SCIENCE, MATHEMATICS & COMPUTING DIVISION

senior projects

spring 2021

Ultrasonic Pollution: A New Kind of Noise Pollution

Cillian Ahearn
Advisor: Bruce Robertson

All organisms use verbal communication to gain information about their surroundings, in order to hunt, feed their chicks, and call or warn one another. This communication is increasingly masked by anthropogenic noise pollution, but that might not be the only type of noise pollution to exist. Recently, there has been a rise into the research of organisms that use ultrasound, but virtually none into anthropogenic ultrasound and whether or not it has the possibility to mask ultrasonic vocalizations. As such, my study hopes to fill in this gap of knowledge by doing an exploratory study in a city, Hartford, CT, where I identified sources of man-made ultrasound, as well as their frequency ranges. These ranges were then compared against ultrasonic vocalizations of mice, Richardson's ground squirrels, and tomato plants. My study found that the more narrow a biological frequency range is, the more at risk it is to be fully masked. This implicates ultrasound as a potential new source of noise pollution that should be mitigated as part of conservation efforts to preserve the environment.

Road to a Resilient Financial Sector:
Impacts of the Dodd-Frank Act on Systemic Risk

Muhammad Ali
Advisors: Steven Simon & Guatam Sethi

The U.S. financial sector has been plagued by crises in the last few decades. The Dodd-Frank Act was the most substantial set of reforms in recent history aimed at making the financial sector more resilient and stable than before. We analyze the effects of the Dodd-Frank Act in reducing systemic risk in the financial system. We find that the Dodd-Frank Act reduced systemic risk in the financial system by conducting a panel regression on 15 of the most prominent financial institutions in the U.S. However, our results suggest that the enactment of the Dodd-Frank Act and the Global Financial Crisis '08 coincide, acting as the main driver for the reduction in systemic risk. It is imperative to refine risk- management tools and make data more accessible in order to protect the financial sector from future crises as the health of our economy depends on it.

Charm of Hummingbirds, Murder of Crows: A Bird's Eye View of Perception Versus Reality in Animal Conservation

Liam Gehrig Bach
Advisors: Arseny Khakhalin & Frank Scalzo

Animal conservation research has looked at how human perception of animals changes our willingness to protect them—more specifically, research has investigated the effects of charisma upon distribution of conservation attention. However, past research has not considered the interactions between charisma, conservation status, and ecological importance. These factors play a role that cannot be understated in large-scale conservation projects. Human perception of animals and the biases humans hold could be responsible for the life and death of any species on Earth! I conducted a survey to understand which species people believe to be charismatic and parsed out potential reasons why. I then applied a methodology geneticists used to find gene-gene interactions based on co-occurrence in published scientific literature to animals and sought high interactivity to find importance. These studies aimed to find out if charisma, conservation status, and ecological importance were correlated, and how each may impact the conservation attention a species receives.

Gibbs Phenomenon for Jacobi Approximation

Riti Bahl
Advisor: John Cullinan

The classical Gibbs phenomenon is a peculiarity that arises when approximating functions near a jump discontinuity with the Fourier series. Namely, the Fourier series “overshoots” (and “undershoots”) the discontinuity by approximately 9% of the total jump. This same phenomenon, with the same value of the overshoot, has been shown to occur when approximating jump discontinuous functions using specific families of orthogonal polynomials. In this project, we extend these results and prove that the Gibbs phenomenon exists for approximations of functions with interior jump discontinuities with the two-parameter family of Jacobi polynomials $P(\alpha,\beta)\ n(x)$. In particular we show that for all α, β the approximation overshoots and undershoots the function by the same value as in the classical case – approximately 9% of the jump.

Module Basis of Mixed Splines over R[x]

Philip Barnet
Advisor: Lauren Rose

A mixed spline is a piecewise polynomial with varying degrees of smoothness. In this project, we characterize a basis for mixed splines over subdivisions of the reals based on a characterization for integer spline bases. We use our new characterization to find bases for modules of splines with boundary conditions with particular differentiability requirements on their boundaries and compare various aspects of the two.

https://youtu.be/AHiaZFlWbV8

The Complex Propagation of Light: How to Make a Hologram

Bruno Becher
Advisor: Christopher LaFratta

The complexity of light's wave nature is shown in the paths that light takes. In this project I will show several useful ways to imagine and predict how light will travel from one place to another. Once light is produced it does not immediately fill a room, instead it undulates through free space as if the space itself was a fluid. Once we understand the way light flows and interacts with its environment not only can we predict and control its shape with a hologram, but also discover clues which give secrets about where the light has been. Telescopes and microscopes reveal hidden packets of information, coded into the light itself,that would normally be lost to eyes. Using a tool called the Fourier Transform I will show how anyone can intuitively "feel out" what motivates light to move through space in its unique way.

Do Butterflies Actually Send Out Hidden Visual Signals?

Ethan Beneroff
Advisor: Bruce Robertson

The perception of polarized light is a tool butterflies use to enhance the contrast of objects independent of wavelength and brightness. Previous studies have demonstrated the usefulness of this tool for mate recognition, especially in complex lighting environments such as forests; however, they have left some basic questions about butterfly scales' polarization properties unanswered. Here I investigate the Brewster angle of butterfly scales, what degree of linear polarization is relevant to butterflies' perception, and whether or not my findings support the habitat-based polarization theory. Through examining the light polarizing properties of *Danaus plexippus*, *Limenitis Archippus*, and two varieties of *Papilio troilus*, I found Brewster angles varied between species/variety and scale type, proposed relevant values for degree of linear polarization in mate recognition, and found that these specimens do conform to the proposed habitat-based polarization theory.

Impact of Distance and Antibiotics from a Waterway have on the Soil Microbiome

Christopher Benincasa
Advisor: Gabriel Perron

Antibiotics, while humans didn't discover them until 1928, occur naturally in the environment and have been for thousands of years, but after they were discovered, they were altered from their natural state, they were concentrated to create today's modern medicine. The issue is when these man-made antibiotics are then reintroduced into the environment and make their way into the waterways through discharge from waste treatment plants and run-off from farms. These antibiotics then alter the microbial communities that they interact with, but we don't know how far the reach of the antibiotics go. Utilizing 16S rRNA and shotgun metagenomic sequencing, we took a transect of soil samples going away from the Esopus Creek looking at the microbial alpha and beta diversity. Using the 16S rRNA samples we compared the different distances. Both distance and antibiotic resistant genes are correlated to microbial diversity.

How Fast are “Fast-Friends”? Do People Make Accurate Friendship-Relevant Judgements of Strangers Within the First Minute of Interaction

David Koehn Benson
Advisor: Kristin Lane

Impression formation involves the use of swift, automatic judgements in combination with slower controlled processing of incoming information to adjust those judgements. “Thin-slice” literature has also shown us that humans are capable of surprisingly accurate interpersonal judgements from small snippets of expressive behavior. Although friendship does take time to develop, assessing others along dimensions that seem to be related to friendship development during the acquaintance process often involves interpersonal judgements. This researcher sought to determine whether interpersonal judgements made in the first minute of zero-acquaintance interaction (strangers meeting) are accurate and resilient enough to resist adjustments made after a subsequent longer introductory conversation. Findings did not support the original hypotheses. Results indicated that perceptions of personality were not very accurate after the first interaction, nor especially resilient to later updating over the second interaction. However, there were some differences in accuracy and resiliency depending on the personality domain assessed. Additionally, friendship-factors were not found to be resilient across interaction periods, although they were significantly related. Although the results were not what was predicted, they suggested the paradigm of the study has the potential to be useful in the fields of “thin-slices”, impression formation, and friendship/acquaintanceship processes. Suggestions for future research with this paradigm and the implications for these findings in the context of “thin-slice” and impression formation literature are discussed.

Wnt3 Expression in Zebrafish as a Pathway for Hair Cell Regeneration

Stephanie Blanco
Advisor: Michael Tibbetts

Throughout the world, millions of people currently suffer from hearing loss in some capacity due to the death or damage of hearing cells. Although humans are unable to regenerate hearing cells, as most mammalian species are unable to regenerate hair cells, non-mammal species like the vertebrae zebrafish (*Danio rerio*) can. While it has been determined that Wnt signaling pathways function in many processes of regulating development including cell cycle regulation and hair cell orientation, scientists like Aaron B. Steiner have identified many genes that are differently regulated early in regeneration and may contribute to the development of hair loss treatment; one of which is the gene known as Wnt3. For my senior project, a research proposal consisting of 3 different experiments will be conducted to address Wnt3 gene expression in zebrafish to determine if Wnt3 expression can function as a pathway for hair cell regeneration. To analyze this candidate gene, a proposal using the experimental methods of morpholino knockdown, hair cell ablation, DIAsp hair cell labelling, tail fin electroporation, and statistical analysis will be made to study the rate of hair cell regrowth in zebrafish when Wnt3 activity is inhibited. The hypothesis for this study is that Wnt3 activity functions as a precursor for early processes of development and hair cell regeneration.

The Effects of Social Media on Mental Health: A Proposed Study

Grant Bossard
Advisor: Frank Scalzo

There are about 3.8 billion social media users around the world (How Many People…, 2020). How does social media use affect the mental health of its users? Excessive social media use has the potential to increase vulnerability to the development of psychological disorders, specifically increasing psychological distress, decreasing self-esteem, and increasing depressive symptoms. With social media use on the rise among people of all ages, it is important to understand the potential adverse effects so that usage guidelines and interventions can be developed. This is a proposed study to determine what the effects of using Instagram, Facebook, or no social media for a week will have on mental health. Specifically, this proposed study will examine the effects of using Instagram, Facebook, or no social media for a week on the Patient Health Questionnaire-9, Rosenberg's Self-Esteem Scale, and the Kessler Psychological Distress Scale. These scales measure depressive symptoms, self-esteem, and psychological distress. Taken together, results from this proposed study will contribute to understanding the potential deleterious effects of social media use and provide information to help shape the development of social media usage standards and interventions for individuals adversely affected by social media usage.

Self && Self: An Art Show on the Duplication of Self

Shuang Cai

Advisors: Keith O'Hara & David McKenzie

Seldom before the COVID-19 pandemic have so many people simultaneously had their lifestyle drastically changed in the same way. The forced physical isolation is, ironically, a communal experience. The sickening quarantine left everyone nothing but time to confront and reconnect with themselves. Another inevitable result of corporal isolation is the predominant awakening awareness of digital existences and connections. Evoking the shared sensitivity and delicacy, studying the tectonic activity of the digital world, the project - *Self && Self* - documents the endured contemplation in the upcoming resurgence. *Self && Self* - is a clustering of bridges, connecting the physical and digital dimensions, enabled by computational image processing and stereo vision technology. Installed by the entry hall of the Fisher Studio Arts Building - transitional space, the show is constructed by five components: The Invitation, The *Surveillance Screens* with non-functional ceramic cameras, The *Emergence Dance* video series, The *Conversation* on Zoom, and The Pointcloud *Interaction*.

Online Waiting: Are You Anxious Yet?

Christopher Campbell

Advisor: Frank Scalzo

Anxiety is on the rise, and due to limitations on social interactions because of the COVID-19 pandemic, people have been forced to meet online rather than in-person. One aspect of these online interactions is waiting. Many studies have been conducted examining waiting in-person and found that the average wait time in an experiment is around twenty minutes, but no studies have attempted to replicate those studies in an online setting. Does waiting online cause a significant amount of anxiety, and if so, how may we be able to change that? I will test if people are more anxious waiting in groups than by themselves in an online Zoom call. To do this, participants will be instructed to wait for me for an online meeting. After thirty minutes or until they attempt to leave, I will ask them to self-report the anxiety that they felt during the experiment. I hypothesize that those in groups will experience more anxiety due to the social pressures that are telling the participants to wait patiently for the experimenter.

https://youtu.be/NpvXxq6xYj0

Don’t Jump In! How Local Bodies of Water May Contain Fecal Indicator Bacteria and *Legionella pneumophila*

Grace Baruchin Yang Carter
Advisor: Elias Dueker

After rain, all storm runoff contains a variety of bacteria, including total coliforms, fecal coliforms, and enterococcus, derived from the land the water flows over. The fecal coliforms and *Fecal streptococci* originate from the feces of animals. *Legionella pneumophila* (*Lp)* is a genus of gram-negative bacteria and it is known to cause a disease known as Legionnaires’ disease, which is contracted by inhaling the pathogen in aerosolized water. My senior project investigates what communities of bacteria live in temporary water bodies (puddles); is *Lp* present?, and are fecal indicator bacteria (FIBs) also present? I asked the questions,``Do temporary bodies of water serve as reservoirs for bacteria or microbial agents of concern, like FIBs, in ways that differ from permanent bodies of water?” *Lp,* is transmitted to humans through inhalation of contaminated aerosols. Through tests for FIBs I was able to come to the conclusion that there is a high concentration of FIBs in the temporary water bodies and there are also high counts of *Lp*. There is a significant relationship between *Lp* and E. coli. The frequent presence of *Lp* in puddles of rainwater on asphalt roads, especially during wet weather, indicates the possibility of frequent contact with *Lp* containing aerosols. These results present an indication of wet weather contamination from street water discharge into the bioswales, tributaries and river samples.These findings are promising for the relationship of *Lp* in the environment in order to address global ignorance of harmful bacteria existing in public waterways.

Cultural Taxation and College Students: Undergraduate College Students and Their Experiences With Unfair Cultural and Identity Taxation

Sherry Chowdhury
Advisor: Justin Hulbert

A popular but burdensome commonality amongst minorities is the seemingly universal experience of bearing some mental or emotional burden as a result of our identities and membership in said minority group, where expectations are made of us to educate, endure, and explain culturally relevant issues. Amado Padilla (1994) initially coined this experience with the term “cultural taxation,” but specifically in relation to faculty of color and ethnic scholars who did double the work their White colleagues did in respective fields. As much past research on cultural taxation and identity taxation (Hirschfield & Joseph, 2012) has been conducted largely on faculty and through qualitative means (interviews, etc.), there is yet to be quantitative analysis done on marginalized students’ experiences of cultural taxation. This study aims to tentatively measure cultural and identity taxation in college students in the United States and see how it correlates with stress, being measured using the Perceived Stress Scale. Past research has shown how taxing the many additional burdens, which individuals are either consciously aware of or not, are to marginalized groups, and how they have self-reported being very stressed as a result. I hypothesize that students who report experiencing more cultural taxation through the scale will also have higher scores on the Perceived Stress Scale, showing a positive correlation and relationship between the two. Data collected from 147 students found a significant positive relationship between PSS scores and cultural taxation scores. Exploratory analyses found that within White participants, there was also a positive significant correlation, but none for other racial subgroups or all BIPOC grouped together. They also found a positive significant relationship for cisgender individuals, but none for non-cisgender, heterosexual, or non-heterosexual subgroups. These findings provide evidence for the idea that students who feel more culturally taxed will also experience higher levels of stress.

The Effects of PMMA Thin Films on the Photophysical Properties of Pt(II) Complexes with Chelating Diphosphine Auxiliary Ligands

Belle Coffey
Advisor: Craig Anderson

Cyclometalated platinum(II) compounds with cheating diphosphine ligands were synthesized, characterized, and their photophysical properties were measured. The compounds were characterized by multi-nuclear NMR spectroscopy. Absorbance spectra, emission spectra, and quantum yields were determined in solution, solid state, and in PMMA (poly(methyl methacrylate)) films. When doped in PMMA films, the quantum yield doubled, if not tripled, when compared to samples in other states.

Join The Club:
How Uncertainty Affects Adolescent Group Choice

Isabela Cruz-Vespa
Advisor: Thomas Hutcheon

Uncertainty-Identity Theory hypothesizes that the more uncertain people are about themselves, the more likely they are to identify with groups as a way to define themselves and guide their behavior (Grieve & Hogg, 1999). Research has shown that this identification can happen to an extreme level when the group is highly entitative, or provides clear expectations for how group members should behave, think and feel, thereby resolving their uncertainty. Adolescence is a development period defined by self-uncertainty, and therefore also heightened vulnerability to highly entitative, extremist groups. This experiment tests the prediction that adolescents who are experiencing high self-uncertainty will be more likely to report wanting to join a college with characteristics of high entitativity. After being primed to feel either self-certainty or self-uncertainty, participants in both conditions were asked to rate how much they would like to attend two different college options, where one was described with items reflecting low-entitativity and the other with items reflecting high-entitativity. Then, participants were asked to rate various college characteristics, reflecting either high or low entitativity, on how important each is at their "ideal college". Results did not support the hypothesis, yielding no significant differences between any of the ratings of participants in the self-uncertainty and self-certainty conditions. The limitations of this study design are considered and suggestions are made for further research. The implications of these results regarding adolescent vulnerability to social extremism and radicalization are also discussed.

Electronic Properties of Flat and Curved Graphene Sheets

Yanpei Deng
Advisors: Paul Cadden-Zimansky & Harold Haggard

This project explored the electronic properties of the graphene sheet and also developed a basis for understanding the electronic properties of the curved graphene sheet. The project began with setting up basic knowledge about solid-state physics including introducing band structure, bandgap, crystal structure, and reviews for quantum mechanical operators. Then this project described two potential models that are suitable for considering periodic potential: the weak potential and the tight-binding model. We discovered the tight-binding model is better for our graphene case and by applying this model, we found the energies of the graphene sheet. Next, we constructed the 1D and 2D Hamiltonian matrix in python with periodic potentials and plotted the energy levels and wave functions. Finally, this project touched on gaussian curvatures and two possible shapes for graphene to be curved.

Polyhydroxybutyrate:
An Emerging Option for Mitigating the Plastic Waste Crisis

Madeline Epstein
Advisor: Elias Dueker

Current waste disposal practices (i.e., landfilling, incineration, recycling) are proving insufficient in mitigating plastic pollution and accumulation in the environment. Microbial degradation is a fairly new biological process in which microorganisms break down materials, such as plastics, into non-toxic by-products through metabolic and enzymatic reactions. This process could be a potential solution to degrading plastic waste without releasing harmful by-products or destroying the environment. While microorganisms are capable of degrading current synthetic plastics, it is only to a minimal extent; more efficient and complete degradation is seen with biodegradable/bio-based plastics, such as Polyhydroxybutyrate (PHB). PHB consists of intracellular granules of stored carbon that are synthesized inside certain microorganisms when carbon is in excess and there is a limitation of other nutrients (e.g., sulfur, nitrogen, phosphorus) in the environment. The success and efficiency of microbial degradation is dependent on several factors, all of which should be optimized when attempting to exploit this process in the real-world. This meta-analysis investigated scientific literature focusing on the extracellular microbial degradation of PHB to determine whether or not we are nearing a consensus on the optimal conditions (i.e., microorganism, pH, temperature, microbial environment) for PHB degradation. 20 scientific studies were analyzed to answer this question. Although no consensus on the optimal conditions was achieved after analysis, the documented range of conditions and synthesis of current research may prove beneficial when attempting to transfer and apply these conditions in the real-world to degrade PHB.

Investigating the Efficiency of Energy Transfer in Vehicular Motion

Joshua M. Etukudo
Advisor: Paul Cadden-Zimansky

One of my principal interests in life is transportation, which involves building and working with vehicles and that is why I chose to pursue this task. The main purpose of this project is to investigate the motion of vehicles travelling in a straight line and attempts to use the data gathered to establish a basic understanding of the efficiency of energy transfer in vehicular motion; specifically, from chemical to kinetic. However, in addition to this, the project serves as a guide for others who wish to pursue such an endeavor in the years to come.

A Computational Model of Swarming in *Proteus mirabilis*

Katherine Filpo Lopez
Advisor: Arseny Khakhalin

The bacterial species, *Proteus mirabilis*, is a unique bacteria that differentiates into different cell types that are important in the cell's virulence. This bacteria goes from vegetative cells that are able to divide into moving swarmers that are not able to carry out cell division and form groups referred to as rafts in order to move in an organized manner. The cyclical pattern of this bacteria in environments that are ideal for swarming results in the formation of many rings. The way this bacteria swarms can be unfortunate for people as it is one of the leading causes of catheter-associated urinary tract infections due to its persistence of swarming on many different surfaces.

In this project, I will model an agent-based simulation of *P. mirabilis* movement in order to see what aspects of the cell cycle are important to the formation of these rings and possibly how to disrupt them. With my model, I will look at age dynamics and density dependence of the cell cycle of *P. mirabilis.*

Relevance-TCAV:
Explaining Deep Neural Nets in Human Concepts

Henning Fischel
Advisor: Sven Anderson

Neural Networks, a form of machine learning, are used in increasingly important roles in the modern world. They are being used in self-driving cars and medical diagnoses. However, they are "Black Boxes": they cannot be easily interpreted by humans. This project combines two methods of explaining a neural network's decisions in an attempt to improve their accuracy. This new method, relevance-based testing with concept activation vectors (R-TCAV), yields promising results on two small experiments but is less precise than the previous TCAV method.

The Development of a Collaborative Tool to Teach Debugging

Sam Furr
Advisor: Keith O'Hara

Debugging is rarely formally taught, despite being used by programmers every day. Research indicates that it is valuable to teach debugging, and suggests that teaching it collaboratively may be maximally effective. The goal of this project is to create a collaborative debugger. The debugger aims to be the ideal platform to teach and learn debugging. This paper briefly reviews relevant literature covering teaching debugging and teaching programming collaboratively. Most of the paper is devoted to the design of the collaborative debugger.

A Unification Algorithm For the First Order Theory of Quandles

Elliot Goldstein
Advisor: Robert McGrail

The long-range goal of this project is to develop an algorithm to decide whether two terms are unifiable over the theory of quandles. First, it is shown that the general E-unification reduces to the E-matching problem due to the right-cancellation axioms of quandles. The E-matching process takes the general narrowing approach to equational matching. However, a naive application of narrowing is, at best, recursively enumerable and hence will not terminate given terms that do not match. This modification of narrowing places a hard limit on the use of the delta rules of the term rewriting system for quandles to ensure termination. It is implemented in the SWI-Prolog logic programming language. The question remains open as to whether the imposed limits still allow the program to find a unifier for all matching pairs.

Is Money Enough to Liberate Women from Their Abusers? Examining the Effects of Unconditional Cash Transfers on the Psychological Well-Being of Impoverished Women Experiencing Intimate Partner Violence

Nora Grace-Flood
Advisor: Kristin Lane

Intimate partner violence affects over ten million individuals in the United States each year (Huecker et al., 2021). Household income is a major predictor of IPV. Thus, this study proposal explores how giving unconditional cash assistance to women in abusive relationships may impact their susceptibility to abuse alongside their psychological well-being. This experiment aims to recruit 450 impoverished female survivors and offer half of them monthly cash transfers of $1,000 throughout one year. I use a 2x12 mixed design and path analysis in order to illustrate the following predictions: (1) Those who receive cash will experience significantly less abuse and greater psychological well-being when compared to themselves over time as well as to a no-cash control group and (2) significant changes in resource utilization and coping strategies will mediate the relationship between cash and these two outcome variables. My predicted findings build on previous research connecting poverty and partner violence, suggest a potential role for financial assistance as an IPV intervention tactic, and highlight the necessity of investing in accessible social services.

“Lightskin is the Right Skin and Long Hair Don't Care?”: An Investigation of Colorism and Texturism Amongst Black and Latina Women

Rakim Griffin
Advisor: Richard Lopez

Conversations related to slavery and colonization can be difficult, yet they are necessary in order to address the negative impacts they still have on people of color today. Racial phenotypicality bias is one lasting racist practice that originated during slavery and colonization periods in Latin America and the United States. This form of bias operates by favoring and praising eurocentric phenotypes (such as light skin and straight hair) compared to afro-centric phenotypes (such as dark skin and afro-textured hair). Colorism and texturism (C&T) are two primary forms of phenotype biases that are specifically related to skin and hair. These two phenotypes are deemed as primary because they are highly salient and often used as markers of one's racial identity. There is a scarce amount of empirical research that examines how skin tone and hair texture affects Black/Latina people's psychological health, general health, and social experiences. The current study aims to evaluate Black and Latina women’s narratives associated with colorism and texturism. A survey was developed that includes key questions about personal feelings, experiences, and perspectives related to skin and hair. The goal of it was to elicit responses that illustrate how C&T is internalized and socialized in society. Responses from each of the participants showed that these biases currently exist and how they affect some Black and Latina women. The data suggests that C&T can impact women either similarly or differently depending on the phenotypes they possess. Current findings are beneficial because they create opportunities for researchers and activists to address the problems associated with the biases.

Clarifying the Relationship Between Instagram Use and Mental Health: Exploring the Role of Individual Differences in Problematic Instagram Use and Goal Pursuit

Ana Guaba Perez
Advisor: Richard Lopez

Social media platforms are increasingly becoming part of the everyday life of Americans. The increasing use of social media platforms has been parallel to the declining mental health of adolescents, and young adults causing scientists and the public alike to wonder if there is a link between these trends. The aim of this study was to explore how the self-regulation framework can enrich social media use research by considering individual differences in goal pursuit, and conflict. In addition, this study aimed to clarify the relationship between screen time and mental health. Social media use, mental health, and self-regulation strategies were measured in a digital sample of young adults ages 18-29 (N=200). The results indicated that there were no significant relationships between anxiety, depression, negative affect, and Instagram screen time. There was, however, a significant relationship between anxiety, depression, negative affect, and problematic Instagram use which depicted conflict between social media use and other goals. In addition, results suggested that the process model of self-control can be applied to self-regulatory strategies in relation to social media use. Situational strategies seem to be more effective at reducing Instagram use, as opposed to cognitive strategies. These findings clarify the current contradictory screen time literature, and expand the domains in which the process model of self-control has been examined. There are practical implications from these results. Namely that future research about social media use and mental health should decentralize screen time as a key factor and begin to further explore the role of goal pursuit and conflict in this domain.

Dimentia: Footnotes of Time Abstract

Zachary Hait
Advisors: Harold Haggard & Benjamin Hale

Time from the physicist's perspective is not inclusive of our lived experience of time; time from the philosopher's perspective is not mathematically engaged, in fact Henri Bergson asserted explicitly that time could not be mathematically engaged whatsoever. What follows is a mathematical engagement of time that is inclusive of our lived experiences, requiring the tools of storytelling.

A Deductive Database for Knot Colourings

Dong Hyun Han
Advisor: Robert McGrail

This work constitutes progress toward the development of a knowledge base for braids, knots, and their colourings. The main result of this development is the creation of a logical model for storing data pertaining to braids, two-dimensional projections of three dimensional knots, finite quandles, and colorings of braids and knots by quandles. It uses the Entity Relationship data reference model as its starting point and makes the original design there. In addition, it includes a conversion of the Entity Relationship Diagram (ERD) to SQL queries that define tables corresponding to the ERD entity sets. Finally this work demonstrates how to populate the database on a given set of data in the input format for the Color My Knot (CMK) application by McGrail, Nguyen, and Granda.

Polarized UV Light Vision in Birds

Sarah Hart
Advisor: Bruce Robertson

Polarized light vision is a broad field of study spanning many species from insects to cephalopods to reptiles. The presence of polarized light can provide an important cue to aid in navigation, communication, and resource locating in many animals. The field of bird polarization vision is still fairly young and not a lot is known about how birds use polarized light. Most research in the field has focused on how birds use skylight polarization for navigation. Recent research has provided promising results for the potential of birds using visible spectrum polarized light to locate water and food. Birds do not only see light on the visible spectrum, though. They can see UV light as well. There has been no research on whether birds can see polarized UV light. This study attempts to address this gap in our knowledge by asking the question of whether birds can see polarized UV light and use it as a cue to locate resources. I investigated this question by assessing the current literature on both polarized light vision and bird UV vision and by observing visitation frequencies of birds to high UV polarizing feeders and low UV polarizing feeders. I found that birds tended to visit the highly UV polarizing feeder more frequently, suggesting that they can detect the presence of UV polarized light and that they are attracted to it.

Framing Narratives for Resilience:
A Proposal Utilizing a Narrative Approach for Remote Students

Dayveliz Hernandez
Advisor: Justin Hulbert

Globally, COVID-19 left students vulnerable to the mounting stress of balancing different role responsibilities all under one roof. This period of isolation negatively impacted people's mental health: parents' poor well being obscured their children's needs with increased life demands, an increase of verbal aggression within these relationships were visible, and students reported higher levels of academic stress (PeConga et al., 2020; Prime et al., 2020; Lee et al., 2021; Horita et al., 2021). Because demands on parent-child relationships are high, resilience's protective factors are at risk with low family cohesion (Rivera et al., 2008). Therefore, this proposal aims to ameliorate students' stress, work/family conflict, and resilience through a narrative approach that hones in on a person's ability to reframe rooted beliefs. Bard's remote undergraduate students will be randomly placed in either a control condition, does not write an alternative narrative, or the individual condition, participants process write from their perspective, or the family condition, the family's perspective is considered (N=156). I predict that students creating new narratives will have higher levels of resilience, lower levels of stress, and lower levels of work/family conflict. I also predict that the family condition will report lower work/family conflict than the individual condition. Every prediction was supported by mock data but the last one. Implications of these findings can lead to programming for remote students. Yet, further research is needed to understand the pathways of narratives' influence on students' well-being.

https://drive.google.com/file/d/1CGdxvk8gv7lFoigtM6LpkxvPEzYLrpPx/view?usp=sharing

Effect of Seed Dispersal Mode on the Strength of the Janzen-Connell Effect in Secondary Growth Temperate Forests

Isa Pistello Jones
Advisor: Cathy Collins

Tree dispersal modes reflect many different trade-offs. Some trees rely on animals to eat the fruit containing their seeds and expel them far from the tree; others rely on wind to blow their seeds to other parts of the forest. Seeds face many risks to their survival, and these risks may vary with dispersal model. Some seeds will be consumed by insects; others may become diseased. There is a chance, however, that the seed finds the perfect spot and grows into a healthy tree. Why don't all tree species invest in protection against seed enemies and simply drop their seeds directly underneath them, rather than invest energy in dispersal? Simply, seedling survival is lower underneath parent trees, or even under trees of the same species. Janzen (1970) and Connell (1971) proposed that species-specific enemies such as insects and other pathogens accumulate near parent trees, decreasing survival for nearby seedlings of the same species as the parent ("Janzen-Connell effect"). What is little understood, however, is the degree to which tree species' dispersal methods impact the strength of Janzen-Connell effect. I investigated the impact of tree seed dispersal mode on the strength of the Janzen-Connell effect on tree seedlings. By observing enemy damage on seedlings and density of seedlings both near and far from adult tree species with differing dispersal methods, I found that there was no significant effect of dispersal mode on the strength of the Janzen-Connell.

Brightening of the Bridge:
Reflections of a Past Sgr A* Outburst in Galactic Center Molecular Clouds

Nathalie Jones
Advisor: Shuo Zhang

The center of our Milky Way galaxy is located more than 200,000 trillion km from Earth in the constellation Sagittarius. At the very center of our galaxy is a super-massive black hole called Sgr A* (pronounced Sag A-star). The black hole is surrounded by many interesting objects, including molecular clouds. Molecular clouds are large, cold clouds of gas in which stars are formed. Telescopes like NuSTAR have observed X-rays (radiation 10,000 times higher in energy than visible light) coming from these molecular clouds. Since cold gas cannot create such high energy emission by itself, there must be some external source of radiation interacting with these clouds. In my senior project, I studied the “Bridge” molecular cloud, which is nearby Sgr A*. Using data from 2012, 2016, and 2020, I determined that the brightness of this cloud doubled over the last 8 years. The most likely cause for this change in brightness is that the “Bridge” cloud is reflecting a powerful outburst from the central black hole.

Solitary Confinement is Predicted to Lead to Higher Levels of PTSD and Exposure to Torture Distress

Photini Kamvisseli Suarez

Advisors: Justin Dainer-Best & Thomas Keenan

The focus of this project is to evaluate whether solitary confinement as used in United States prisons is a form of torture. This will include examining the United States' implementation and rejection of acts of torture, which will provide insight into what exactly America defines as torture, and when or why the line is drawn in some places and not in others. Examining domestic and international legal documents and conventions will provide further insight into definitions of torture outside of the scientific realm of understanding. Philosophical and anecdotal evidence will also be used to explore the topic of solitary confinement as a form of torture. The proposed study will focus on the effects of solitary confinement, drawing from the psychological reactions to solitary confinement and different forms of torture as they have been cited in other studies. This study will include 159 participants who will be split into three groups of 53 participants each: a group of people who have not experienced incarceration or solitary confinement, a group who have experienced both, and a group who has been incarcerated but has never been placed in solitary confinement. The measures used will include the PTSD Checklist for the DSM-5 (PCL-5) and the Exposure to Torture Scale (ETS). This study hypothesizes that the group who has experienced solitary confinement will have a higher mean PTSD score on the PCL-5 and a higher mean distress score on the ETS than both of the other two groups. These results will provide insight into the long term effects of solitary confinement as compared to incarceration or general life trauma through the PTSD scores, and will also provide evidence that people who have experienced solitary confinement show higher distress scores from exposure to torture than those who have not.

https://qrco.de/bc7a7A

Protective Pathways Against Hypoxia: A Literature Review and its Implications

Izabel Kickner
Advisor: Heather Bennett

Inadequate delivery of oxygen to organisms is known as hypoxia. Extended periods of oxygen deprivation can lead to cellular death and lifelong disabilities. However, there are a few biochemical and molecular pathways that have been shown to provide protection against the devastating effect of oxygen deprivation. Currently, the cellular, genetic and molecular pathways that lead to adaptation and survival to low oxygen environments have not been fully described. To identify pathways and conditions that yield protection and confer a survival advantage to low oxygen environments, we undertook a meta-analysis of published literature for mammalian studies to identify genes and mRNA transcripts changes that confer resistance to oxygen deprivation through the model organism of *Caenorhabditis elegans*. With the data collected from the cross-species analysis, we developed an extensive list of conserved genes that mediate survival to oxygen deprivation. We then took a bioinformatics approach to identify potential genetic and molecular pathways that regulate adaptation to oxygen deprivation that are conserved across species. This list was used to determine biologically relevant pathways of interest. For ensuing steps, we provide procedural steps to further characterize the impacts of these genes for conserved roles in regulating oxygen deprivation in *C. elegans* by testing loss and gain of function alleles in a hypoxia survival assay. To our knowledge, this level of cross-species analysis has not been done and will implicate conserved genetic and molecular pathways that regulate response and survival to oxygen deprivation.

Stereoselective Oxidative Addition to Platinum (II)

Juliette Knapp
Advisor: Craig Anderson

Diimine, thiophene or benzene derived, ligands containing two stereocenters were synthesized and their subsequent reactions with a tetramethyl platinum (II) dimer were monitored. Platinum (IV) and platinum (II) complexes were obtained through oxidative addition, or oxidative addition and a subsequent reductive elimination reaction, respectively. The cyclometalated platinum (II) complex reacted with alkyl halides to explore the stereochemical consequences of oxidative addition reactions. Reductive elimination of synthesized platinum (IV) complexes were attempted.

https://youtu.be/NZpaWquQ1bk

Programming Abyss with Artificial Intelligence

Karolina Krajewska
Advisor: Kerri-Ann Norton

The objective of my Senior Project is to create a simplified version of a board game *Abyss* designed by Bruno Cathala and Charles Chevallier. By simplified I mean consisting only of one part of the original game, which is the Exploration phase. For the purpose of constructing the game I use the idea of a finite state machine implemented in Processing.

Aside from the game itself, I have also created three different artificial players. Each of them makes decisions based on different types of calculations. Deterministic player takes into account part of a state in which the environment is in to determine its decision. Probabilistic player operates similarly to Dungeons and Dragons mechanics - it calculates probability of undertaking a specific action based on the state of the environment, and then picks a random number - if the number is lower than the probability, then the action is chosen. Utility player on the other hand, compares utilities of possible actions before making its decision. In this paper I analyze and compare 100 gameplays of these artificial agents to determine which type of artificial intelligence is the best at winning the game.

Avian Attractiveness to Vertically Polarized Light

Aurora Belle Kuczek
Advisor: Bruce Robertson

It is well-known that many animal species can detect polarized light cues of water and water-like objects in the visible and ultraviolet range. However, studies investigating if birds can see polarized light in field-based settings are rare. Furthermore, no studies have yet been conducted to understand avian attractiveness to vertically polarized light, nor have studies considered other natural polarizers of light such as tree sap. I designed a choice-field experiment to investigate if birds can detect, and are attracted to vertically polarized light. First, I cut six pieces of clear vinyl into a foot by 54 inches. I painted each vinyl sheet with Black 3.0, advertised as the blackest paint in the world. Two treatments were wrapped around two trees similar in dbh (<40 dbh) and close in distance (<5 feet): one had shiny exposed, and the other matte, painted side, exposed. Suet feeders were hung directly below each treatment on both trees. Two remote cameras were placed on a fence post away from both tree (10 feet in fall; 6 feet in spring). The suet feeder height, camera distance, and the height of both vinyl stayed the same. These treatments were exposed to birds. A baseline study was conducted before installation of treatments to understand bird biases or preferences to one tree position over the other. I made conclusions about birds being able to see, and their attraction to, vertically polarized light by capturing and counting visitations from images, and comparing treatments' bird visits over a designated period of time. My results revealed that birds are able to detect and are attracted to vertically polarized light, and use it to guide foraging behavior. Attraction to polarized light is dependent upon the location of the site, as well as the position (left or right tree), and certain species may play a role in these conclusions, though they do not overwhelm the data. The baseline study to treatment comparison reveals that any preferences to one position over the other were eliminated when treatments were added, and the polarized, shiny treatment had more of a signal than the matte treatment when each treatment were compared separately to the baseline. These results suggest a need to expand site-wise across various habitats to understand the effects of site location, to understand the effects of the positionality of treatments on different species of trees, and to understand how different species may have an effect on treatment visitation. Sap was imaged using a polarimeter to understand if natural Maple sap polarizes light compared to my polarized proxy for sap. My analyses reveal that natural Maple sap polarizes light, and this is strongest in the ultraviolet range. My treatments polarize a high degree of light in both the visible and ultraviolet range, making it an effective simulator of natural Maple sap. This exciting discovery gives insight on how birds may navigate a complex landscape according to polarized cues of that landscape (polarization of sap), and how they use these cues to facilitate their foraging behavior (eating sap).

An Exploration of Condorcet-Approval-Range Voting

Jiangli Liu
Advisor: Ethan Bloch

In contrast to most social choice methods, which use ranked ballots, range voting is a well known social choice method that offers the voters more choices in the form of an allowed range of possible scores. In this project, by allowing voters to give positive and negative scores, we hope to find a way that can explicitly show how voters disapprove, feel neutral, or approve of the alternatives instead of just giving ranking orders. Also, by applying a function to constrain the scores given in range voting, each voter will have the same influence when they give scores. After combining these conditions with Condorcet method by transferring scores into ranked ballot, we get a new voting function that involves Condorcet, approval and range voting. In this project, we explore how this new voting function behaves with respect to certain voting criteria.

https://www.bilibili.com/video/BV1454y1L7MJ/

Art as Therapy:
Using Fictional Written Accounts in the Treatment of PTSD

Nathanael J. Matos
Advisor: Frank Scalzo

Though art therapies and cognitive therapies are both well-established as treatments for PTSD, no studies thus far have tried to consolidate the pros of each into a single therapy. Through modifications to CPT procedures to include expressive fictional written accounts rather than the standard autobiographical account of traumatic events, I believe that the expressive writing paradigm can be utilised to create a new therapeutic procedure for PTSD. Due to lesser emotional intensity and the freedom allowed by creative endeavours, I believe that this procedure would not only yield positive outcomes comparable to CPT, but also have lower drop-out rates than CPT and exposure therapies. The present paper proposes an experimental procedure to test the effectiveness of the modified CPT procedures and compare them to the current standard CPT. Drop-out rates of groups will also be closely monitored and compared between each other.

Square Peg Problem in 2-Dimensional Lattice

Nathan Son Matsubara
Advisor: Ethan Bloch

The Square Peg Problem, also known as the inscribed square problem poses a question: Does every simple closed curve contain all four points of a square? This project introduces a new approach in proving the square peg problem in 2-dimensional lattice. To accomplish the result, this research first defines the simple closed curve on 2-dimensional lattice. Then we identify the existence of inscribed half-squares, which are the set of three points of a square, in a lattice simple closed curve. Then we finally add a last point to form a half-square into a square to examine whether all four points of a square exist in a lattice simple closed curve. A sage program was used to find all missing corners of all inscribed half-squares. This has enabled us to look at the pattern of sets of all missing corners in specific shapes like rectangles. By the end, we were able to conjecture that there exist missing corners in the interior and the exterior of the lattice simple closed curve unless the shape is a square. It is obvious that the square has an inscribed square. Hence if we could prove that the set of all missing corners is connected, we could give a new proof of the square peg problem in 2-dimensional lattice.

Biomaterials and Bacteria: The Microbial Communities of Spider Webs in the Hudson Valley

Grey McAlaine
Advisor: Brooke Jude

In the past, studies have shown that biomaterials may be good for harboring microorganisms due to the provision of specific amenities that facilitate microbial growth, such as a moist environment, a substrate rich in nutrients, or a surface that is amenable to bacterial attachment and growth. Despite the fact that spiderwebs are one of the most common biomaterials found in nature, there is a dearth of research on what types of bacteria can be found on them. One such type of bacteria may be the antibiotic-producing actinomycete, as other insects have been associated with this bacteria in the past and there is likely to be a great deal of interaction between the soil microbiome and the spider web microbiome. By culturing and isolating the microbes that grow on sheet webs in the Hudson Valley, the microbial communities that live on spiderwebs can be further characterized through gene sequencing and Gram staining, as well as an assay that tests the antibiotic-producing capability of eight isolates against ESKAPE pathogens. Although they could not be successfully sequenced due to unfavorable time constraints, three of the bacterial isolates cultured from sheet webs were shown to have a potential antibiotic effect against *Bacillus subtilis.* Another four of the bacterial isolates formed unique cell aggregates that require further study.

Testing and Improving an Optimization-Based Digital Colorblindness Corrective Filter

Zachary McIntyre
Advisor: Kerri-Ann Norton

Computers often communicate essential information via color which is lost to colorblind users. In order to address this information loss, designers and computer scientists have created a variety of different correction methods to improve computer accessibility. One such method was created by Luke Jefferson and Richard Harvey in their 2006 paper, “Accommodating Color Blind Computer Users” which consists of a difference histogram, differences of key colors, optimization and interpolation to adjust images for specific types of congenital colorblindness. I have recreated their algorithm as well as their original test images. I then conducted extensive tests on challenging images to examine the strengths and weaknesses of the algorithm. Finally, I further improved the algorithm in an effort to determine if this method might be useful for a real-time corrective filter.

An Investigation on Love in the Bacterial Cell

Sacha H. Medjo-Akono
Advisor: Brooke Jude

Hi, my name is Sacha, I love to study bacteria and I'm obsessed with pheromones, attraction, and love. As far as I know, pheromones are little particles that help create the chemistry between two people. Knowing so little about how these work I think that the perfect way to start learning is by looking at small organisms in a lab. Recent findings have shown us that certain bacteria can use pheromones to regulate themselves i.e. sexual reproduction. In this project, I would like to find ways to recognize pheromone presence in the bacteria that we have in our lab. I hope that this can turn into something bigger and help us understand the science of love. A series of experiments leading to sequencing its whole genome was executed to see if what I suspected was happening on a genetic level. At the end of this project, I've found that a certain strain of purple bacteria native to Sawkill Creek at Bard College used several mechanisms indicating that they reproduced sexually using different modes of communication know to be mediated by pheromones.

Employing CRISPR-Cas9 to Disrupt the Violacein Biosynthesis Operon of BJB302, a Unique Violacein-Producing Isolate from the Hudson Valley

Cailey Mitchell
Advisor: Brooke Jude

Violacein is a purple-pigmented small metabolite that has significant biomedical and ecological importance. Significantly, violacein has been studied for its killing effect against *Batrachochytrium dendrobatidis* (*Bd*), a toxic and invasive chytrid fungus causing dramatic declines of amphibians worldwide. Violacein production in bacteria is completed through a five gene operon (*vioA-E*). Violacein-producing species are of scientific interest due to their potential use as an environmentally-friendly bioremediation agent against the invasive *Bd* fungus. Here we report the development of the genome editing method, CRISPR-Cas9, to disrupt *vioA* of a Hudson Valley native *Iodobacter* species, BJB302. Our work is also one of the first to contribute to CRISPR-Cas9 genome editing in undergraduate research. By utilizing CRISPR-Cas9 mechanisms and comparative genomic strategies, we offer insight into violacein biosynthesis and its regulation. The findings in this study further the work to improve violacein-producing strains as a bioremediation agent.

The Intersectionality of Anti-Fat Prejudice

Lily Moerschel
Advisors: Frank Scalzo & Kathryn Tabb

Anti-fat prejudice has received little to no attention in social justice discourse. Fat Americans are discriminated against in healthcare, education and in the workplace. This discrimination includes, but is not limited to, lowered salary, unexplained termination from a job, unsolicited medical advice, body scrutiny, bullying, social exclusion, and being denied *in vitro* fertilization. Situating anti-fat prejudice in an intersectional framework will facilitate the dismantling of weight-normative doctrines. In the present study, participants completed a race IAT and a weight IAT, as well as a demographic questionnaire and the Multigroup Ethnic Identity Measure (MEIM). Implicit racial bias was positively correlated with implicit weight bias. Non-white participants scored significantly higher in ethnic identity than white participants. There was no difference in implicit weight bias and implicit racial bias between white and non-white participants. However, white participants scored significantly lower in implicit weight bias when controlling for BMI.

Pseudomonas aeruginosa Biofilm Traps Polystyrene Microplastics

Sarah Kane Moser
Advisor: Brooke Jude

The accumulation of plastics in the environment is a problem of vital concern. Plastics are destructive toward ecosystems in many ways; one particularly concerning issue is the danger of tiny plastic fragments, or microplastics, to organisms. This is a complex problem: the convenience and utility of plastics combined with their extreme durability and long life necessitate creative solutions. Bioremediation, or cleanup using biological means, is one approach that has been proposed. Recently, the use of the sticky structure bacteria form, biofilm, has been demonstrated to physically trap microplastics. The goal of this study was to assess the ability of *P. aeruginosa* biofilm to trap microplastics, and observe the bacteria-microplastic dynamics. This was done by comparing the numbers of microplastic beads trapped by *P. aeruginosa* in the gradient between air and liquid in a culture tube. We found that the biofilm trapped microplastic beads in differing levels depending on proximity to the air, which indicates that *P. aeruginosa* may trap the beads more efficiently with increased access to oxygen. This study serves as a starting point for further research into the associations between microplastics and bacterial biofilm, and the possible utilization of trapping as a bioremediation technique.

Effects of Invasive Asian Jumping Worms on Entomopathogenic Fungi, a Biocontrol Agent for Tick Populations

Ashley Nicolich
Advisor: Cathy Collins

Lyme Disease has a high incidence rate in the Northeast due to Black-legged ticks (*Ixodes scapularis*) using humans as a blood meal. There has been a great deal of research done on different mechanisms of trying to control tick populations, and one such method of killing ticks may come in the form of entomopathogenic fungi. *Beauveria bassiana* is one of a few naturally occurring types of fungi that are pathogenic to ticks, and with a widespread application, could play a role in controlling populations. However, invasive Asian jumping worms, of the genera *Amynthas* and *Metaphire*, which have drastic impacts on forest floor ecosystems, are also spreading in the Northeast among other areas. In this senior project, I tested if jumping worms alter the amount of fungi in forest soils. I used mesocosms— bins containing forest soils—to mimic forest ecosystems. All mesocosms received applications of *Beauveria bassiana,* but only half of the mesocosms contained jumping worms. I tested for differences in fungal activity in soils with and without worms using a waxworm assay. I found no difference in the rate of waxworm mortality in the worm and no-worm soils. Further, the jumping worms did not influence soil parameters I measured, including leaf litter, although jumping worms are known to decimate litter on forest floors. It is possible that the fungi impact not only ticks but also jumping worms. More research is needed to understand the interaction between entomopathogenic fungi and jumping worms if widespread spraying is to occur.

The Effect of Theatre of the Oppressed on "The Cop in the Head"

Sophie Niles
Advisors: Kristin Lane & Miriam Felton-Dansky

In this proposed research study, I attempt to provide a way to collect empirical evidence on the reducing effect of Theatre of the Oppressed on automatic behavior. Augusto Boal, creator of Theatre of the Oppressed, came up with a theory called "The cop in the head". This theory refers to the individual's limitation of their action based on those allowed by an oppressive force. The specific action I will target with my proposed intervention is the tendency for White community members to quickly call the police upon perception of an emergency situation, especially when a Black, Indigenous, Person of Color is involved. Justification for this study is based on previous research in automaticity, helping behavior and the connection of the two through automatic stereotype activation and subsequent behavior. I believe that the practice of Theatre of the Oppressed can be used as an intervention for white community members, teaching them to resist automatic behavior, improving the level of safety for BIPOC community members.

A Bilingual Advantage for Children with Autism: Effect of a Bilingual Education on Set Shifting in Children with Autism Spectrum Disorder

Chandler O'Reardon
Advisor: Sarah Dunphy-Lelii

The proposed study will examine the effect of an early bilingual school environment on the set shifting abilities of children with autism spectrum disorder (ASD). More specifically, it will evaluate how an English-French bilingual education program affects the set shifting abilities of children with ASD compared to a monolingual English education program. Set shifting will be measured by the Dimensional Change Card Sort (DCCS) task both before and after the respective education programs. I hypothesize that there will be a main effect of both time point and education program on set shifting abilities such that (*a)* set shifting abilities will improve from pre-instruction to post-instruction, and (*b)* those who receive a bilingual education will outperform those who receive a monolingual education on set shifting ability overall. I also hypothesize that these main effects will be qualified by an interaction, such that (*c*) bilingual classroom instruction will result in better set shifting abilities particularly at post-instruction when compared to monolingual classroom instruction. If future results from this proposed study do indeed suggest that the proposed hypotheses are correct, it would be interesting to further explore what this would mean for a possible restructuring of current programs in place for the education of children with autism such as the Applied Behavior Analysis (ABA) program.

The Differences in Visuospatial Attentional Distribution Between Synesthetes and Non-Synesthetes, Identified Through Covert Visual Search

Kirsten Ostbirk
Advisor: Thomas Hutcheon

Synesthesia is a condition whereby sensory stimuli evoke unusual additional sensory perceptions and experiences, and can be identified through a visual search task. Grapheme-colour synesthetes have shown increased efficiency in visual search tasks, which some have hypothesized is a result of synesthetic colours drawing attention to the target stimulus, and have likened it to a weakened “pop-out” effect. Visual search has also been used to measure visuospatial attentional distribution, and findings from this method have supported the gradient model of attention, which proposes that cognitive resources are the most concentrated centrally in our visual field, and taper off, such that the perimeters of our visual field deploy fewer cognitive resources. In the first part of this study, an online pilot study was conducted to diagnose synesthetes using a consistency screening and questionnaire. No grapheme-color synesthetes were identified in this pilot. The second part of this study proposes two experiments, the first being an attempt to replicate the increased efficiency in visual search tasks demonstrated by synesthetes. The second experiment aims to identify the differences in attentional gradients between synesthetes and non-synesthetes in a covert circular version of visual search, across three trials types: physically incongruent, synesthetically incongruent, and congruent. Stimuli will be presented in circular arrays of varying eccentricities, and accurate performance on larger circles will reflect flatter attentional gradients. When performance is averaged across trials types, synesthetes are expected to exhibit superior performance and have flatter attentional gradients than non-synesthetes on this task.

The Role of a Polyrhythm's Pitch Interval in Music-Dependent Memory

Hadley Parum
Advisors: Justin Hulbert & Kyle Gann

When listening to music, humans can easily and often automatically assess the perceptual similarity of different moments in music. However, it is difficult to rigorously define the way in which we determine exactly how similar we find to moments to be. This problem has driven inquiry in music cognition, musicology, and music theory alike, but previous results have depended on behaviorally mediated responses and/or recursive analytic strategies by music scholars. The present work employs the context-dependent memory paradigm as a novel way to investigate the extent to which listeners consider two musical examples to be similar. After incidentally learning words while listening to a 5:4 polyrhythm forming a perfect fifth, participants could hear no sound or the polyrhythm at a different pitch interval during a surprise test of recall. Between-subjects comparisons found no effect of the actual sound context at test on recall; however, participants who reported being in the same sound context did recall significantly more words than others. Interactions between actual and reported sound context were not accounted for by musical experience or other participant factors, and reported sound context was more often incompatible than compatible with actual sound context. Contributions to mental context theory and the boundaries of conclusions about musical features are discussed.

A Machine Learning Approach to the Perception of Phrase Boundaries in Music

Evan Petratos
Advisor: Sven Anderson

Segmentation is a well-studied area of research for speech, but the segmentation of music has typically been treated as a separate domain, even though the same acoustic cues that constitute information in speech (e.g., intensity, timbre, and rhythm) are present in music. This study aims to sew the gap in research of speech and music segmentation. Musicians can discern where musical phrases are segmented. In this study, these boundaries are predicted using an algorithmic, machine learning approach to audio processing of acoustic features. The acoustic features of musical sounds have localized patterns within sections of the music that create aurally perceptible “events” that musicians identify as distinctive characteristics of a phrase. An experiment was conducted to gather data from musicians for the machine learning algorithm, and to set an upper bound on the performance of such an algorithm. The algorithm succeeded in detecting phrase boundaries, as determined by the participants, with accuracy scores of 0.91, 0.67, and 0.60 for the data from three participants, but there are still improvements to be made--specifically, the low specificity of the machine learner’s prediction is a challenge for a future endeavor.

Quantum Optics, Entanglement, and Bell's Theorem

Andrew Poverman
Advisors: Harold Haggard & Antonios Kontos

The field of quantum optics provides a wonderful setting in which to study fundamental aspects of quantum mechanics such as entanglement, Bell's theorem, and non-locality. This thesis presents theoretical discussions of qubits, entanglement, and Bell's theorem in addition to experimental discussions on the nature of photons, creating entangled states using Spontaneous Parametric Down-Conversion (SPDC), and a Bell Test with polarization entangled photons. The experimental sections are written to be useful as instructions for one to conduct these experiments on their own. By doing these experiments, one will gain familiarity with quantum optics experiments as well as a firmer grasp on the intricate nature of measurements in quantum mechanics. On the topic of measurement, there is a brief discussion on the von Neumann model of measurement and the concept of decoherence.

Exercise as a Moderating Variable of Social Media Usage and Life Satisfaction

Gabriel Profumo
Advisor: Justin Hulbert

Research has shown that the relationship that young men and women have with social media are very different from one another, although both parties have the same amount of access to the usage of popular social media platforms like Facebook, Snapchat, and Instagram. It is commonly known that young women and men are socialized to behave and think differently which leads to a variety of differences in how they lead their lives. Young women are made to emphasize their physical appearance and relationships with others more so than men are. Because of this young women spend more time on social media platforms to the detriment of their mental health because they are bombarded with unrealistic beauty standards, higher rates of cyberbullying than men experience, and unrealistic standards of how they should behave and live their lives. Although it is clear that social media usage is particularly harmful for young women's well-being, it is less clear how their engagement in other activities propel or distance them from using social media. Exercise is known to be an activity that boosts the mood of those who engage in it, with the effects being even greater the worse ones wellbeing is. I hypothesize that exercise will moderate the relationship between social media usage and life satisfaction among women.

Design and Characterization of an In Vitro CRISPR/Cas9 Model System

Danil Ratnikov
Advisor: Swapan Jain

CRISPR/Cas9 is a technique in molecular biology yielding effective DNA cleavage. For effective DNA cutting, CRISPR/Cas9 system requires appropriate single guide RNA (sgRNA) and a functional sgRNA binding site on Cas9 enzyme. The goal of this project is to design a functional CRISPR/Cas9 test tube model system for further research in the lab. The costs and inaccuracy associated with RNA synthesis constitute a limitation for CRISPR technology use. To this end, a truncated functional sgRNA is desired. In this study, we will also design a shortened sgRNA that is missing the trans-activating CRISPR RNA (tracrRNA) portion. The cleaving potential of sgRNA system composed entirely of shortened sgRNA is evaluated thermodynamically using isothermal titration calorimetry (ITC) and *in vitro* gel cleavage assays. The findings indicate cleavage ineffectiveness of the designed RNA, while full sgRNA is functioning normally. The ITC data suggests no noticeable difference in the thermodynamic interactions between the modified sgRNA cas9 system and the full sgRNA cas9 system.

Class 1 Integron Abundance as a Measurement of Pollution in Hudson River Tributaries

Mary Reid
Advisor: Gabriel Perron

Antibiotic resistance has become a formidable threat to public health in recent years, particularly due to the excessive use of antibiotics. Modes of resistance have rendered some cures for bacterial infections useless. While antibiotic resistance is a normal component of the environment, anthropogenic pollution has catalyzed a greater presence of resistance in nature. A considerable portion of antibiotics consumed by humans and other animals remains the same upon excretion. Moreover, wastewater treatment plants are ineffective at properly depleting the amount of antibiotics in the resulting sewage. One gene mechanism that plays a role in antibiotic resistance is the class 1 integron, a structure that can contain genes responsible for resistance. In this study, we have examined the relationship between class 1 integrons and pollutants in the Saw Kill, a tributary of the Hudson River. In the summer and fall of 2015, a research group collected samples from the Saw Kill both above and below a sewage discharge pipe, measuring the presence of class 1 integrons, pollutants such as *E. Coli*, and other environmental factors. They also collected data employing metagenomics protocols to gain an understanding of microbial diversity in relation to integron 1 abundance. After analyzing the data from this study, we found that class 1 integrons could serve as a proxy for pollution, particularly for water pollution. Moreover, we found that sediments below the outflow displayed higher levels of integron 1 abundance than sediments above, indicating that the sewage discharge does have an effect on the Saw Kill.

Tuition Cost is Correlated Most with Pressure to Succeed

John Michael Richards
Advisor: Richard Lopez

This study was aimed at understanding the various factors that affect pressure to succeed amongst American college students, with an emphasis on the financial burden of tuition. Previous research on tuition costs demonstrates that the cost to attend university has steadily and drastically increased since the mid-1970s. Student well-being and satisfaction is considered in light of the many causes of stress in a student's everyday life. The burden of tuition, familial pressure, and academic self-concept are discussed as dynamic factors in student pressure to succeed. Student well-being and the impact of stress on student learning is also introduced in the research. In this study I analyzed students' pressure to succeed using a survey that was distributed over the online platform Prolific to 78 participants . Results indicated that the most highly correlated factor with overall reported pressure was tuition cost. Second to tuition, I found that parental pressure was marginally correlated with overall pressure. Lastly, there was no correlation between academic self-concept and overall reported pressure. Possible causes for these findings are discussed. I hope that this research will create further interest into possible areas that affect students' pressure to succeed and aims at promoting equal opportunity for all students to succeed in higher education.

Untouchable Money and Impossible Clones: Applications of Quantum Picturalism and ZX-Calculus

Shea Roccaforte
Advisor: Stefan Mendez-Diez & Paul Cadden-Zimansky

Quantum Picturalism allows a new technique for researchers and students alike in the areas of quantum computation and quantum information. This picturalistic method represents fundamental math concepts and quantum theory in a diagrammatic manner. This method is a high-level language that allows for the exploitation of quantum weirdness. Using these techniques, quantum processes and the composition of those processes are highlighted as a structure referred to as process theory. Viewing these processes in a purely diagrammatic language allows for an unambiguous universal language for qubits, and the manipulation of these diagrams is referred to as ZX-calculus. These concepts allow for a hybrid diagram-symbol formalism that allows for research in finite spaces. In this thesis, we focus on the connectivity between processes and study quantum algorithms such as the no-cloning theorem and quantum money to see what can be explained and explored diagrammatically.

https://youtu.be/XuY5DpDORAs

Music as Medicine:
Supporting NASA's Advancement into Long-Duration Space Missions

Gabriela M. Rosado Torres
Advisor: Thomas Hutcheon

Considering that a new era for space exploration has begun, space scientists and engineers have devoted their time to develop the capabilities needed to send humans abroad into extended forays in space. Individuals who are subjected to these hostile environments experience various aspects of social isolation and confinement. The stress induced by living under these environmental conditions has been shown to cause changes in brain structures that negatively impact mood cognitive performance. However, it has been found that musical training can positively impact the structural and functional organization of the human brain, thus improving the mood and cognitive performance of individuals. The present study proposes to investigate the effects of musical training on 12 individuals who will spend 9-months in a space analog facility in Antarctica. Mood questionnaires and cognitive tests will be used to assess distinct changes as a response to the environment. The findings of this study will presumably support the idea that musical training prevents cognitive decline and improves psychological health under conditions of isolation and confinement. What researchers learn from this study will potentially help astronauts prepare for longer, farther exploration missions, and will also contribute insight with regard to mitigating the effects of prolonged social isolation and confinement on other members of our population.

Low One-Photon Absorption (LOPA) for 3D Microfabrication

Cecily Rosenbaum
Advisor: Christopher LaFratta

Direct Laser Writing (DLW) opened the doors for the efficient and customizable fabrication of both 2D and 3D micro- and nanostructures. Currently, Two-Photon Polymerization (TPP) is the ubiquitous DLW method; however, its use is cost inhibitive. Low One-Photon Absorption (LOPA) provides a cheap avenue for DLW and yields comparable 2D and 3D structures in their size and complexity. The underlying absorption process of LOPA is largely unknown, and thus require further investigation in order to optimize low one-photon polymerization methods. This work seeks to elucidate this underlying process, as well as demonstrate LOPA's use as an alternative to TPP.

Exploring the Roles of Exoenzymes ExoS and ExoU in the Co-Evolution of Virulence and Antibiotic Resistance in *Pseudomonas Aeruginosa*

Audrey Russell
Advisor: Gabriel Perron

Pseudomonas aeruginosa is a Gram-negative opportunistic pathogen that has been under intense scrutiny in recent years due to its rapidly evolving levels of antibiotic resistance and virulence. Although some strains of *P. aeruginosa* are harmless and can be found in virtually all soil and aquatic environments, other strains thrive in hospital environments and infect patients suffering from burn wounds and those with catheters or intubation. There are also clinical strains of *P. aeruginosa* specific to cystic fibrosis patients. *P. aeruginosa* uses a type III secretion system to inject effector proteins into host cells via a needle-like apparatus, but the specific exoenzymes it uses depends on the strain: although ExoT and ExoY are found in virtually every strain of *P. aeruginosa* , ExoS and ExoU are mutually exclusive. Nearly every existing strain of *P. aeruginosa* has one exoenzyme or the other, but on rare occasion a strain will be found that has both or neither. This study uses statistical methods in R to analyze genotype and phenotype data from a pre-existing library of *P. aeruginosa* strains with the goal of learning more about both exoS and exoU, and how selection for either exoenzyme contributes to the antibiotic resistance and virulence of a given isolate. Results varied, but most were compatible with existing literature on the *P. aeruginosa* type III secretion system. While selection for either exoenzyme did not directly correlate with antibiotic resistance, ecological niche influenced isolates' resistance to several antibiotics. A deeper dive into how exoenzyme selection and virulence differed between ecological niches revealed that although ExoS was consistently more common, ExoU was indicative for higher virulence in every niche except that of cystic fibrosis, where infections are chronic rather than acute. Another result serving as an avenue for further research is increased selection for ExoU, the more fast-acting and virulent of the exoenzymes, over time. This indicates co-selection for ExoU alongside antibiotic resistance genes.

Detection of C-Reactive Protein Using an ELISA Immunodot as a Proof-of-Concept for Paper Microfluidics

Frank John Rybicki IV
Advisor: Christopher LaFratta

Medicine relies heavily on diagnostic testing. Before the end of 2019 – the beginning of 2020, the modernized world took for granted accurate and available diagnostic tests. The COVID-19 pandemic taught the world, even the wealthiest countries, how fragile human health can become when tests are lacking. The assumption of available testing and the confidence in test results has been seriously challenged. With these challenges, Point-of-Care (PoC) tests have transgressed medicine and science to include politics, finance, and humanity at its core. This Bard senior project is rooted in the science of a proof-of-concept paper-based ELISA Immunodot assay for the detection of C-reactive protein (CRP). CRP can be identified at varying blood concentrations found in humans physiology and disease. CRP testing is used for clinical diagnoses millions of times per month in the United States. The results confirm that the ELISA Immunodot can both distinguish CRP+ and CRP standards and semi-quantitively predict the CRP concentration of the standard. The ability to relate the intensity of the CRP colorimetric output to a standard CRP concentration has potential applicability in future medical testing.

Investigating the Role of GABA Signaling in Oxygen Deprivation Using *Caenorhabditis elegans*

Elias Ryu
Advisor: Heather Bennett

Oxygen is vital for multicellular organisms to respire, produce energy, and ultimately survive. Anoxia, as medically defined, is a complete deprivation of oxygen to the brain and is considered one of the deadliest injuries. Evidence shows that a short period of sublethal stress can protect cells from the harmful effects of anoxia in an effect known as preconditioning. While the benefits of hypoxic or ischemic preconditioning have been documented in several organisms, it remains unclear how anoxic preconditioning is working. Recent work by Bennett et al. showed that inactivation of the general nervous system, specific neuronal groups including cholinergic and GABAergic neurons, or body wall muscles prior to a 48-hour anoxic insult conferred a survival benefit in *C. elegans*. This indicates that the nervous system and GABA signaling are driving the preconditioning response to oxygen deprivation. GABAergic neurons connect to enteric, body wall, and head muscles. GABA mutants show defects in enteric function, locomotion, and foraging. Currently, it is unclear how loss of GABA signaling yields protection against oxygen deprivation and which specific GABAergic genes are responsible. This paper proposes a series of anoxic assays testing how loss-of-function in GABAergic genes affects survival in order to locate the GABAergic genes responsible for conferring the protective effect under anoxia. The information gained from these experiments will highlight the role of GABA in sensitivity to oxygen deprivation.

Progress Toward the Biochemical Characterization of a Protein Involved in the Production of Microbial Plastics

Stella Rose Schneeberg
Advisor: Atahualpa Pinto

Poly(3-hydroxyalkanoates) (PHAs) are biodegradable polymeric materials that are of interest due to their ability to serve as green alternatives to the less environmentally friendly petroleum-based plastics that populate our modern world. PHAs are produced by various microorganisms from sugar and fatty acid feedstocks, and they are degraded by microorganisms as well. The metabolic fundamentals of the production of PHAs can be investigated through studying the behavior of the protein PP_0763 from the soil bacterium *Pseudomonas putida KT2440*, which is involved in the metabolic redirection of intracellular fatty acids toward PHA biosynthesis. PP_0763 has been successfully expressed and purified, and insight can now be gained into the substrate specificity of this protein via biochemical assay. In order to move forward with assay design, in this study we demonstrate our progress towards the synthesis of a panel of enantiopure 3-hydroxyfatty acids via an asymmetric aldol strategy. Once complete, our assay will test the protein's affinity for 3-hydroxyfatty acids of varying hydrocarbon chain lengths, leading to clarification of the role the protein plays in PHA biosynthesis.

Figuring Out White-Tailed Deer Habitat Selection with Camera Traps: Another Step Towards Mitigating Human-Wildlife Conflicts

Colin Schroeder

Advisor: Bruce Robertson

White-tailed deer are a prominent and very recognizable species that inhabits the Hudson Valley. Yet, tracking their movements and lifestyle preferences is not so easy. Through the use of camera trap technology, I monitored wildlife for constant 24-hour days. With these cameras, I answered the question, does mating season have an effect on what habitats white-tailed deer spend their time in? The answer here aids in mitigating human-wildlife conflicts, such as car collisions, with white-tailed deer. This is because when we know where they prefer to spend time, we can either better avoid them or deter them from spaces in which they will interact with humans. In the field I had 5 forest sites and 5 grassland sites, the two habitats I chose to determine habitat preference. Each site was equipped with two cameras that used infrared monitoring to take pictures when a species moved into its field of view. Cameras were in the field for 3 weeks each for both seasons. I hope the photos I captured that helped me determine habitat and other trends for white-tailed deer on Bard campus can lead to further studies on white-tailed deer behavior and further conflict reduction strategies at or around Bard College.

https://www.linkedin.com/posts/colin-schroeder-470738157_senior-project-poster-presentation-activity-6798629612977995777-kbhO

Back to Wonderland:
Can Imaginative Play Improve Creativity in Adults and Children within a Single Session of Play?

Poppy Field Sheehan
Advisor: Thomas Hutcheon

This experimental proposal examined the immediate effects of imaginative play on the creativity of fifty adults (ages 18-65) and fifty children (ages 6-10). Both children and adults were randomly assigned to an experimental group (Group A) or a control group (Group B). After arriving at the lab, all participants, regardless of age or group, completed the Alternate Uses test for the first time. Those in Group A were individually taken into an empty room that contained a table and a chair. On the table there were three toys (a small dollhouse, a Calico Critters treehouse, and a Lego fire station). Participants were strongly encouraged to play by the researchers, and given twenty minutes to do so. Adults in Group B were given twenty minutes to read a positive article, while children in Group B were read to for twenty minutes by a researcher. After either reading or playing, all adult participants completed the Subjective Happiness Scale (Lyubomirsky, & Lepper, 1999), and all child participants completed a Smiley Face Likert Scale. Then, all participants took the Alternate Uses Test again. As I had hypothesized, participants who played with toys showed a greater increase in their Alternate Uses Test scores than those who read/were read to.

Exploring the Biotic and Abiotic Environmental Interactions of Soil Chemistry and Novel Bacillus Spp. Isolates

Mia Sheshova
Advisors: Brooke Jude & Emily McLaughlin

The complex heterogeneity of soil makes it challenging to study the biological and chemical processes involved in its biotic environment. Nevertheless, the interaction between the biotic and abiotic environment can explain the symbiotic and antagonistic relationship between the soil and its surroundings. In fact, soil microbiota plays an essential role in the decomposition, nutrient cycling, and fertilization of the soil, which exemplifies the importance of bacteria in affecting the soil's chemistry. Bacteria are the messengers of chemical diversity in the soil. Therefore, measuring the distribution of inorganic matter while trying to unravel the bioactive compounds secreted by the bacterial secondary metabolism highlights the differences between soil locations. To better understand the presence of certain bacteria and their metabolites, this study aims to compare the soil chemistry of locations with artificial or natural turf in order to correlate their distinction with the production of bioactive compounds that elicit antimicrobial activity against the ESKAPE pathogens, species known for virulence and antibiotic resistance. This study focuses on the characterization of phenotypic and genomic identities from three novel *Bacillus* strains isolated from natural and artificial turf. Our goal is to examine the relationship between the three bacterial strains and the soil's chemical composition through digestion/extraction and analysis techniques using NMR, GC/MS, ICP/OES and FT-IR analysis.

The Effect of Remittances on Ethnic Tension

Suyog Shrestha
Advisors: Stefan Mendez-Diez & Aniruddha Mitra

With the massive increase in global remittances in the recent decades, migration study has gained a lot of attention from scholars in social sciences. In particular, the effect of remittances on various socio economic variables have been studied. Furthering this literature, we study the effects of remittances on ethnic tension. Using the Ordinary Least Squares with Panel-Corrected Standard Errors, we find that i) remittances has less impact on ethnic tension in countries with lower variance of ethnic tension than those with higher variance ii) remittances increases ethnic tension in countries that already have higher ethnic tension than the global mean, whereas it lowers ethnic tension in countries that have lower ethnic tension than the global mean.

https://youtu.be/d7FcuqGyLhw

Ultrasound as a Potential Communication Pathway in Tomatoes

Parker Smith
Advisor: Cathy Collins

Communication is a cornerstone of organisms' fitness and survivability. Whether announcing a food source or warning of danger, the ability to communicate shares the benefits of a group's collective senses, rather than relying on an individual. When imagining these behaviors, a tomato plant may hardly be what comes to mind, yet plants are surprisingly more receptive to inter- and intraspecies communication than one may originally think. In the case of attack from herbivory, certain plants will emit volatile organic compounds (VOCs) through the air, which other plants may receive and use to activate certain defense genes, even before the plant itself is attacked. Alongside VOCs, certain plants will emit an ultrasonic "squeal" at a consistent rate throughout the course of the stressor. Previous studies done with flowering plants and bees shows that the ultrasonic noise produced by the vibration of nearby bees increases the concentration of sugar in the plants' nectar to attract the pollinators. Given that plants are capable of physiologic changes triggered by environmental cues, I plan to observe the physiological changes that occur in plants within environments containing ultrasound. Ultrasonic noise pollution is a growing concern in a rapidly modernizing world, and understanding the connection between plants' response to this noise, may help inform farmers and agricultural technology in order to minimize damage.

Fungal Endophytes in Pre-Dispersed Seeds Can Influence Germination in Hosts and Non-Host Plant Species

Peter Sojka
Advisor: Cathy Collins

To date, it's been commonly thought that endophytic bacteria and fungi have been horizontally transmitted onto the seed, however, vertical transmission from the parent plant to offspring (via seed) is becoming a more widespread phenomenon. Here, I explore the idea that vertically transmitted endophytic fungi exist in pre-dispersed seeds. It was also of interest to test whether fungi grown from these seeds influenced germination of their host, or seeds of other species. I find that *E. rugosum*, *Solidago spp*., and *A. syriaca* seeds harbor vertically transmitted endophytic fungi which morphologically appear to be of the same species. I find that Fungi isolated from *E. rugosum* seeds decreased germination of host seeds. I also further examine the relationship between fungi and non-host seeds by studying *T. aestivum*, *R. sativus*, and *L. perenne* seeds, and find that *E. rugosum* fungi and *A. syriaca* fungi can decrease germination in *T. aestivum* seeds.

Can You Hear Me Now?
Observing Zebrafish larvae (*Danio rerio*) to Investigate Arpc1a Gene Expression in Hopes of Developing Hair Cell Regeneration to the Mammalian Cochlea

Lia Solensten
Advisor: MIchael Tibbetts

The sense of hearing helps organisms function within their environment. Species with biological structures for auditory function use hair cells rooted along the tympanic membrane to transmit the pressure waves from the environment into a signal recognizable to the brain, resulting in the interpretation of sound. Over time, these hair cells can face damage from a multitude of different factors including loud nose, physical trauma, and ototoxic drugs, which eventually result in hair cell loss decreasing the ability to hear. The hair cells within the ear of humans cannot regenerate causing permanent hearing loss or deafness. Zebrafish (*Danio rerio)* possess the ability to regrow hair cells located within their lateral line system in a matter of hours. This system helps the fish detect movement throughout the water, consisting of structures called neuromasts. The hair cells within the neuromasts are analogous to that of the hair cells found within the mammalian cochlea making zebrafish an excellent model species to study hair cell regeneration.There is little information on the mechanism behind hair cell regeneration in humans, and therefore turn to studying hair cell regeneration within the zebrafish lateral line. Scientists investigate this by identifying the location of certain genes and their expression within the zebrafish lateral line using *in situ* hybridization. For my senior project, I will be using *in situ* hybridization to examine the location of expression of the gene Arpc1a three hours post hair cell ablation. By understanding the location of the gene expression in the zebrafish, this will identify whether or not the gene plays a role in hair cell regeneration and could help contribute towards a cure to solve degenerative deafness in humans.

Tverberg Type Partitions: Sub-Regular and Elliptical Polygons

Tobias Timofeyev
Advisor: Steven Simon

Tverberg's theorem states that given a set S of $T(r, d) = (r - 1)(d + 1) + 1$ points in R^d, there exists a partition of S into r subsets whose convex hulls intersect. A feature of Tverberg's theorem is that $T(r, d)$ is tight, so in this senior project we investigate Tverberg-type results when $|S| < T(r, d)$. We found that in R^2, given a set S of $T(r, 2) - 2 = 3r - 4$ points, and assuming $r = r_1 r_2$, there exists a partition of S into r sets such that when grouped into r_1 collections of r_2 sets, the convex hulls of each collection overlap, and we can find the vertex set of a regular r_1–gon with one point from the intersection of each collection. We also show that given a similar construction but with $|S| = 3r–6$, we can find the vertices of an r_1–gon in the intersections of convex hulls, with vertices on an ellipse, and other nice regularity properties.

Lagrangian Cobordisms of Legendrian Pretzel Knots with Maximal Thurston-Bennequin Number

Raphael Walker
Advisor: Caitlin Leverson

In the study of Legendrian knots, which are smoothly embedded circles (i.e., knots) constrained by a differential geometric condition, an actively-studied problem is to find conditions for the existence of Lagrangian cobordisms, which are surfaces (with a similar geometric condition) whose slices are specific Legendrian knots at either end. We demonstrate an infinite family of smooth knots {P_n}, each of which has a Legendrian representative which both maximizes (over all Legendrian representatives of P_n) the Thurston-Bennequin number, and admits a Lagrangian cobordism from a Legendrian unknot (the simplest smooth knot: a circle).

The Use of Virtual Manipulatives in Teaching Sorting Algorithms

Olivia Witanowska
Advisor: Keith O'Hara

This project builds an online tool for users to practice tracing sorting algorithms on a virtual set of cards. Sorting algorithms are crucial to computer science. Visualization of such algorithms can aid in cementing the concepts. The purpose of a virtual manipulative is to create a similar effect of a physical manipulative but on a digital platform so that it is more accessible than its physical alternative. This project is motivated by the educational adjustments needed to be made during the 2020 Covid-19 pandemic. By building off of a previous Deck of Cards project, an algorithm to check a user's work is implemented to allow users to receive immediate feedback on their tracing of a sorting algorithm at any point in time.

Using Markov Chain Monte Carlo Algorithms to Predict Gerrymandering

Jazmin Zamora
Advisor: Lauren Rose

Current research in the mathematics of Gerrymandering involves the use of Markov Chain-based algorithms called the Flip and ReCom algorithms. The Flip algorithm creates new districts by checking for contiguity and adding vertices to a graph if contiguity is preserved, and removing vertices if equal population is violated. The ReCom algorithm creates new districts by creating spanning trees onto grid graphs, and bipartitioning these spanning trees if it preserves equal population. Our work focuses on using these methods to study the districting structures on mxn graphs and spanning trees on grid graphs.

https://tinyurl.com/25k6kbd7

fruitless in *Drosophila melanogaster* and the Specification of Courtship Circuitry

Sarah Zylka
Advisor: Michael Tibbetts

Male-speciic courtship behavior in *Drosophila melanogaster* occurs as a result of sexually dimorphic neural structures. The *fruitless* gene in *Drosophila melanogaster* encodes for sex-speciic transcription factors and is considered to be the master regulator in the speciication of courtship circuitry. Sex-speciic and common *fruitless* transcripts encode for an array of putative transcription factors that regulate downstream targets. Antibody staining was used to visualize the localization of male-speciic FRU^M proteins. FRU^M protein expression was detected in the central brain region and the ventral nerve cord of the central nervous system in third-instar larvae males. The FRU^Mlocalization observed was consistent with *fruitless* speciied neural structures in the brain and neural innervation from the abdominal ganglion into the Muscle of Lawrence. Further investigation into *fruitless* 's role in a regulatory hierarchy paired with its role in sensory integration and behavior execution allow it to give useful insight into the relationship between genes and behavior.