through Downtown East, and bisecting two communities already suffering from disinvestment and institutional racism.

Jessie O’Brien
VARIATION IN THE RATE OF PHOTOLYSIS OF THE STEROID GESTRINONE IN THE PRESENCE OF SODIUM AZIDE
Faculty mentor: Dr. Kristine Wammer

The widespread use of steroids by humans and livestock has raised concerns about their presence in the environment. Because steroids are not fully metabolized, various concentrations of biologically active
steroids can be found in surface water. Many of these steroids are classified as dienones (like gestrinone) and trienones. These structures allow the steroids to absorb sunlight and break down into different photoproducts by the process of direct photolysis. As steroids enter the environment they may also interact with a series of reactive species that additionally contribute to the steroids' photodegradation. One fundamental class of reactions that occurs in our environment is nucleophilic attack. In order to better understand the environmental fate of steroids, it is necessary to understand the role nucleophiles have on photolysis in various conditions. In this study, we focus on the steroid gestrinone in the presence of the electron rich nucleophile sodium azide. Gestrinone is a synthetic progestin that is used to treat endometriosis. It is sold under the trade name Dimetriose®. The objective of this study was to examine the rate of photolysis of the steroid gestrinone as well as its photoproducts in the presence of different concentrations of sodium azide at pH 5 and 9. It was found that in the presence of sodium azide gestrinone is transformed into two different photoproducts during photolysis at both pH 5.00 and 9.00. The rate of photodegradation of gestrinone increases as the concentration of sodium azide increases at pH 5.00 while at pH 9.00 the concentration of sodium azide has little effect on the rate of photodegradation of gestrinone.

Tyler Ogorek, Maya Audi and Josiah Bardwell
SYNTHESIS OF A NOVEL OXAZOLIDINONE ANTIMICROBIAL AGENT
Faculty mentor: Dr. J. Thomas Ippoliti

New drugs are needed to combat the growing problem of antibiotic resistance. In 2001, Linezolid, trademarked Zyvox, received FDA approval and went to market. Linezolid is a member of a class of compound known as oxazolidinones, which have been observed to have very high antibacterial activity. After Linezolid's success, Dr. J. Thomas Ippoliti Synthesized an analog to Linezolid, called Ippoliti R1, which turned out to have even higher antimicrobial activity against certain strains, particularly tuberculosis. This poster deals with the synthesis of novel oxazolidinone derivatives based off of the Ippoliti R1 molecule. The functional groups contained within these derivatives include a carboxylic acid, two distinct amides, an aldehyde, and an entirely new fused ring system. These derivatives are currently unfinished and at different points in their respective syntheses. All intermediates have been characterized by NMR spectroscopy.

Oliver O'Keefe
KNOT TYPE CHANGES AFTER QUANTUM TUNNELING EVENTS
Faculty mentor: Dr. Eric Rawdon

Glueballs are subatomic particles, which are hypothesized to take the shape of tightened knotted and linked uniform-radius tubes. Under this hypothesis, one of the ways that glueballs could decay is via quantum tunneling events. In such an event, the tube fully passes through itself at a random self-contact along the tube. The goal of this research is to determine all of the possible knot type changes that can occur from quantum tunneling events in model glueballs.

Justin Roche
CYTOTOXICITY OF GRO-13 G-WIRES IN HeLa CANCER CELLS
Faculty mentor: Dr. Thomas Marsh

In comparison to B-DNA, which has characteristic Watson-Crick base pairing and is a double helix, G-DNA is composed of multiple Guanine repeats able to bond to each other via Hoogsteen hydrogen bonding. G-DNA is able to self-assemble into quadruple helical structures, composed of
G-quartets. Oligonucleotides of G-DNA (GROs) can self-assemble into higher order, supramolecular polymers. These polymers include G-wires (1), which are used in this research, assembled from GRO-13 (5'-GGGGTGGGG 3'). G-wires are stabilized by certain monovalent and divalent cations that are depended on for formation and are important for preventing denaturation (1). Higher levels of G-DNA have been correlated with cancer cells (2). It has been found that some motifs of G-DNA in cancerous cells are similar to those of G-wires. These motifs are located in the promoter region of oncogenes and in the telomere sequences (3, 4). With these similar motifs, it is possible to use a G-wire as a decoy molecule. G-wires acting as decoy molecules could affect the G-DNA gene expression and proliferation of cancer cells. G-wires being translocated into cells have already been shown, but the complete effects of their presence have yet to be determined (unpublished findings, 5). G-wires seem to not have acute effects on cells (unpublished findings, 5), but chronic effects have been shown in a related study (5). Further understanding is needed. If better understood, these chronic effects could possibly lead to an alternative form of effective cancer treatment, aside from typical chemotherapy. Chemotherapy is harmful and lacks specificity. Treatment based on G-wires would use a more specific approach.

Megan Schouweiler

DOES FORGIVENESS FACILITATE FORGETFULNESS? HOW THE DECISION TO FORGIVE RELATES TO MEMORY
Faculty mentor: Dr. Greg Robinson-Riegler

In line with the slogan, “to forgive and forget,” Noreen, Bierman, and MacLeod (2014) tested whether the decision to forgive a transgression facilitates the ability to forget it. Using an intentional forgetting paradigm, they found preliminary evidence to suggest that forgiven transgressions are forgotten at a higher rate than unforgiven transgressions. The current study conducted a partial replication of Noreen et al (2014) with the addition of comparing individual differences in working memory— the cognitive mechanism that facilitates forgiveness— to the relationship between forgiveness and forgetfulness. The results failed to replicate Noreen et al (2014), and working memory played no role in the relationship between forgiveness and forgetfulness. Further research is needed to identify the factors contributing to forgiveness and memory because a greater understanding of these factors is important for the wellbeing of individuals and interpersonal relationships.

Madeline Schuster

SIMPLIFICATION OF IN-PLACE HAAR WAVELET TRANSFORM IN IMAGE COMPRESSION
Faculty mentor: Dr. Pat van Fleet

This project considers the problem of creating a fast Haar Wavelet Transform (HWT). The HWT can be used to facilitate data compression. Images compressed using HWT and similar wavelet transforms can produce results indistinguishable from the original image. Typically, the transform can be applied iteratively to produce better compression results. The usual way to compute this HWT is to apply iterations consecutively; however, this consecutive method does not produce results quickly. For example, to compute two iterations of compression, two matrix multiplications are applied to the entire matrix, and then two more matrix multiplications are applied to the upper left quadrant of the resulting matrix. The goal of this project is to explore the possibility of computing the HWT with a single, in-place matrix multiplication. This would enable images to be compressed more quickly and efficiently with the same end result as the original HWT transform. We proved that is a matrix A expressed as a vector a, the HWT is a linear transformation Ma and we determined the block structure of M necessary to do the in-place computations. Examples will be provided in the presentation.
Marianne Sciamanda

**COMPOST TEA AND THE EFFECTS OF SOIL MICROBES ON URBAN-GROWN VEGETABLE**

Faculty mentor: Dr. Adam Kay

Urban agriculture has risen as a solution to providing food for a rapidly increasing world population. Practices that increase yield are necessary to maximize the benefits of crops grown in urban, and often small, agricultural spaces. Compost tea has emerged as a method to increase plant growth by essentially acting as liquid compost packed with beneficial microbes. To test the effectiveness of compost tea, as well as study the underlying microbial mechanisms of it, I conducted an experiment. Four treatments: dry compost, compost tea, a combination of dry compost and compost tea, and a control with no application, were tested in raised beds. The yield of each identically-planted bed, as well as the microbial content of the soil/compost, was tested. Compost tea application led to highest average microbial content, however, dry compost plots had the highest yield, which suggests potentially adverse effects of compost tea and the microbes it adds to soil.

Nick Sheridan

**MODELING BIOCHEMICAL INTERACTIONS CONTROLLING THE CYTOSKELETON OF SPREADING CELLS USING THE FINITE ELEMENT METHOD**

Faculty mentor: Dr. Magdalena Stolarska

A large number of medically-important applications depend on cell movement over a surface or through the extracellular matrix. For example, experimental research has shown that stem cells differentiate into neurons or osteocytes depending on a single variable: surface stiffness. We want to understand how the intracellular components of a cell react to surface stiffness, chemical patterning, and composition. Our mathematical model describes the reactions that begin with the activation of integrin, a cell membrane receptor that binds to the surfaces on which cells move. These reactions lead to the activation of actin, the primary component of the cytoskeleton that controls cellular movement. We solve these model equations using the finite element method and show that we obtain the expected outcome of activated component concentrations increasing over time.

Michael Simeon

**EXAMINATION OF A HOMOLOGOUS SIGMA FACTOR AND ITS ROLE IN INCREASING METAGENOMIC SCREENING EFFICIENCY**

Faculty mentor: Dr. Justin Donato

Over the past two decades, breakthroughs in biochemical techniques have enabled researchers to study previously unculturable bacterial communities in a lab setting. Specifically, function-based metagenomics uses an unculturable bacterial community's DNA to transform a host cell, usually *Escherichia coli*, enabling the host cell to transcribe and translate foreign DNA and express various phenotypes of the community. However, low gene expression in the hosts is a constant issue. In an attempt to solve this problem, a homologous *rpoD* from *Lactobacillus plantarum* (Lpl-σ) was introduced into the *E. coli* strain MG1655, and enabled increased recognition of metagenomic DNA promoter regions from a soil-based library. We attempted to further study the underlying biochemical processes of Lpl-σ. Examination of the primary structure of the sigma factor coded by Lpl-σ determined that there is moderate variability in the C-terminal region of Lpl-σ when aligned with three other homologous sigma factors, which could possibly play a role in Lpl-σ’s increased metagenomic DNA recognition. To attempt to identify the crucial amino acid residues of Lpl-σ, we removed a segment of 84 base pairs from *rpoD* using overlap extension PCR. This results in 28 amino acid residues being removed from the Lpl-σ C-terminal region. This deletion eliminated Lpl-σ function, indicating either the truncated protein cannot be translated properly, or the
deleted amino acids are crucial for Lpl-σ function.

Additionally, metagenomic DNA expression was tested between two laboratory strains of *E. coli*, EPI300 and DH5α, using a metagenomic DNA plasmid reporter system. It was found that EPI300 was able to express more of the plasmid reporters than DH5α, indicating EPI300 can better recognize metagenomic DNA.

*Claire E. Spangenberg*

**INVESTIGATING TIMING OF SLIP ALONG N-S EXTENSIONAL FAULTS IN THE MODI KHOLA AND MARSYANDI VALLEYS, ANNAPURNA HIMALAYA, NEPAL**

Faculty mentor: Dr. Jeni McDermott

Hosting some of the world’s most extreme topography and nine of the world’s ten highest peaks, the Himalayan mountain range is one of the most extensively studied regions in the world and offers a prime example of ongoing continental collision. It is through geologists’ understanding of this system that they create models and interpretations of other, similar orogens. One key element in creating models for mountain ranges is the ability to recount movement of faults and fault blocks as accurately as possible. Although the Himalaya have been studied for decades, there is still debate over how the stress of 50 million years of convergence has been accommodated for over time.

Despite continued convergence, north-south extensional faulting has been documented along the South Tibetan Fault System (STFS). This system of primarily north-dipping, low-angle extensional faults has been of particular importance in the evolution of the Himalayan range. Concurrent movement along the STFS and the Main Central Thrust is responsible for the extrusion of the Greater Himalayan Sequence: the metamorphic core of the Himalaya. Slip along the STFS has typically been confined to the Early-Middle Miocene. However, recent research presents evidence for slip as recently as the Pleistocene.

Through mounting evidence suggesting regional continuity in Recent slip along STFS strands, the question remains of whether or not this is the case. The extreme topography of the region makes it difficult to sample along the entirety of the system, limiting sampling to accessible river valleys. The goal of this research is to fill in geographic gaps in the data by conducting thermochronologic analysis of samples collected in the Modi Khola and Marsyandi valleys in central Nepal. It may be the case that extension of the STFS has played an important role in the evolution of the Himalaya more recently than was previously believed.

*Sydney Steger*

**SYNTHESIS OF IMIDAZOLE, TRIAZOLE, AND BENZIMIDAZOLE N-H CONTAINING HETEROCYCLES**

Faculty mentor: Dr. Marites Guino-o

Three N-H containing heterocycles were synthesized: 1,3-bis[(2-pyridyl)methyl]-1H-imidazole (1) bromide, 1,4-Bis(pyridin-2-ylmethyl)-1H-1,2,4-triazol-4-ium bromide (2), and 1,3-bis[(2-pyridyl)methyl]benzimidazole bromide (3). NMR, infrared, absorbance and fluorescence spectroscopy were used, along with mass spectroscopy and single-crystal X-ray diffraction, to gather information about the structure and optical properties of these molecules.

*Michael J. Stodolka*

**SOLID-STATE STRUCTURES AND REACTIVITY OF HALOGENATED BENZONITRILE OXIDES: CRYSTAL STRUCTURE OF bis(3-CHLOROPHENYL)FUROXAN**

Faculty mentor: Dr. William H. Ojala

Halogenated benzonitrile oxides are compounds bearing both a halogen atom and a fulminate group (C=N+–O⁻) on a benzene ring. Because nitrile oxides in general are useful in 1,3-dipolar cycloadditions,
their solution chemistry has been studied extensively, including their potential dimerization into a furoxan (in the absence of added catalyst), a dioxadiazine (in the presence of added pyridine), or a 1,2,4-oxadiazole N-oxide (in the presence of added triethylamine); however, their solid-state chemistry has not yet been investigated in detail. The primary focus of our project is to investigate the crystal chemistry of halogenated benzonitrile oxides, motivated by the published observation that the solid-state stability of these compounds is strongly dependent on the ring substitution pattern; 2-chlorobenzonitrile oxide and 4-chlorobenzonitrile oxide possess reported stabilities of 3-6 days and 10 days, respectively, while the reported stability of 3-chlorobenzonitrile oxide is only 50-60 minutes. As part of our efforts to elucidate the role of molecular packing in the enhanced reactivity of the 3-chloro isomer and to determine the product(s) of solid-state dimerization, we have now synthesized the bis(3-chlorophenyl)furoxan from solution and have determined its crystal structure. No chlorine···chlorine approaches closer than the sum of the van der Waals radii are observed in this structure. If halogen···halogen contacts play a significant role in the packing arrangement of the parent nitrile oxide, and if the crystal structure we have obtained for this furoxan is the same as that formed as the result of solid-state dimerization, it would appear that halogen···halogen contacts are not so significant to the course of solid-state dimerization that they must be maintained in the final solid-state product. Future work will focus on determining the crystal structure of the parent 3-chlorobenzonitrile oxide and its remaining two dimers.

**Drew Stolpman**

**USING INTERNAL STANDARDS TO MEASURE CONCENTRATIONS WITH RAMAN SPECTROSCOPY**

Faculty mentor: Dr. Gary Mabbott

Raman spectroscopy is a really good qualitative spectroscopy technique, but it has been less successful for quantitative work. Our hypothesis is that quantitative analysis would be possible for Surface Enhanced Raman Spectroscopy if internal standards were used. Internal standards correct for uncontrolled variables such as the environmental variable pH by using the ratio of signals from two similar molecules. We anticipate that a ratio of signals will be less influenced and permit the determination of concentration in dilute solutions of compounds of interest. Work with pairs of analytes and internal standards will be presented.

**Mitchell Sullivan**

**MEMORIALS AND MEMORY: COMING TO TERMS WITH THE PAST**

Faculty mentor: Dr. Susanne Wagner

The Holocaust altered the human condition and has all but faded from human memory. The murder of six million Jews and five million non-Jewish victims gave rise influential pieces of international law, the creation of the State of Israel, and a new world attitude toward totalitarian regimes. Unfortunately, the Holocaust was only one of many events that earned the prompted many to coin the twentieth century as the bloodiest, most atrocious one in history. With that comes survivors of atrocities, and with survivors come memories. How society decides to remember such heinous events like The Holocaust speaks volumes about the public’s sentiments toward said events. This paper aims to address how the differences between the Jewish experience of The Holocaust and the Homosexual experience of the same time period impact how the world has memorialized victims. In order to do so, we must first discuss the definition of The Holocaust and how that definition has come to be. Then, I will discuss the Homosexual Experience of National Socialism with information from numerous first hand accounts. Following with a brief discussion of Jewish memorials, I will discuss the true purpose of having memorials dedicated to the homosexual victims of The Nazis.
Chantz Tessier

LIQUID/GAS COAXIAL JET FLOW
Faculty mentor: Dr. David Forliti

Two-phase coaxial flow has a large amount of applications that range from manufacturing processes to fuel injectors for jet engines. Gaining a greater understanding of the characteristics of this type of flow has many benefits. It could lead to more efficient engines or improve the effectiveness of coaxial jets used on assembly lines. The basis of the two-phase jet being studied consisted of a water jet surrounded by high-speed air flow. The main objective of this study was to take an equation and test the rigidity of it to see if it holds true under a variety of parameters. This equation was derived to find the velocity of the waves of water that occur in the interface of the flow otherwise known as convection velocity. Two liquid/gas coaxial injectors were constructed with a different wall thickness of the inner jet, then the flow from both jets was captured using a high-speed camera. The videos of the flow were used to calculate the convection velocity, which was then compared to the theoretical values obtained from the equation. The injector with the thinner inner wall agreed with the equation while the other’s convection velocity deviated. This suggests that the inner injector wall has a greater effect on the convection velocity than anticipated. In future studies we plan on investigating the significance that the geometry of the injector has on the behavior of the flow.

Ryan Trapp

STABLE ISOTOPES INDICATE ZEBRA MUSSELS (DREISSENA POLYMORPHA) INCREASE DEPENDENCE OF LAKE FOOD WEBS ON LITTORAL ENERGY SOURCES
Faculty mentor: Dr. Kyle Zimmer

The influence of zebra mussels (Dreissena polymorpha) on reducing phytoplankton abundance is well known, but their impact on overall energy flow in deep, mesotrophic lakes is less clear. We assessed impacts of zebra mussels on energy flow by comparing two Minnesota lakes: Lake Carlos has a dense population of zebra mussels, while upstream Lake Ida was free of zebra mussels until 2014 and densities are still extremely low. We used the stable isotope $^{13}$C to assess patterns of energy flow as $\delta^{13}$C values are lower in organisms supported by phytoplankton production relative to organisms supported by littoral energy sources such as periphyton and benthic algae. We sampled $^{13}$C in the tissue of multiple species in each lake to quantify energy sources for the overall food web. We analyzed eight taxonomic groups for this analysis (three fish species, five invertebrate groups), and calculated the difference in $\delta^{13}$C between each taxonomic group and filter-feeding mussels in each lake (hereafter corrected $\delta^{13}$C). Mussels rely on phytoplankton as a primary energy source, so larger corrected $^{13}$C values in our eight taxonomic groups would indicate greater reliance on littoral energy sources. Results showed corrected $\delta^{13}$C values differed between Lake Carlos and Lake Ida for seven of the eight taxonomic groups, and all seven groups had higher corrected $\delta^{13}$C values in Lake Carlos. The presence of widespread, higher corrected $\delta^{13}$C values in Lake Carlos indicate a greater reliance on littoral energy sources relative to the Lake Ida food web, likely driven by high zebra mussel densities reducing phytoplankton abundance. If littoral and benthic production do not compensate for reduced pelagic primary production, overall availability of energy to native secondary consumers and fish may be lower in Lake Carlos compared to Lake Ida. Increased importance of littoral energy sources could also cause shifts in invertebrate and fish communities towards species better adapted to littoral niches.

Thomas Tuohy

NOVEL SYNTHESIS OF A TETRASUBSTITUTED FURAN MOLECULE
Faculty mentor: Dr. J. Thomas Ippoliti

The goal of this research was to determine the scope of the newly discovered synthesis of tetrasubstituted furans via an unprecedented rearrangement. This was accomplished by synthesizing different starting
materials and converting them to furans. Various propargylic diols were synthesized and then the reaction conditions necessary to convert them to tetrasubstituted furans were determined. It was found that weaker electron donating substituents on a propargylic diol required longer heating times in order for them to be completely converted to the furan ring via the newly discovered rearrangement. Characterization of each new tetrasubstituted furan molecule was determined using nuclear magnetic resonance spectroscopy and mass spectrometry.

Emily Vecchia
DEFINING OPEN KNOT TYPES WITH CLOSURE METHODS
Faculty mentor: Dr. Eric Rawdon

Open knots, which are knots with two endpoints and a tangle in between, are scientifically significant due to the recent discovery of their presence in the structure of DNA and proteins. For scientists to link the knotted structure of these systems to a function, a rigorous mathematical definition of knot type for open knots is needed. Because traditional knot theory focuses on closed knotted loops, such a definition does not yet exist for open knots; however, many scientists have developed ways of closing open knots to classify their types using traditional knot theory. We test and compare various closure methods that have shown promising results in practice in order to define knot types for open knots in a mathematical way. I will present results from a test we devised that will demonstrate characteristics of these closure methods and statistical differences between them.

Andrew Wang
LEPTIN AS A POTENTIAL MEDIATOR OF TRADE-OFFS AMONG PERFORMANCE, REPRODUCTION, AND IMMUNE FUNCTION IN GREEN ANOLE LIZARDS
Faculty mentor: Dr. Jerry Husak

Life history trade-offs result from allocation of limited energetic resources to particular traits, restricting those same resources from different traits. This differential allocation of resources is dependent on the conditions the organism is living in, and promotes traits that suit the organism’s best needs between survival and reproduction. In previous studies, green anole lizards were shown to have dramatic decreases in fat stores, immune function, and reproduction when physically trained, and this was exacerbated by diet restriction. We gave supplemental leptin to green anole lizards in an attempt to mitigate the negative effects of shifting resource allocation due to a combination of exercise training and diet manipulation. We hypothesized that supplemental leptin would ‘rescue’ energy allocation to reproduction and immunity due to the artificial signal that there is more energetic resources than there actually is available. Lizards were assigned to one of six treatment combinations across three factors (diet restricted or not, trained or not, and leptin or saline control) over the course of nine weeks. To measure immune function, we measured the swelling response to phytohemagglutinin. Leptin supplementation did not override the stress of injections to ‘rescue’ reproduction, but leptin did increase immune response across both diet treatments. Endurance and growth were unaffected by leptin, though the stress of injections seemed to decrease performance enhancement. Diet restriction decreased growth in both sexes, with or without leptin supplementation. Our results highlight the complex nature of how trade-offs are mediated, and suggest differential and interactive roles for leptin, corticosterone, and pathways associated with the exercise response.
Endocrine disrupting chemicals (EDCs) are a group of contaminants of emerging concern commonly found in wastewater treatment plant (WWTP) effluent. EDCs alter normal hormonal functioning in organisms, sometimes resulting in reduced reproductive success. WWTPs tend to be sites of concentration of EDCs, as they receive large amounts of inflow of EDC-containing domestic waste. Effluent is typically discharged into larger bodies of water, resulting in urban waterways with high volumes of WWTP effluent. Considering that EDCs are not completely broken down during the treatment process, and that they are toxic to aquatic life at the extremely low concentrations found in WWTP effluents, we can conclude that EDCs pose a significant threat to the aquatic ecosystems that receive a high volume of effluent from WWTPs.

The O'Brien and Calumet Wastewater Reclamation Plants, two WWTPs in Chicago, implemented UV radiation and chlorination treatments (respectively) following public pressure to improve disinfection of effluent. The Metropolitan Water Reclamation District of Greater Chicago (MWRD), hoped that the added treatments would not only remove pathogens, but oxidize EDCs into less environmentally harmful products. However, in order for EDCs to be completely oxidized, UV radiation needs to be strong and followed by oxidation, which is not how the new UV and chlorination upgrades treat the effluent. This may be problematic because incomplete oxidation of EDCs can produce toxic metabolites, which are sometimes more endocrine disrupting than their parent compounds. Furthermore, chlorination has been shown to increase estrogenic activity of certain EDCs, such as bisphenol A. The uncertainties surrounding the possible impacts of these infrastructural changes necessitated analyzing effluent for endocrine disrupting activity after undergoing the UV or chlorination treatment.

In order to characterize the impacts of UV and chlorination treatment on the EDC loads in the effluent of the Chicago O'Brien and Calumet WWTPs, we used biological assays to assess whether the endocrine toxicity of the WWTPs effluent was reduced or enhanced by these added treatments. For information on what specific chemicals may be responsible for the endocrine disruption, I referenced a paper by Larry B. Barber (et al.) that characterized biologically active organic contaminants in the North Shore Channel of the Chicago River.

Samantha R. Whitcomb

SOLID-STATE CHEMISTRY OF REACTIVE NITRILE OXIDES
Faculty mentor: Dr. William H. Ojala

Nitrile oxides dimerize in solution to yield three possible products, depending on the reaction conditions: a furoxan, a dioxadiazone, or a 1,2,4-oxadiazole-N-oxide. We are examining the solid-state chemistry of
benzonitrile oxides that should be capable of solid-state dimerization. Here we describe our studies on compounds relevant to the solid-state chemistry of two particular nitrile oxides, 4-methylbenzonitrile oxide and 3-nitrobenzonitrile oxide. In previous work we determined the crystal structure of the bis(4-methylphenyl)furoxan; we have now found through hot-stage microscopy that this compound undergoes a solid-state phase transition to a new, high-temperature polymorph. We have meanwhile obtained a new polymorph of this furoxan independently by crystallization from solution; future work will include determining whether the new polymorph obtained from solution is the same as the one obtained as a result of the phase transition. We are also attempting to co-crystallize this furoxan with its bis(4-chlorophenyl) analogue to determine whether the course of the phase transition can be influenced by solid solution formation. In this 4-methyl series we have also now determined the crystal structure of the bis(4-methylphenyl)dioxadiazine, which has a severely nonplanar central ring. In addition, we have determined the crystal structure of the bis(3-nitrophenyl)furoxan, which, like the 4-methyl analogue, is disordered about the approximate twofold axis through the molecule. Characterization of these dimers both crystallographically and spectroscopically will be useful in determining the outcome of solid-state dimerization of the parent 4-methylbenzonitrile oxide and 3-nitrobenzonitrile oxide.

Thomas Wieser
DECREASED CYTOTOXIC ACETYLATED AND PHOSPHORYL CHOLINATED G5 POLY(AMIDOAMINE) DENDRIMER AS PROMISING GENE DELIVERY AGENT
Faculty mentor: Dr. Lisa Prevette

Gene therapy has become a growing area of interest as it allows for the treatment of various diseases ranging from arthritis to cancer. G5 poly(amidoamine) dendrimer (PAMAM) is a spherical, branching polymer with 128 terminal amines which can be used as gene delivery agent. DNA binds to G5 PAMAM via electrostatic interactions between the positively charged terminal amines of PAMAM and the negatively charged phosphate backbone of DNA. Unmodified G5 PAMAM, however, is cytotoxic. Previous studies show that the cytotoxicity of G5 PAMAM can be decreased by attaching neutral acetyl groups or zwitterionic 2-methacryloyloxyethyl phosphoryl choline (MPC) to the terminal amines. G5 PAMAM was conjugated in different end group ratios with acetyl groups and MPC to study their effect on binding pDNA. Electrophoretic mobility shift assays were used to study pDNA binding to acetylated PAMAM (Ac-P) and phosphoryl choline PAMAM (PC-P). Increasing the degree of acetylation leads to decreased pDNA binding, with 100% acetylation preventing association of pDNA. PC-P conjugates have been synthesized and characterized by NMR, but pDNA binding remains to be studied.
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