THIRTY-SECOND ANNUAL

Research COLLOQUIUM

SOUTH CAROLINA GOVERNOR'S SCHOOL FOR SCIENCE + MATHEMATICS

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Abstract Book for the Thirty-Second Annual Research Colloquium

March 3, 2021

South Carolina Governor's School for Science & Mathematics
Hartsville, South Carolina

Volume XXXII

The art throughout this book was provided by students participating in the Pandemic Pen and Ink Project under the guidance of Patz Fowle, GSSM's Visual Arts Coordinator & Art Instructor.

Luke Phillips (Class of 2021) - *This work is meant to portray the role of COVID-19 in my life. The depiction of the virus is meant to feel dark and imposing over the figure. In contrast, the figure below the virus is meant to look bright and elegant. The background is watercolor. The virus and figure were drawn with micron pens.*

PROGRAM

1:30PM ……...Welcome & Distinguished Research Leadership Award

1:45PM …….Concurrent Research Presentations – Session One

2:45PM ……..Break

3:00PM …….Concurrent Research Presentations – Session Two

4:00PM …….Annual Research Colloquium Concludes

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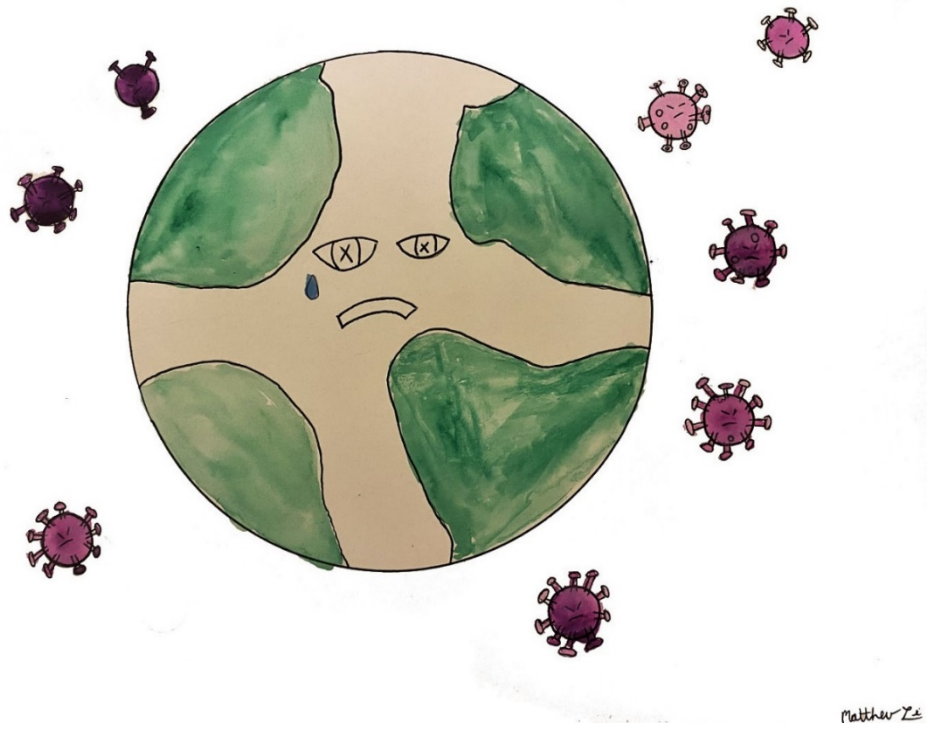

Matthew Li (Class of 2021) - *When I first thought of COVID I thought of it as little germs. This image represents how I viewed COVID as something that has harmed the Earth, specifically the people. I believe that COVID has ruined many lives and has caused people's morals to become worse. I drew the Earth with a face that is crying because it represents how the people are suffering in the world caused by the Coronavirus.*

Anavami Isa (Class of 2021) - *Recently, we've been surrounded by various problems and challenges, whether it be restrictions caused by the coronavirus or damages caused by deforestation and air/water pollution. In my piece, I illustrate how these different elements, along with our own cognitive ability and creativity come together to create a composition that is chaotic yet balanced, similar to our night sky. This composition defines us and makes us who we all are, almost as if it is in our blood.*

THE GOVERNOR'S SCHOOL FOR SCIENCE & MATHEMATICS

One of the few specialized public residential high schools of its kind, the South Carolina Governor's School for Science & Mathematics (GSSM) exists to push motivated young learners beyond their perceived levels of academic ability. Founded in 1988 under the leadership of the late Governor Carroll Campbell, GSSM has consistently raised the bar for STEM education in the Palmetto State. GSSM's two-year residential high school program—as well as its virtual high school program, summer camps, and outreach programs—all invite young people to explore the subjects they love in a diverse, inclusive, and uncommonly supportive academic environment. Here, challenge is viewed as a gateway to opportunity. GSSM students embrace the school's rigorous approach to education and in so doing begin to realize their full potential.

RESEARCH & INQUIRY AT GSSM

GSSM provides unique opportunities for students to engage with the process of research & inquiry under the mentorship of experts across a diverse array of disciplines. Since the founding of the Summer Program for Research Interns in 1989, more than 2500 students have worked with over 750 mentors at 125 institutions. Major participating institutions include Clemson University, the Medical University of South Carolina, and the University of South Carolina, as well as many other colleges, universities, industries, and private institutions across the United States and the world.

Through these distinctive opportunities, GSSM students experience rigorous approaches to solving challenging problems, develop critical & creative thinking skills, and practice communication of complex information. Research & inquiry at GSSM is preparing creative problem solvers for the challenges of tomorrow.

ANNUAL RESEARCH COLLOQUIUM

Since 1990, GSSM's Annual Research Colloquium has been an opportunity for GSSM students to share their research accomplishments and experiences. The GSSM research & inquiry experience provides our students with the opportunity for exploration, discovery, and individual growth. Colloquium also reflects the duty of scientists, explorers, and innovators to not only discover, but to effectively communicate that knowledge to others. In this time-honored tradition of science, Colloquium is our opportunity to share, celebrate, and learn as a community.

ABOUT THE COVER ART

From the Cover: "For my Pandemic Pen and Ink Project, I used Pigma micron pens and a Faber-Castell Pitt Artist Pen to draw zentangle patterns and accentuate the stark white hands. The hands work to make the drawing COVID-related as they represent human contact. The hands, linked only by one finger, symbolize tenuous physical connection during this time of low-to-no contact due to the pandemic and the struggle faced by people craving interpersonal connection." - Gracen Anne Thompson (Class of 2021)

DISTINGUISHED RESEARCH LEADERSHIP AWARD

Randy M. La Cross

Senior Vice-President for Virtual & Outreach
South Carolina Governor's School for Science & Mathematics (Hartsville, SC)

Randy M. La Cross has been an integral part of GSSM since 1998. He became the Vice-President for Outreach & Research in 2005 and Senior Vice-President for Virtual & Outreach in 2021. Prior to joining GSSM, Mr. La Cross taught high school science in Darlington County, as well as coaching football and girls' track & field. He has also taught science in Kershaw County and science education at Francis Marion University. Mr. La Cross received his Bachelor of Science and Master of Education degrees from Francis Marion University. He is the 2008 recipient of the Lawrence S. Swails Outstanding Alumni Award from the Biology Department at Francis Marion University for outstanding contributions to STEM education.

Without the leadership and significant contributions of Mr. La Cross over many years, the student research & inquiry experience would not be available to all GSSM residential program students. Mr. La Cross worked with GSSM research partners to expand opportunities to keep pace with the growth of the GSSM student body from a starting point of 60 student placements to as many as 150 each Summer.

Under his leadership, GSSM's student research & inquiry program not only expanded in size, but also in reach to include national opportunities, such as GSSM's ongoing partnership with the Massachusetts Institute of Technology's Beaver Works Summer Institute, and international research in China, Germany, and South Korea through the Research Experience Scholars Program. Mr. La Cross has also been a valuable partner for the GSSM Foundation as they raise funds to support student research & inquiry and outreach experiences.

Dr. John Morse - Clemson University Professor Emeritus of Entomology, inaugural Distinguished Research Leadership Award honoree, and research mentor from 1991-2014 - said, "I consider the privilege of working Randy a singular honor and a highlight of my career. He did an amazing job to improve the national stature and expand the number of notable and dedicated mentors for the GSSM's Summer Program for Research Interns, even as the school doubled in size. My congratulations and best wishes for you, Randy, as you are appropriately honored in this special way."

GSSM's Outreach programming reaches several thousand South Carolina students every year through camps, after-school programs, classroom visits, and teacher training. During the Summer of 2020, Mr. La Cross led the Outreach team in pivoting to highly successful remote learning experiences when the COVID-19 pandemic made in-person camps impossible. For many students, these programs are their first contact with the opportunity that a GSSM education provides.

GSSM selected Mr. La Cross to receive the Distinguished Research Leadership Award prior to the impacts of the COVID-19 pandemic. However, the student projects presented by the Class of 2021 at the GSSM Annual Research Colloquium were only possible due to the strength of the relationships Mr. La Cross nurtured between GSSM and South Carolina's research institutions.

MR. LA CROSS – THANK YOU FOR YOUR TIME, TALENT, AND COMMITMENT TO GSSM STUDENTS!

GSSM RESEARCH & INQUIRY AWARDS

There are many people who have contributed to the success of student research & inquiry at GSSM represented among the honorees and acknowledgements in the following pages.

Two individuals, Dr. William C. Alexander and Randy M. La Cross, stand out for their essential contributions to the student research & inquiry experiences at GSSM.

The **Dr. William C. Alexander Excellence in Research Award** is presented annually to the graduating senior who best represents the principles of scientific research & inquiry as applied to real world problems, the ability to clearly communicate that understanding, and the resiliency to work through the challenges presented. Presented at the academic awards ceremony at the end of the school year, it is considered one of the most prestigious student academic awards bestowed by GSSM. "Dr. Bill" founded the Summer Program for Research Interns during the 1989-1990 school year.

Starting this year, the Distinguished Research Leadership Award will be known as the **Randall M. La Cross Distinguished Research Leadership Award**. This award honors an individual who has made significant contributions to the success of GSSM student research & inquiry experiences through years of service to the transformative potential of engaging students in the rigorous processes of research & inquiry. Through Mr. La Cross's leadership, the ability to connect students with research mentors has grown with the expansion of GSSM's student population, students have gained opportunities to conduct research internationally, and GSSM built relationships with research partners to provide sustained access to these experiences to all students.

It is fitting that the two research & inquiry awards bestowed by GSSM – the Dr. William C. Alexander Excellence in Research Award and the Randall M. La Cross Distinguished Research Leadership Award – reflect these two pillars upon which the GSSM research & inquiry experience is built.

AWARD RECIPIENTS

Dr. William C. Alexander
Excellence in Research Award

2012 – Kiersten Rule
2013 – Esme Kemp
2014 – Natalie Alvarez
2015 – Sean Cosh
2016 – Bailey Fallon
2017 – Anish Chaluvadi & Claire Moore
2018 – Madelaine Tedrick
2019 – Colie Brooks Taylor
2020 – Katelynn Thorne

Randall M. La Cross
Distinguished Research Leadership Award

2015 – John Morse (Clemson University)
2016 – James Carson (University of South Carolina)
2017 – Barbara Speziale (Clemson University)
2018 – Steven Kubalak (MUSC)
2019 – Julian P.S. Smith III (Winthrop University)
2020 – Caryn E. Outten (University of South Carolina)
2021 – Randy M. La Cross (GSSM)

Andrew Chekanov (Class of 2021) - *In the drawing, the coronavirus is represented by the two circles, and the two V-shaped arrows or chevrons represent the new vaccines, like mRNA, that are being developed to combat the coronavirus. The complex 3-D design in the chevrons represent the new vaccine technology that is being used to combat the coronavirus. My theme is that we have to adapt and use new technology that may be foreign to us in order to defeat this new virus. In the drawing, one of the chevrons is seen directly piercing through one of the coronavirus cells, destroying it.*

ACKNOWLEDGMENTS

Student research & inquiry experiences require collaborations within GSSM, but also across South Carolina, the nation, and the world. This group includes world-class researchers volunteering to serve as mentors, GSSM faculty & staff, coordinators and advocates at our diverse array of research partners, the material support of the State of South Carolina, and the donors to the GSSM Foundation. Our gratitude goes out to the individuals & organizations listed below, as well as the family and friends who provide the support necessary for our student to truly challenge themselves.

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The South Carolina Governor's School for Science & Mathematics thanks the researchers and institutions that provided mentored research & inquiry experiences to GSSM Students.

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Sudeep Popat
Apparao Rao
Yongqiang Wang

Clemson University International Center for Automotive Research
Bing Li

Clemson University Pee Dee Research & Education Center
Sachin Rustgi

Clemson University Restoration Institute
Eric Patterson

College of Charleston
Lancie Affonso

Converse College
Christopher Varnon

Furman University
Chris Healy

MIT – Beaver Works Summer Institute
Rebecca Arenson
Robert Seater

Native American Studies Center, USC – Lancaster
Christopher Judge

Newberry College
Charles Horn

Piedmont Pediatrics
Sally Burgess

SC Department of Natural Resources - Heritage Trust
Meg Gaillard

SC Economics
Jim Morris

SC GSSM
Gordon Brown
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Kathryn de Ridder-Vignone
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Julian Smith III

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GSSM RESEARCH ADVISORS

GSSM thanks our faculty & staff members who guided students in the preparation of their presentations.

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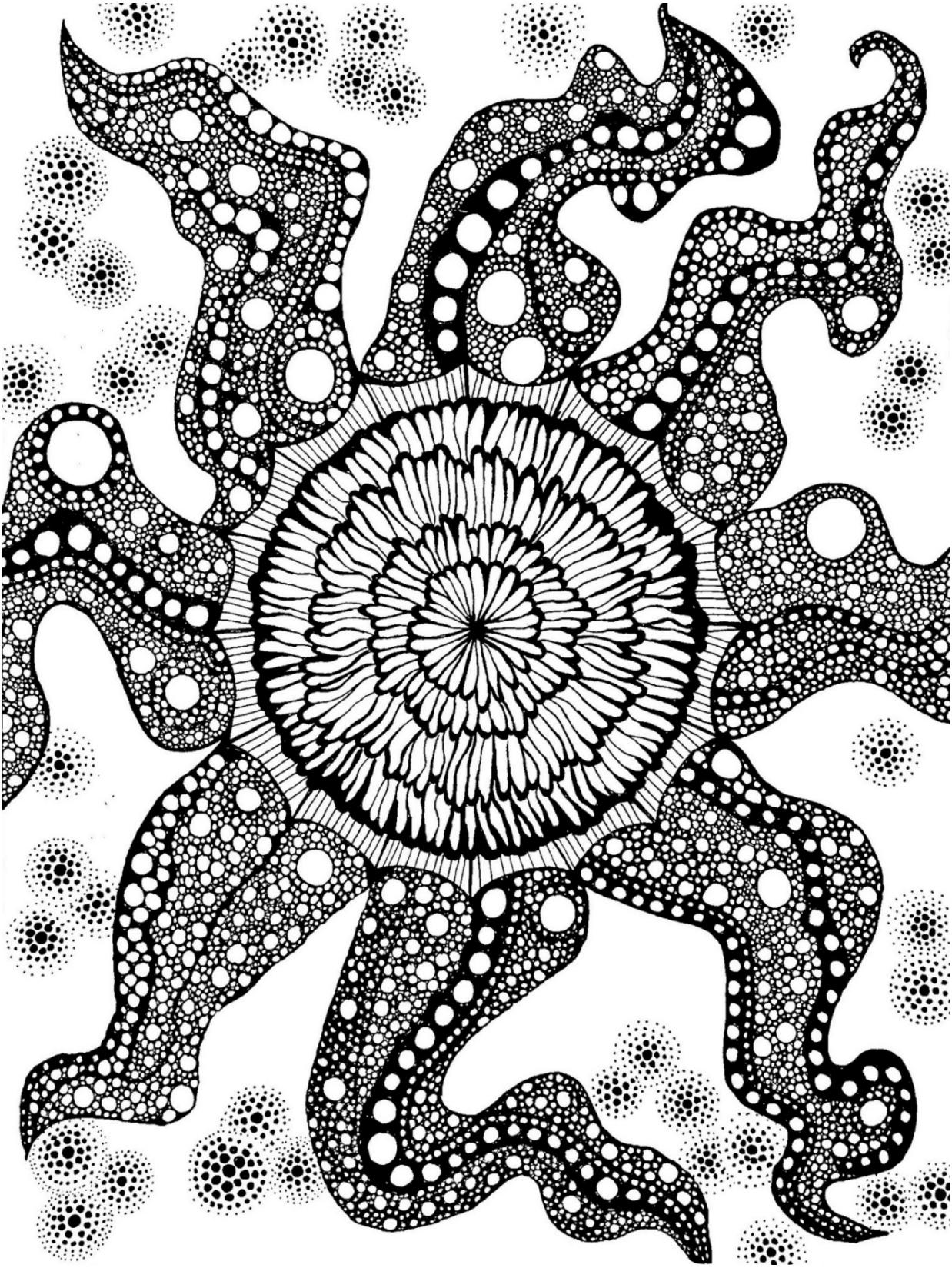


Pia Kayser (Class of 2021) - *When creating my art, I started with the basic shape of the virus itself, a circle. From there I tried to imagine what it looked like almost personified. I gave it long tentacle like structures that represent the spike proteins on the actual virus. Around the main virus cells are other smaller ones, almost following the lead of the "evil" main virus attacking and invading its host.*

ABSTRACTS

MODIFYING SERIOUS GAMES USING REINFORCEMENT LEARNING FOR DATA COLLECTION

Evan Ackerman
Mentor: Robert Seater (Massachusetts Institute of Technology - Beaver Works Summer Institute)
GSSM Advisor: Paul Dostert

Serious games came to fruition within the past fifty years or so; their predecessor and/or relative is better known as a simulation. Serious games gather important data through putting users in certain conditions and situations, gathering reactions and choices, and often testing against an artificial intelligence agent. To create these data collection testing environment, my software team and I made a modification to an existing game that used disease propagation to model a zombie and flu-like pandemic. We approached the modification with ideas on how to make the rudimentary data more valuable through creating a better environment for the player. We accomplished this through three changes: creating a graphical user interface to increase ease of use, implementing a trust system to increase realism, and generating random events to better analyze impulse user decision and again further realism. We tasked an artificial intelligence agent to find the best possible score using reinforcement learning, which is a category of machine learning that utilizes trial and error to discover trends, exploits, and non-human results. Given that my research experience was not focused on gathering specific data or testing a certain hypothesis but was rather a chance to gain valuable professional and educational experience with computer science while also creating a feasible project, I only have proposed theoretical data claims that I can make. Our modification does indeed present a more detailed account of both general disease propagation and our specific chosen zombie and flu viruses and human behavior when put in these scenarios.

EXAMINATION OF NUTRITIONAL INTAKE AMONG COLLEGIATE MARCHING BAND ARTISTS

Raeva Bali & Lillian G. Coats
Mentor: Toni Torres-McGehee (University of South Carolina)
GSSM Advisor: K Sris

Statistics show that marching band artists do not receive enough information on basic physiological guidelines to stay healthy, so this research was utilized to examine the low energy availability, to examine low energy availability and macronutrient intake, and to examine hydration statue and micronutrient intake (Potassium, Sodium, and Calcium) in collegiate band artists. MB artists from the University of South Carolina "Carolina Band" completed a survey and measured their bodily dimensions. For one week, participants were asked to complete food logs to measure energy intake (EI), wore a Polar m200 watch to estimate the energy exercise expenditure (EEE) during performances, and provided a urine sample to measure urine specific gravity (Usg). Basic statistics analyzed all energy needs and Usg for subjects in the study. Chi-square was used to identify proportions of participants "at risk" for LEA and dehydration and compared the variations with sex. Significant differences were found for EI between males and females in the study. No significant differences were found for EEE and EA between males and females. Overall, 73.7% of participants (n=28) were at risk for LEA. No substantial differences were found for Usg and sex, however, 36.8% (n=14) reported being chronically dehydrated (≥4/7 days>1.025). Of those with LEA (n=28), 31.6% (n=12) also reported as chronically dehydrated. Due to performances in hot and humid environments while also wear heavy and hot uniforms, and the actual physical demands associated with MB, healthcare professionals should provide appropriate nutritional resources and education on hydration and proper fueling for MB artists.

LITERATURE REVIEW ON COVID-19 IN SEARCH FOR POSSIBLE TECHNIQUES TO DEVELOP SARS-COV-2 MIMETIC PARTICLES

Karthik Beeraka, Caspen Gregory, Ethan Mills & Savannah Pender
Mentor: Bruce Gao (Clemson University)
GSSM Advisor: Reginald Bain

SARS-CoV-2, the novel coronavirus that causes the disease COVID-19, has had a devastating impact on peoples and nations across the world. COVID-19 shows high rates of human-to-human transmission and can be deadly, causing the World Health Organization to declare a global pandemic on March 11th, 2020. Researchers have had to scramble to adapt as the virus rapidly spreads and new information is found. Here, we review recent publications on COVID-19 with the intention of understanding the structure of the SARS-CoV-2 virus, its impact on the human body, its modes of transmission, contemporary treatments for those affected by COVID-19, and the difficulties of researching the virus. One of the chief goals of our literature review is to study how so-called "mimetic particles" may be developed to study the SARS-CoV-2 virus and potentially aid in the development of treatments or vaccines for COVID-19.

ACADEMIC CHANGES DURING COVID-19: ANALYSIS OF THE RELATIONSHIP BETWEEN TEST ANXIETY AND EDUCATION MODALITY

Aubrey Best
Mentor: Michael Newsome (South Carolina Governor's School for Science & Mathematics)

This research project considered student preferences on testing in the virtual environment, and factors contributing to student test anxiety. To gather student opinions, a three section survey was distributed electronically to seniors at the South Carolina Governor's School for Science and Mathematics in September of 2020. Due to COVID-19, these student respondents had experienced a switch from residential to a completely virtual environment in the spring of 2020. The first section of the survey utilized questions from the valid and reliable Test Anxiety Inventory, written by Charles Spielberger, to gauge a general measure of student test anxiety. The second section asked the students to respond to statements regarding the effectiveness of online learning. The final section elicited responses concerning online and in-person testing.The survey results show that students with higher TAI scores are less likely to agree that online education is as effective as in-person education. These results may be used to improve future effectiveness of online learning and to reduce student anxiety surrounding testing.

OPTIMIZING THE COMPUTATIONAL PARAMETERS OF FERRITE COMPOUNDS

Jada Bonds
Mentor: Rachel Getman (Clemson University)
GSSM Advisor: Gordon Brown

The compounds nickel ferrite ($NiFe_2O_4$), cobalt ferrite ($CoFe_2O_4$), manganese ferrite ($MnFe_2O_4$), and zinc ferrite ($ZnFe_2O_4$) have many useful magnetic properties. We have experimented with these compounds to try and stabilize them to make them easier to use for medical purposes – such as magnetic drug delivery, radio-frequency hyperthermia, magnetic resonance imaging (MRI), medical diagnostics – and materials like loud-speakers, small electric motors, and refrigerator magnets. In order to make these compounds stable, we tried to optimize the magnetic moment and lower the energy. Doing these two things will change the structure and distribution of ions in the compound, making it more efficient and stable. We adjusted the magnetic moment and energy of these compounds through computational parameters such as the mixing flags in the INCAR coding file. Mixing flags change how the ions in compounds are distributed and structures. This directly affects the energy and magnetic moment of the compound. We tested multiple different combinations of values with these mixing flags to see how they affected the compounds. We used values specific to each mixing flag according the VASPwiki website. We found that mixing flags do not affect the values of the magnetic moment or energy of the compound, therefore not affecting how stable the compound is as well. In the future we will experiment with other methods and parameters to see what can affect the stableness of a compound and how it is affected.

NATIVE BEADS AND BURIALS

Camryn Brown & Emily Geraghty
Mentor: Christopher Judge (Native American Studies Center - University of South Carolina - Lancaster)
GSSM Advisor: Karl Rohr

Native burials require meticulous sensitivity when unveiling their secrets. Every piece of them counts in the search for conclusions on native culture and connections. Burials appear in all shapes and forms, and are not necessarily an individual thing. Commingled burials have been a common occurrence between many different tribes. Through our readings, we put together spreadsheets about a variety of burials through the Carolinas and surrounding areas. This allowed an effective analysis of the various methodologies and different relationships between burials. This also allowed us to see similarities between tribes in the Southeast. Covid heavily affected our research as well. Instead of physically going to the Native American Studies Center to conduct our research, all materials were set to us. However, we were lucky enough to receive field experience on an active dig site in South Carolina. Most of the commingled burials we have studied are family members, such as the mother and child, or the siblings found at the Kobe site. Analysis of this data had to consider the sensitivity of intrusive burials and what to take from those burials. We also investigated the significance of shell beads found in burials across the East. Shell beads were not found in all burials, only select ones. Our research can help explain the long process of making shell beads, trade between tribes, and shell beads designating certain accomplishments or affiliations.

SYNTHESIZING SEIR DIFFUSION AND ERLANG DISTRIBUTION TO DEVELOP A MORE REALISTIC, APPLICABLE EPIDEMIOLOGICAL MODEL

Lucia Brown & Vansh Nagpal
Mentor: Paula Vasquez (University of South Carolina)
GSSM Advisor: Nicole Kroeger

The creation of effective, comprehensive models is critical for understanding the spread of disease. The basic SEIR model is commonly used in epidemiology, with a crucial application being disease policy development. The SEIR model compartmentalizes the population into four groups—those who are susceptible, exposed, infected, and recovered. The model can be made more realistic by considering further variables. Using the computer software MATLAB, this study analyzed variables for two main SEIR modifications, the SEIR diffusion model (SEIRD) and the SEIR Erlang distribution model, with the goal of synthesizing the two to create a more realistic SEIR model. To investigate the SEIRD model, initial conditions and distribution spread values for Gaussian models were first altered in MATLAB and graphs were produced. The results of different modifications to the SEIRD model were further investigated by examining altered diffusion constants. A similar approach was taken to the analysis of the Erlang distribution model. Through alterations in initial variables, including spread of the disease, coefficient of migration rate, and contacts per unit time, differences in the SEIR curves were analyzed. In combining the ideas investigated for the SEIRD model and the Erlang distribution model, a framework for a more applicable model was created, with the flexibility to alter both the diffusion variables and those of contact and spread in the same model.

MANDATORY MASKING: LIBERTY VS. LAW

Anna Caddell
Mentor: Carl Yackey (South Carolina Governor's School for Science & Mathematics)
GSSM Advisor: Joshua Witten

The COVID-19 pandemic brought various concerns about supporting the safety and health of the public. One such question is the required wearing of masks. It has been argued that the government cannot force the public to wear masks on grounds of abridging Constitutional rights. However, state governments have the liberty to enforce a mandate, as specified by the 10th Amendment of the Constitution. There is court precedence, where such matters have been fought and discussed. Most notably, Jacobson v. Massachusetts of 1905. "Mandatory Masking: Liberty vs. Law" discusses these matters and adds the perspective of the Influenza Pandemic of 1918 that killed at least 2.5% of the global population. Within this paper, a reflection and comparison between the COVID-19 pandemic and the 1918 pandemic is offered with regards to public reactions and government measures taken. It addresses and reflects upon actions that states have the power to use when refusal to comply with mask wearing mandates occurs. This comparison reveals different approaches and possibilities a government could take with enforcing these directives.

ROTATIONAL CONSTANTS OF 2-FLUOROBENZOTRIFLUORIDE FROM MICROWAVE SPECTROSCOPY

Josue Cervantes, Anish Kanthamneni & Garrett Youngblood
Mentor: Gordon Brown (South Carolina Governor's School for Science & Mathematics)

Microwave spectroscopy is the study of how electromagnetic radiation with frequencies within the microwave range interact with molecules. In general, the purpose of such studies is to determine a molecule's rotational constants, and thus its structure. Our team used a chirped-pulse Fourier transform microwave spectrometer to measure the microwave spectrum of 2-fluorobenzotrifluoride. The molecule was measured over a range of 8 to 18 GHz in 1 GHz intervals, with each interval consisting of 10,000 averages. The measured spectrum was then compared to an expected spectrum made from Gaussian 03W software calculations, and the measured spectral lines were assigned to their calculated counterparts. As more data points were assigned throughout our analysis, we developed an increasingly accurate set of rotational constants for the molecule. The results of our completed analysis found the rotational constants A, B, and C of 2-fluorobenzotrifluoride to be 1906.22269(28) MHz, 938.93636(19) MHz, and 707.12957(15) MHz respectively.

INCREASING THE SELECTIVITY OF BRIMONIDINE TO DIFFERENT ALPHA ADRENERGIC RECEPTORS

Katie Chung
Mentor: Christopher Roberts (South Carolina Governor's School for Science & Mathematics)

Glaucoma, the second leading cause of blindness in the world, is a series of eye diseases that arise from high intraocular pressure on the optic nerve, deteriorating a person's vision. Brimonidine is a neuroprotective medication helping to reduce intraocular pressure by reducing aqueous humor production and increasing uveoscleral outflow. It is regularly self-administered three times a day. Since glaucoma primarily targets people over the age of 60, many forget to administer it that many times a day, so their eyesight still rapidly deteriorates. The aim of my research is to improve the biological properties of brimonidine to increase its selectivity to the alpha-adrenergic receptor so it can be effective and taken less frequently. In order to accomplish this, I used the Avogadro molecular editing software to build different derivations of the Brimonide ligand and docked each derivative against three alpha-adrenergic receptors in PyRx. The results of my docking concluded that my hydroxyl and sulfhydryl derivations of Brimonidine produced a more negative binding energy to the alpha 2B and 2C receptors than the original Brimonidine. A more negative binding energy increases the selectivity of the drug with the receptor correlating to longer times that Brimonidine can stay in the eye; therefore, decreasing the number of doses required each day. In the future, experiments can be run to test each of my Brimonidine derivatives compared to the original Brimonidine to test which one has the longest duration of action while still being an effective glaucoma treatment.

LOWERING THE PROTEOGLYCAN TO COLLAGEN RATIO IN AN IMPLANT TO MIMIC NATURAL CARTILAGE

Katie Chung & Devin Laye
Mentor: Jeremy Mercuri (Clemson University)
GSSM Advisor: Phelesia Jones-Cooper

Osteoarthritis caused by untreated cartilage defects affects thirty-one million Americans. Current scaffolds on the market only provide short term relief without combatting the cause of osteoarthritis, whereas our scaffold, involving a decellularized nucleus pulposus, works to stop the source of pain while treating the defect. We worked to reduce the proteoglycan (GAG) to collagen (HYP) ratio in the scaffold to mimic natural cartilage. The primary material utilized for our research purposes was the decellularized nucleus pulposus extracted from an oxtail due to its role in the cartilage analog. In order to improve the mechanical properties of the implant, important steps include the use of natural cartilage components, the increase in collagen content by swelling in a PureCol solution, the use of Hexosamine and Hydroxyproline assays to identify the GAG: HYP ratio, and the development of a proposed in vivo animal model for future testing. After undergoing fibrillogenesis, Test1 samples yielded a final ratio of 4:1, while Test 2 samples yielded a final ratio of 5:1. The original ratio of the acellular bovine nucleus pulposus (ABNP) was 15:1 so the tested conditions were successful in lowering the GAG: HYP ratio and supported our hypothesis. The aforementioned results suggest a future focus on fine-tuning of the PureCol swelling solution, improving in vitro testing, and ensuring that the mechanical properties of the implant and natural cartilage are as similar as possible. In order to ensure the effectiveness of future in vivo testing, we propose a dual-phase animal model, including a first phase rat model and second phase goat model.

DESIGNING SEROTONIN NOREPHEDRINE DOPAMINE REUPTAKE INHIBITORS FROM EXISTING ANTI-DEPRESSANTS

Lillian G. Coats
Mentor: Christopher Roberts (South Carolina Governor's School for Science & Mathematics)

The main goal of this project was to create a new anti-depressant that would bind to serotonin, norepinephrine, and dopamine transporters (SERT, NET, and DAT respectively) with a high binding affinity. Existing anti-depressants were hybridized by using existing features of Bupropion and Paroxetine. All three derivatives were made by taking the basic structure of Bupropion and adding elements of Paroxetine to make it bindable to SERT. This created a novel anti-depressant that is classified as an SNDRI - Serotonin Norephedrine Dopamine Reuptake Inhibitor. To do this, AutoDock VINA, a virtual screening and docking program that allows flexibility in the ligand, was used to compare the binding affinities of the control SSRI/NDRI against the drugs created in this research on all receptors. Paroxion – the drug created in this study – has three derivatives differentiated by being called Mark I, II, and III. The results showed stronger binding to all three transporters than the original drugs it was based off. Paroxion bound at a significant -9.1 kcal/mol compared to the value of -7.2 for Paroxetine. All dockings showed a lower binding energy than the NDRI/SSRI the drug was based off of, for all three Marks. In future work, Paroxion should be further modified to increase binding affinity, examine all Marks using molecular dynamics simulation NAMD. In addition, experiments should be run to test biological compatibility, with the ultimate goal of reaching a clinical trial.

DEGRADING PLASTICS: THE PETASE ENZYME VS. ITS MUTANTS

Elise Curran
Mentor: Christopher Roberts (South Carolina Governor's School for Science & Mathematics)

Interest in this research began with an interest in solving the enormous plastic waste problem in the modern world. The biggest problem with plastic is that it can take decades to centuries for it to degrade in the environment. Enzymes that break down plastic into molecules more digestible for nature are of interest for solving this problem. PETase (6ANE) can break down Polyethylene terephthalate (PET), which is a common form of plastic that is often used in bottles. Due to extensive research in this subject area, many mutations have been made of the 6ANE enzyme. The research's goal was to computationally compare the bonding energies of four PETase mutants and PETase with a 2-monomer polymer. This was done using a method called molecular docking. Docking is a computational modeling technique that predicts how an enzyme and small molecule interact. Docking was applied to all five of the enzymes using an exhaustiveness of 16 (the default is 8), which is somewhat proportional to the time the computer puts into searching for interactions. One mutant, 6KUS, had a significantly lower bonding energy than the rest of the enzymes. Computationally, 6KUS was the most effective out of all of the enzymes and even performed better than the original PETase. This means the enzyme could bind quicker and break down PET faster, which allows for more practical use of PETase.

EXAMINING VALENCE AND AROUSAL IN RELATION TO NATURALISTIC EMOTION IN VISUAL STIMULI

Nika Eichhorn & Jordan Veurink
Mentor: Svetlana Shinkareva (University of South Carolina)
GSSM Advisor: Jenny Salazar

The two key components of the affective state examined in this project were valence and arousal. The authenticity of the stimuli as perceived by participants- e.g. whether an emotional response is acted/fake or authentic/real- is also a crucial component. This project attempted to explore valence and affect in relation to the authenticity of variables within purely visual stimuli. Valence assigned to audio-visual stimuli is highly arbitrary and can be drastically different between individuals; this is partly due to the individual's past associations and their influence on the perception of new stimuli. To avoid this, the audio tracks were removed from four-second clips of a person or people exhibiting a particular emotion. Video clips were sourced from YouTube and were controlled for the appearance of logos, text, brands, actions of the subjects, as well as perception of language through lip-reading or text. Through an online portal, participants were instructed on how to rate each stimulus for the emotion they thought was presented, intensity of arousal and valence across a 4 quadrant 2-axis graph, and how to rate a 1 to 9 scale for authenticity. Many aspects of this study were inconclusive due to the nature of removed interaction and research in compliance with COVID safety guidelines. This project is incomplete and the research is ongoing; however, the results of this experiment may have significant benefits for the psychiatric and medical fields, especially in understanding conditions on the Autism Spectrum where authenticity is not perceived in the traditional manner.

BIKE TO THE FUTURE

Chisom Emetu, Amelia Fischer, Maura Hilbourn, Suma Ravi & Margaret Wensink
Mentor: António de Ridder-Vignone & Kathryn de Ridder-Vignone (South Carolina Governor's School for Science & Mathematics)

Bike to the Future is an ongoing interdisciplinary project focused on improving cycling and pedestrian infrastructure in Hartsville and elsewhere in South Carolina. In 2020-21, the Bike to the Future team has expanded its work to build a public website informing lay audiences about our research and to include South Carolina towns outside of Hartsville. Our presentation will include an explanation of our website in general and of our current students' individualized, particular interests. For the former portion, students will demonstrate the website's functionality and organization; for the latter, they will display and explain their design or policy briefs. Our website includes sections focusing on relevant news and events, individual faculty and student team members, case studies of different cities, useful sources of information about inclusive transportation infrastructure, current students' research, and stakeholder interviews. Our five current students are concentrating on complete streets policy for York County (Amelia Fischer); community engagement and smart growth in Simpsonville (Suma Ravi); a traffic garden proposal for Florence (Maura Hilbourn); ghost bike memorials for two high-profile bicycle accident fatalities in Hartsville (Margaret Wensink); and bike/ped network optimization through the improvement of key intersections in Hartsville (Chisom Emetu).

IDENTIFYING AND ANALYZING GENOME SEQUENCES OF POTENTIAL BIOSYNTHETIC GENE CLUSTERS (BGCS) FROM TEN DIFFERENT STRAINS OF *STREPTOMYCES* TO PRODUCE A NOVEL ANTIBIOTIC

Tiffany Felix, Ananya Hota, Arija Makela-Harms & Kaylin-Mahal Smith
Mentor: Jie Li (University of South Carolina)
GSSM Advisor: Bhuvana Parameswaran

Microbial organisms are known for generating secondary metabolites such as antibiotics. Due to the rise in the number of antibiotic-resistant pathogenic bacteria, there is a need for identifying secondary metabolites for drug development. One way to identify a novel drug is to study microbial Biosynthetic Gene Clusters (BGCs). A BGC is a group of genes that code for enzymatic pathways that create specialized metabolites, which provide the microbe specific evolutionary advantages. The goal of this research is to perform a computer analysis to analyze, compare, and identify various BGCs and their enzyme domains of ten specific *Streptomyces* species with known BGCs to identify novel domains in each species. The genome sequence of each strain was obtained from the NCBI website and was then uploaded onto AntiSmash software program which mines the sequences of the ten strains to identify BGCs. This analysis compares the BGCs of these species with known BGCs and the various enzyme domains in each one of them. These mined BGCs were then compared using Cytoscape program which collected the known BGCs from MIBiG software, and then integrated this information into spatially arranged, potential molecular pathways. The preliminary results indicate that each strain of *Streptomyces* had the enzyme domain to generate terpene intermediate, but chemical analysis could not be done due to pandemic constraints. The identified BGCs may be useful for drug development but further chemical analysis using liquid chromatography (LC) and mass spectrometry (MS) is needed to determine the potential of the unknown BGCs.

LEARNING IN MADAGASCAR HISSING COCKROACHES

Georgina Fitzmaurice
Mentor: Christopher Varnon (Converse College)
GSSM Advisor: Kristin Walker

The purpose of this research was to display learning in hissing cockroaches and to see if ideas such as behaviorism, like habituation and classical conditioning, are the same in a wide variety of animals. To effectively use comparative psychology and eventually figure out why humans learn and behave certain ways. In the experiment, eight cockroaches were collected randomly and set on a heating pad, then moved to the experimental apparatus, the stimulus (scent extract of peppermint or orange) was presented, and then the subject was picked up and observed to see its response (hiss and movement). Each trial was 30 minutes apart with eight trials per subject and one preference test (both scents placed in each end of container and reactions recorded for five minutes). In the experiment, habituation has occurred during the US (unconditioned stimulus of them hissing) and post time period which is good, but the bad part is that they didn't do much else and learning has not occurred. In conclusion, all the experiments conducted show that Madagascar Hissing Cockroaches are unable to show learning. Although we do not know why this is, our next step would be to see what exactly it takes to get the hissers to learn for future comparative psychology research.

STUDY OF AN ETHENE HYDROGENATION REACTION ON A NICKEL OXOCLUSTER CATALYST USING DENSITY FUNCTIONAL THEORY

Justin Furgala
Mentor: Rachel Getman (Clemson University)
GSSM Advisor: Gordon Brown

A recent abundance of shale gas has shifted efforts back to converting natural gases to liquids for fuel and chemical use. However, this time consuming process cannot be done without the help of catalysts. The primary objective of this research is to find a more energy efficient approach by using Density Functional Theory (DFT) calculations. We believe that by using a small metal oxocluster, we can find the best metals for the extraction process in a fast and efficient way. To conduct this research we used Density Functional Theory, which is an approximate quantum mechanical method to obtain the energies of a molecular system. Using the Clemson supercomputer, we obtained the Gibbs Free Energy values for the singlet and triplet states of my compound. After the calculations had finished we found that the triplet state had a higher energy barrier than the singlet state at every reaction. When comparing the small and large cluster, there were only three instances where there was a discrepancy of 50 KJ/mol or more. This gives evidence that the two clusters are linked in some way. This possible correlation will help us continue the research and determine if the models are actually connected, meaning that the cluster with less atoms will make similar predictions in much less time than the larger cluster. This will help us decide which metal acts as the best catalyst in the natural gas extraction process, ultimately leading to a more efficient system.

GENERATING TRAINING DATA FOR CONVOLUTIONAL NEURAL NETWORKS TO AUTONOMOUSLY NAVIGATE UNDERWATER STRUCTURES

Samuel Garcia, Son Nguyen & Amelia Stensland
Mentor: Ioannis Rekleitis (University of South Carolina)
GSSM Advisor: Alfred DeGennaro

Manual exploration of underwater shipwrecks is dangerous, time consuming, and expensive. Using the Convolutional Neural Networks (CNN), the USC Field Robotics Laboratory established the viability of using a Neural Network to train the Aqua2 robot to automatously navigate through underwater structures. However, the limits of such an algorithm is that the dependent on data used to train the algorithm; because of the size of the dataset and the complexity of the task, an accuracy rate of only 80% could be achieved. However, this can be remedied by increasing the amount of data to train the CNN. Using video footage of the Aqua's manual exploration of the Stavronikita Shipwreck alongside a defined decision matrix, a human generated training dataset was created by student researchers; using frames the videos as the inputs and the indicated direction by the user as the output, training data for the CNN was generated. It is hypothesized that this larger and more well-defined dataset would yield a greater accuracy rate, with an ideal rate of 85% or greater. If this accuracy rate is achieved, then field testing of the Aqua2 robot can be conducted. Additionally, the research team will develop a newer version of Convolutional Neural Network in later stages of research. Thus far, the research has shown that the autonomous mapping of 3-D underwater environments by a robot is possible, though the practical viability of such methods still needs to be investigated though field testing.

EVALUATING INHIBITORY EFFECTS OF ANTI-SIGLEC-8 TREATMENT ON SIGLEC-8 EXPRESSING JURKAT CELLS

Haleigh Gartner
Mentor: Emily Brock (Allakos Inc.)
GSSM Advisor: Joshua Witten

The Siglec-8 receptor naturally exists on only two types of cells: mast cells and eosinophils. Siglec-8 identifies allergens and causes the cell to degranulate. Allakos has worked on creating a treatment for this, an antibody targeting Siglec-8, called 2E2. We want to further study the inner workings of Siglec-8, therefore, having an easily accessible cell line with functional Siglec-8 on it would be extremely useful. My project was to see if Siglec-8 would be functional on Jurkat cells. We first transfected Jurkat cells with varying amounts of Siglec-8 DNA plasmid and determined an appropriate concentration. Next, we attempted to activate wild type Jurkats using a variety of anti-CD3 stimuli, including CD3/28 beads and soluble CD3 both alone and crosslinked with secondary. Then, we attempted to internalize Siglec-8 transfected Jurkats using 2E2 treatment. Finally, we attempted to stimulate Siglec-8 transfected Jurkats using the stimuli above and inhibit activation with 2E2. We found that Jurkats respond to Siglec-8 transfection successfully, soluble CD3 alone induces the greatest activation, and Jurkats have moderate internalization of Siglec-8. However, no inhibition of activation via Siglec-8 was seen in transfected Jurkats using the anti-Siglec-8 antibody. Further steps in this research would be to obtain a clonal Jurkat population and to further optimize Jurkat activation.

A MICROWAVE SPECTRAL ANALYSIS OF TRANS-2-PENTENAL

Emily Geraghty & Elic Weeks
Mentor: Gordon Brown (South Carolina Governor's School for Science & Mathematics)

We measured the microwave spectrum of trans-2 pentenal to identify the constants that defined the shape of the molecule. We measured the spectrum from 8,000 MHz to 18,000 MHz using a total of 10,000 averages. Using our spectrum and comparing it to the theoretical spectrum, which was generated by Gaussian 03W software, we started assigning lines, a process where we took the theoretical lines, and compared them to the gathered data. We found the following constants: A = 11512.80(50) MHz, B = 1530.71560(78) MHz, and C = 1374.26930(77) MHz. We also found the distortion constants which will be discussed in the presentation. The A, B, and C rotational constants are related to the shape of the molecule while the distortion constants are related to how "stretchy" the molecule is.

DIG DEEPER: HOW CHEMICALS IN COMMON PESTICIDES ACT ON THE SOIL FAUNA IN RELATION TO ABUNDANCE AND DIVERSITY

Mary Abigail Gorospe
Mentor: Julian Smith III (Winthrop University)
GSSM Advisor: Joshua Witten

Soil fauna are essential to the breakdown of plant and animal remains and restoring the nutrients to the soil, which contributes to the structure of the soil. The diversity and abundance of the soil fauna is affected by several elements such as thatch, how often the lawns are mowed, pesticides and fertilizers, the types of trees and grass grown there, and whether or not there is a garden kept. Soil samples were taken from two different lawns that are kept in the same manner, one treated with pesticides while one was not. The fauna was collected from the samples and separated by species. After all of the organisms are separated, each was then placed under the microscope for further examination. We were comparing and contrasting the total abundance of the two collections and the diversity of the fauna collected. With results that are currently inconclusive when a statistical t-test was conducted, this research needs more trials, samples, and improved methodology. In the future, this research can be used to create pesticides and fertilizers that are more sustainable for the environment and the organisms living within. With new pesticides and fertilizers, we can then keep the fauna healthy while maintaining the healthy grass and trees as wanted. This research is just the beginning of building a healthier and more sustainable way to achieve the same results of appearance of lawns.

NEURAL NETWORK REINFORCEMENT LEARNING FOR SIMPLE GAME PLAYING

Nitin Gupta
Mentor: Yuyuan Ouyang (Clemson University)
GSSM Advisor: Elizabeth Bunn

The purpose of our research was to learn the basics of neural networks and network-based reinforcement learning. Furthermore, to exercise this learning, we played with some simple image classification tasks and trained AI that played simple games. The understanding of this topic is very important in this day and age as everything around us, from social media to automobiles, is getting automated and this is achieved through machine learning. Our research methods consisted of learning about neural networks and convolutional neural networks. We also learned some basic linear algebra and calculus which helped us understand the gradient descent method of training networks. Using this knowledge, we were able to learn about Markov Decision Processes and State Value Functions under the bigger picture of machine learning. Using this research, we were able to make an AI that could beat the game of Pong from the Atari console. We were also able to solve simple Grid World environments. We did approach the idea of beating another game called "QWOP", and also solving other, more sophisticated, Grid World examples, but due to the time constraints, we were not able to fully conduct research in that area. These aforementioned results serve as a basic understanding of the concept of machine learning and while we do have a long way to go before understanding the machine learning involved in making a self-driving car, this research proves as a great stepping stone for anyone to reach that milestone in the future.

DEVELOPING A MOBILE FLOOD WARNING APPLICATION FOR THE CHARLESTON, SC REGION

Raviteja Guruvelli & Jacob Nichols
Mentor: Lancie Affonso (College of Charleston)
GSSM Advisor: Christopher Roberts

We are experiencing the oncoming effects of global warming, and this is especially prevalent in coastal cities where frequent flooding of the city's roads and property are flooded by rising tidal levels. This problem is no stranger to Charleston, SC where flooded roads and areas pose a hazard for drivers and pedestrians. Funded by the South Carolina Sea Grant Consortium, this project's goal is to develop a map application that shows current and predicted street flooding levels in the Charleston area, so that the public, first responders, and municipalities may use it to prevent hazardous encounters and safely navigate the county during tidal flooding. The project focuses on mining, cleaning, and analyzing data for use on cellular phone app from multiple sources of tide and precipitation data, using data science and engineering processes. Considerations included data from the National Oceanic and Atmospheric Administration, the National Weather Service, crowdsourcing websites, and proprietary agencies. Data were chosen based on factors such as accuracy, resolution, and refresh frequency. After collection, the data is reorganized for use in an ArcGIS environment—software allowing for the creation of interactive maps. Python scripts using Pandas were integrated within layers of an ArcGIS WebApp, and all of this allows for the user, through the graphical user interface, to view current and future flood level information from storm surges, tropical cyclones, and other weather phenomena. The app is still under development but hopes to achieve an independent platform that can be downloadable by users in the future.

VISCOELASTIC BIOLOGICAL FLUIDS EXAMINED THROUGH MICRORHEOLOGY

James Ham
Mentor: Paula Vasquez (University of South Carolina)
GSSM Advisor: Nicole Kroeger

The idea of this research project is to gather data on viscoelastic biological fluids as to better understand their properties. Because the sample size of the fluids is often quite small, the examinations must be done on a microscopic level. Prior to the research, videos were recorded that displayed the tracking of microscopic probes inside these fluids, but the color markers indicating the probes were not always accurate. They would blink in and out of existence or mistake the halo around the probe for a probe itself. The main objective was to better organize and document the path of the probes. This was done using MATLAB. First, an ideal signal-to-noise ratio (SNR) was identified that would serve as an appropriate cutoff for what could be considered a probe. However, it was more complex than just that. The SNR of each video was plotted onto a chart in order to get a better idea of what the cutoff SNR should be. The main result was a table that contained all of the accurate particle trajectories so that they could be better used for microrheology analysis. Further analysis towards the behavior of these fluids could be useful information in the study of artificial organs, an example being the pumping of blood by an artificial heart.

HISTORICAL ARCHAEOLOGICAL DATING OF A NINETEENTH-CENTURY AFRICAN-AMERICAN HOME

Emily Anne Harris
Mentor: Meg Gaillard (South Carolina Department of Natural Resources - Heritage Trust)
GSSM Advisor: Karl Rohr

After South Carolina Department of Natural Resources (SCDNR) archaeologists excavated a duplex home on the Fort Frederick Heritage Preserve property, thousands of dirt-covered artifacts were recovered. This study will identify and date these artifacts to verify when this house was occupied and who its residents were. This process began by cleaning the artifacts with a simple toothbrush and water basin, and then leaving them to dry. They were then sorted into categories by type, including ceramics, glass, and nails. From there, individual artifacts were identified by using online databases such as Digital Archaeological Archives of Comparative Slavery (DAACS). Once a sherd, for example, had been recognized as one particular type of ceramic, the range of dates for its popularity and/or manufacture could be found on these databases. While some artifacts were dated to the late 1700s and early 1800s, other artifacts' production did not begin until approximately 1840. For this reason, it is estimated that the house was inhabited between the years of 1840 to 1860. In order to get more accurate findings, it would be necessary to date all of the artifacts from the home, not just a small range from one plot, which contained some of the first artifacts to be identified from the property since their excavation. However, this date range verifies historical records including pictures and journal entries that mention small homes occupied by enslaved persons on the Old Fort Plantation.

IDENTIFICATION OF CANDIDATE APTAMERS TO FACILITATE SARS-COV-2 DETECTION

Maura Hilbourn, Tianna Kidd & Ankita Menon
Mentor: Sachin Rustgi (Clemson University Pee Dee Research & Education Center)
GSSM Advisor: Glenn Morrow

Several viral detection tests have been developed for Sars-CoV-2 but due to the fragile, immunogenic nature of the target molecules used in the tests, they take months to develop and are costly. However, aptamers, which are short, synthetic strands of DNA or RNA, can virtually bind to any target molecule. Aptamers' sequences can be computer generated and are a more efficient method of viral testing. Here we report on the process to find candidate aptamers to bind to the spike proteins of three members of the coronavirinae genus. This process began with the splitting of the virus' genome into 40 nucleotide length sequences, followed by a prediction of the two-dimensional structure of each sequence and sorting based on the free energy of the structures. The strands with relevant free energy were run through a 3D structure prediction program and docked on to the viral spike proteins through the HDock Server. This generated about 200 confirmations of the aptamer bound to the spike proteins. The aptamer with the best fit will later be tested in the laboratory to create an efficient and more accurate test for COVID-19 detection.

OPTIMIZING THE COMPUTATIONAL PARAMETERS OF FERRITE COMPOUNDS

Zachary Hoover
Mentor: Rachel Getman (Clemson University)
GSSM Advisor: Gordon Brown

The compounds nickel ferrite ($NiFe_2O_4$), cobalt ferrite ($CoFe_2O_4$), manganese ferrite ($MnFe_2O_4$), and zinc ferrite ($ZnFe_2O_4$) may have magnetic properties that could surpass current biomedical technology. Currently, nickel ferrite nanoparticles are used in a process called magnetically modulated energy delivery (or MagMED for short). MagMED delivers energy to diseased areas through magnetization. It has seen success in the past, but is limited due to a lack of resources and inefficiency of dosage. Our research group's goal was to see if other compounds could be used in place of the nickel ferrite currently used. For the ferrite compounds to be used safely and successfully, they must be stable. The magnetic moment measures the magnetic strength of the compound. The higher the magnetic moment and lower energy, the more stable the compound is. To see how we could make stable compounds, we ran theoretical calculations through a system and changed the mixing flags. Mixing flags change how the ions in compounds are distributed and structures. This directly affects the energy and magnetic moment of the compound. The only mixing flag we were able to change within the amount of time given was the LMIXMAX flag. We were able to discover that changing this parameter has little to no effect on the magnetic moment or the energy of the compound.

NEURAL NETWORK REINFORCEMENT LEARNING FOR SIMPLE GAME PLAYING

Christian Ihekweazu
Mentor: Yuyuan Ouyang (Clemson University)
GSSM Advisor: Elizabeth Bunn

Reinforcement learning and machine learning are crucial aspects of the ever-growing technology field; it allows us to train a computer to learn and conceptualize information in ways it could have never done before. The purpose of our research was to learn the basics and concepts behind reinforcement learning so that we could create neural networks and programs to automate simple games. Throughout our research, each person had different tasks which ranged from things like a write-up on a specific concept to writing code to complete a task and then reporting back to the group during the next meeting. Throughout the process, we also utilized pre-established resources in our research as well, so that we could better understand some of the logic and reasoning behind why certain things behave in a certain way. By the end of our research, we were able to create a program that was able to play a virtual game of ping-pong by itself. Using this information in the future we will be able to create programs to play more advanced games and potentially dive into other fields that deal with reinforcement learning.

VIRTUAL VEHICLE AUTOMATION

Anish Kanthamneni
Mentor: Bing Li (Clemson University International Center for Automotive Research)
GSSM Advisor: Elizabeth Bunn

The purpose of my research project was to see if it is possible to use Python to drive a vehicle in a driving simulator. This is a fairly new field that interested me due to how much safer it could make our roads if applied to real cars. My main source during the duration of this project was Sentdex, a Youtuber guiding us in a tutorial on how to drive a scooter in Grand Theft Auto 5 using python. I, however, didn't have GTA, so I had to adjust the code to suit my needs and fit the simulator I was using (Top Seep Driving 3). When creating the code, I used grab-screen, a method in python, to obtain the image and used send keys to allow the program to input commands (W, A, S, and D) into the simulator. The end result was a program that was able to "see" the computer screen and send input to the vehicle. Python was able to make the car stay within the lanes; however, it had some trouble when the road had a 90-degree turn. It was supposed to turn and get inside the lanes of the other road, but it would occasionally fail to turn properly. These results, if improved, could aid the self-driving car industry. There are many benefits to automated cars including safety and convenience. Automated driving could prevent the 1.25 million deaths annually from car accidents and 20-50 million injuries.

DIFFERENCE IN INVERTEBRATE COUNTS IN SOIL SAMPLES TAKEN FROM GOLF COURSE AND UNTREATED LAND

Emma Keiser
Mentor: Julian Smith III (Winthrop University)
GSSM Advisor: Joshua Witten

The purpose of this research project was to compare the number of invertebrates found in soil samples taken from untreated land and a golf course. These invertebrates are essential to the overall health of the upper soil layers. The goal of this project was to assess whether treatments used on a golf course impact the number of these invertebrates in the soil. A golf course was chosen due to shared similarities with other large, grassy lawns. Soil samples were taken from each location and placed in a berlese funnel underneath a 60 watt light for 4 days. The invertebrates found were then counted and sorted by taxon. The difference between the counts of individual taxon in each sample were found, and a statistical t-test using the total differences from all taxons was performed. It was found that the difference in total invertebrate counts between the two locations was statistically different from zero. However, when the differences in individual taxons were analyzed, it was found that the difference was not statistically different from zero. This indicates that overall there is a difference between the two areas, but not on an individual taxon scale. While this study showed results that indicated large, grassy areas have less invertebrates, this research project was conducted on a smaller scale, meaning that the data collected was insufficient to be an indicator of any large trends.

EXPLORATION OF PHOTOREALISTIC FACE RENDERING IN A LIGHT STAGE

Kyle Koon
Mentor: Eric Patterson (Clemson University Restoration Institute)
GSSM Advisor: Elaine Parshall

Facial geometry and reflectance data must be captured to produce realistic computer-generated renderings of the human face. The goal of this project was to affordably acquire this necessary facial data by programming a series of cameras and lights in a light stage to take images on command under varying lighting. The data from these images would be used to create a photorealistic rendering of the subject's face with the use of consumer-level equipment. Arduino microcontrollers, .txt files, and Python were used to serially send user-defined lighting data to Digital Multiplex (DMX) controlled lights. The Maya 3D rendering software and Python were used to virtually model the spherical structure of the light stage along with 364 lights and a human face. Python was used to create a user interface that allowed a user to design custom lighting setups, visualize them with virtual lights in Maya, and then test them on the physical lights. The different lighting patterns were visible on the downloaded face model within Maya; however, the results would be more accurate if the face model was supplied with reflectance data. Reflectance data would be used to adjust the face model to replicate how that person's face reflects light based on its geometry. Although the camera control software was not created, upon its eventual completion and connection with the lighting software, images and reflectance data should be able to be captured and sent to the control computer, and then processed to create the face model.

THE EFFECTS OF HEAT STRESS ON POLLEN VIABILITY IN PEANUT GENOTYPES

Christopher LeBarron, Mary Lee, Elizabeth Middleton & Kaylex Wilcox
Mentor: Sruthi Narayanan (Clemson University)
GSSM Advisor: Jennifer Brown

Consistently rising temperatures are a major environmental factor that threatens the yield of one of South Carolina's top cash crops, Arachis hypogaea, or the peanut, because peanuts are heat susceptible during the reproductive phase. Our main goal of this research was to identify the peanut genotypes that have the highest probability of reproducing under increasing annual temperatures. Under greenhouse conditions, samples from six genotypes (Bailey, Wynne, Georgia 12Y, SPT 06-07, Tifguard, Phillips) were grown under either ambient (31/22°C) or heat stress temperatures (41/27°C). Once the peanut plants flowered, pollen was collected and stained with triphenyl tetrazolium chloride to indicate pollen viability. The pollen was observed under a microscope and recorded as viable, semi-viable, and nonviable, based on the shade of the stained grains. Pollen viability was calculated as the ratio of viable pollen grains to the total number of pollen grains. While the pollen viability for each genotype decreased, four genotypes, SPT 06-07, Tifguard, Georgia 12Y, and Phillips, had higher percentages of viable pollen and thus higher probabilities of reproduction. Despite Bailey having the highest percent of viable pollen in ambient temperatures, it produced significantly less pollen when subjected to heat stress. The four peanut genotypes that yielded a high percentage of pollen viability may result in a higher overall crop yield of the peanut plant considering increasing summer temperatures. These results will promote the implementation of more resilient peanut genotypes in agricultural practices, which would maintain peanut production and profits should temperatures continue to rise.

THE MICROWAVE SPECTRUM OF 2,6-DIFLUOROPHENOL

Ziwei Liu & Shamitha Nandi
Mentor: Gordon Brown (South Carolina Governor's School for Science & Mathematics)

The rotational spectrum of 2,6-difluorophenol was measured through microwave spectroscopy. In microwave spectroscopy, a molecule's rotational transition gets excited due to its absorption of microwaves. Then, the molecule relaxes and emits the radiation back. This process helps in having a better understanding of the molecular shape. The procedure begins by measuring the frequencies ranging from 8000-18000 MHz using a Fourier-transform microwave spectrometer. A total of 10,000 averages were obtained. The theoretical rotational spectrum of the molecule was calculated using Gaussian software. The theoretical rotational constants were the following: A = 2344.0833 MHz, B = 1753.4626 MHz, and C = 1003.1035 MHz. The experimental rotational spectrum was determined by using a software where lines were assigned to fit the theoretical transitions to the experimental ones. In conclusion, the experimental rotational constants were the following: A = 2345.3196(27) MHz, B = 1760.9802(33) MHz, and C = 1005.8164(13) with an overall RMS error of 0.035 MHz.

USING DATA DRIVEN TECHNIQUES TO PREDICT CARBON FIBER STRENGTH

Nathaniel Lott
Mentor: Subramani Sockalingam (University of South Carolina)
GSSM Advisor: Lance Riddle

For my research project I used Python and artificial data to better predict carbon strength and find ways to improve upon it. This topic was researched because problems in carbon fiber manufacturing can lead to various issues in the strength of carbon fiber strands. Collecting enough data to analyze these errors and varying strengths would require millions of fibers and would have to be tested in a method that would take a large amount of time. With that being said, it could save a lot of time and resources to use the artificial data produced through the Weibull model to predict what the carbon strength will be for the finished product. When working towards a way to create and analyze the data, we used the Weibull model to form an equation and data structure to calculate the different ranges of failure at different lengths. The Weibull distribution is an indicator of the variability of strength of materials resulting from a distribution of flaw sizes. With this information I created a Python code designed to take multiple values of F (failure probability) and determine what sigma value would be needed to fit that equation. Unfortunately the code still has some issues to work out but does perform the task it was designed to do. Overall, the result of the code and data acquired is a major impact on the improvement upon carbon fiber strength and manufacturing as well as a more developed system of machine learning to create more artificial data.

CORRELATION BETWEEN EMOTIONAL FACTORS AND WORD RECOGNITION

E. Kat McConnell
Mentor: Svetlana Shinkareva (University of South Carolina)
GSSM Advisor: Jenny Salazar

How quickly you recognize a word you are reading is called processing speed, which is subjective, meaning it changes depending on the person reading the word. Valence is how positive or negative a stimulus is; it is also subjective, and is measured on a scale of 9 in this experiment, where 1 is very negative, and 9 is very positive. Many studies have been conducted to see if valence affects processing speed, but there is still not a concrete conclusion. This experiment aimed to discover whether valence influences processing speed or not. A database was created to measure different factors of words, including their valence and the time that it took a pre-selected group of people to recognize them. This database was put into R Studio to create a correlation matrix. The matrix displayed the correlation coefficients between all of the factors to determine whether they are related. This matrix showed that there was a very slight negative correlation between valence and processing speed. It was incredibly small, though, so it was not enough to draw a solid conclusion. This superficially aligns with the Automatic Vigilance Theory, which concludes that words with negative valence take longer to recognize. Despite the fact that the results slightly follow this theory, the correlation is too weak to infer that it is anything other than chance or interference from other factors.

DEVELOPMENT OF ANTIBIOTIC TO COMBAT ISONIAZID-RESISTANT *MYCOBACTERIUM TUBERCULOSIS*

Ethan Mills
Mentor: Christopher Roberts (South Carolina Governor's School for Science & Mathematics)

The disease Tuberculosis, caused by the highly successful *Mycobacterium tuberculosis*, has plagued humanity for thousands of years. With the advent of modern medicine, it has become possible to treat the disease, however it is notoriously hard to cure and requires a combination of many antibiotics. Isoniazid, in combination with other drugs, is the first line of treatment for patients suffering from Tuberculosis, however the increasingly common isoniazid-resistant strains of *Mycobacterium tuberculosis* have greatly reduced the effectiveness of the drug. Due to the dire need of a new drug to combat these drug-resistant strains of the bacteria, I sought out to develop a derivative of Isoniazid that would be able to work as an effective antibacterial drug against the bacteria. Using molecular modeling, docking, and visualization programs, I was able to develop 20 derivatives that had slightly altered molecular structures and calculate their binding energy with the enzyme they inhibit, 2-trans-enoyl-ACP reductase. Using this data, I compared the binding energy and conformation of the derivatives with an isoniazid-resistant mutant of the enzyme. This data revealed that by increasing the length of the isoniazid compound by adding extra carbons, the derivatives were able to bind at a more favorable energy on both enzymes. Although future work will need to be done to determine the true effects of the derivatives, the results suggest that by slightly altering the isoniazid compound, a new antibiotic can be derived that is able to target isoniazid-resistant *Mycobacterium tuberculosis*, greatly improving our current treatment of patients with Tuberculosis.

UNDERSTANDING CRYSTAL GROWTH MECHANISMS VIA MODEL-BASED ANALYSIS AND ATOMIC IMAGE SIMULATION

José Luis Montés
Mentor: Kai He (Clemson University)
GSSM Advisor: Kristin Walker

The goal of the project was to investigate the nature of crystals and use software to simulate images of their structures. It is important to better understand crystals since many materials are crystalline in nature, such as metal, stone, and glass materials, all of which are regularly used to manufacture consumer goods and various technologies. Studying crystals facilitates the development of better technologies and consumer products. These simulated images would be used to better understand how crystal structures work on a molecular level. With guidance from advisors from Clemson, the project focused on modeling the structures of diamond, titanium, and Iron (III) Oxide using Dr. Probe and VESTA, two types of crystallography software. In the process of research, several images of diamond crystals, Iron (III) Oxide crystals, and titanium crystals were created, each with variations to account for differences and irregularities in their growth. As expected, the simulations produced images that closely match the images found by those collected by electron microscopes. Crystal growth was also modeled, and as crystal structures are repetitions of a basic system of atoms and molecules known as the unit cell, only a few repetitions of the unit cell were needed for a crystal nanoparticle to develop, which fits with the current scientific understanding of crystals. In using crystallography technologies, new renewable energy technologies can be created for batteries and solar panels, and new materials can be created for industrial uses in manufacturing.

DETERMINING THE REACTION MECHANISM FOR AQUEOUS-PHASE REFORMING WITH A CATALYTIC PLATINUM CLUSTER OVER AN ALUMINA SUPPORT

Elena Morgan & Shamitha Nandi
Mentor: Rachel Getman (Clemson University)
GSSM Advisor: Gordon Brown

Aqueous Phase Reforming (APR) is a chemical process that transforms oxygenated hydrocarbons, like sugars or alcohols, into hydrogen and light alkanes. Hydrogen has become increasingly popular as an energy source. However, most hydrogen is produced from fossil fuels. The use of APR in biorefinery presents a more sustainable and environmentally friendly way to produce hydrogen. For this project, we used computational models to study the APR reactions with a catalytic platinum cluster over an alpha alumina support. We focused on three main goals: (1) the development of a platinum-8 (Pt-8) model, (2) the lattice optimization of a triclinic bulk alpha alumina support, and (3) the identification of potential binding sites for the adsorbates COH and CHO on a Pt-4 cluster. The first and third goals involved adding either a platinum atom or the adsorbate to the Pt-4 cluster (four platinum atoms bonded together). Several locations were tested to find the structure with the lowest energy configuration. We identified the most favorable structures and confirmed previous studies that found the alpha alumina support interacts with the adsorbate. Future work needs to be performed to investigate the impact of this interaction. For the lattice optimization goal, we compared the energies and volumes of different lattice parameters to identify the optimum parameters for the support. Overall, this research will contribute to the development of more accurate models of APR reactions and provide insight into the interfacial sites for catalysis, which will help improve the APR process in the future.

THE EFFECT OF THE CONDITIONS AND TREATMENT OF AN AREA ON THE SPECIES ABUNDANCE AND RICHNESS OF SOIL FAUNA

Sophia Morrison
Mentor: Julian Smith III (Winthrop University)
GSSM Advisor: Joshua Witten

Soil fauna aids in the breakdown of dead plant and animal matter. Moisture and leaf litter amount increase the abundance of soil fauna. High levels of human activity decrease abundance of soil fauna. The effect of temperature on soil fauna varies with species. The purpose of this research was to determine if the conditions and treatment of an area affects the species abundance and richness of soil fauna. We analyzed the variety and quantity of soil fauna from two different locations. Location A is a suburban yard with regular physical and chemical maintenance, high levels of foot traffic, and low levels of leaf litter. Location B is a rural yard with no maintenance, low levels of foot traffic, and high levels of leaf litter. We took samples from both locations and placed them into a Berlese funnel to slowly dry them and to force the fauna to migrate through the mesh and into alcohol. This fauna was isolated, identified, and separated into order under a stereomicroscope. The specimens were counted and recorded. Recorded data was analyzed using a T-test. Our results did not show a difference in variety or quantity of the soil fauna between the two locations. This is most likely because of the small sample size. However, the difference in soil composition was not taken into account. Future research should take soil compositions into consideration in location selection.

PREDICTING MECHANICAL PROPERTIES OF NANOCOMPOSITES USING CLEMSON'S SUPERCOMPUTER

Natalie Mueller
Mentor: Zhaoxu Meng (Clemson University)
GSSM Advisor: Joshua Witten

There is a great need for lighter, tougher, stronger, and more flexible materials to build new technology. New materials could be used to construct lighter aircraft and vehicular parts, food storage containers that hold food for longer, and for medical procedures. These materials already exist in nature but we looked at how to create them synthetically. This research looked at how to build these materials on a nanoscale or atomic level. Particularly, this research observed Young's Modulus. This was achieved by using computer simulation done by Clemson's Supercomputer. We used computer simulations to test our composites as opposed to physical testing due to it being cheaper and less time consuming. Once more testing is done, physical versions of each material can be made to test further. We looked at different configurations of graphene and polymer to see which would resist deformation the most. Due to our limited testing, we were unable to draw definitive conclusions on how these composites would react under stress. Since this research is fairly new, more testing is required to understand how to replicate biomaterials.

COVID-19 AND ITS IMPACT ON INFECTIOUS DISEASE RATES IN SOUTH CAROLINA

Anders Orr
Mentor: Sally Burgess (Piedmont Pediatrics)
GSSM Advisor: Stephen Kaczkowski

This research was an observational study where two samples of patients from Dr. Sally Burgess, from Piedmont Pediatrics, were compared. The two groups of patients were from two separate years, 2019 and 2020. The main question was if COVID-19 had any effect on the rate of doctor visits or positive test results. Ratios of positive test results to the total number of patients were compared for each year. A preliminary investigation of the data indicated that the positive test result ratio for 2020 was higher than that of 2019's ratio. Under the assumption that our given sample constitutes a simple random sample from the entire population of similar patients within South Carolina, the claim was tested using a difference in proportions statistical test. It was found that the 2020 proportion of results were indeed higher than the 2019 proportion at the $\alpha = 0.10$ level of significance. There are various proposed theories for this difference, including that individuals with mild to no symptoms were less likely to visit a doctor than individuals with more intensive symptoms.

THE EFFECT OF NODULATION AND NITROGEN APPLICATION ON SOYBEAN GROWTH

Phillip Perea
Mentor: Nathan Hancock (University of South Carolina - Aiken)
GSSM Advisor: Cara Roberts

Nodulating soybeans can nitrogen fix atmospheric nitrogen into a bioavailable form through a mutualistic relationship with a special bacterium housed in their root nodules. However, under stressed conditions, some soybeans lose their ability to nodulate and thus are unable to facilitate N-fixing bacteria. The goal of this project is to test the effect of different nitrogen application levels on the soybean growth of nodulated and non-nodulated soybeans. In our field experiment, we planted two different types of soybeans (Williams 82) and (Nod -) designed to test nitrogen application on nodulated and non-nodulated soybeans, respectively. The (Nod-) soybeans we used were genetically modified and represented a stressful year that causes nodulation failure in the soybean's roots. This is attributed to poor water access and nutrients in the soil. The nodulating soybeans represent a regular year for the farmers and were used as a control to see the effects of nitrogen application on nodulating soybeans. After the addition of nitrogen fertilizer, we measured the height, greenness, and canopy fraction of the soybeans using a handheld Green Seeker and with a drone. In conclusion the application of additional nitrogen (Low- 80 lbs./acre, Med - 160 lbs./acre, and High - 240 lbs./acre) at the flowering stage benefited (Nod -) soybean plants. However, we also found that the (Williams 82) soybeans did not properly form root nodules due to outside factors, nullifying our control. This research will be used to develop a test that will tell farmers the optimal amounts of nitrogen fertilizer to put on stressed soybean fields. Further studies are required to clarify the potential benefical impacts of N addition.

ORGANIZATIONAL EFFICIENCY THROUGH GOALS, COMMUNICATION, AND RESPONSIBILITIES: A CASE STUDY OF A LEAN NON-PROFIT ENTITY

Luke Phillips
Mentor: Jim Morris (SC Economics)
GSSM Advisor: Michael Newsome

This study involves an organizational behavior analysis case study to determine factors improving organizational efficiency in one small non-profit entity. The mission of this entity, SC Economics, is to improve K-12 economics and financial literacy in the state of South Carolina. Over a six-week period, the author conducted one-on-one interviews with each staff member and observed everyday operational activity. It was determined that the organization operated at a high level of efficiency, being effective at meeting goals given available resources. SC Economics was able to reach this level of efficiency by having a common goal, well-structured and clear communication, and distinct and clearly defined responsibilities.

EMPIRICAL STUDY OF EARLY ELECTION RESULTS

Julien Pitrois
Mentor: Chris Healy (Furman University)
GSSM Advisor: Christopher Roberts

Election night is a very exciting night with people gathering around to see the news projecting the winners. Using election results from each polling place in Australia's elections from 2004 to 2019 this study investigated how news agencies can predict winners without all the votes being tallied. Using the coding language Python, an algorithm was created to check what number of polling places is needed in a district to predict the winner of the district's house seat with a success rate of 950000 out of 1000000 trials. The algorithm entailed taking a random selection of 1 to the total number of polling places in the district polling places from a list and comparing the aggregate results to the actual winner of the seat. This data proved that there is a correlation between the percent of polling places and the margin of victory. There are several districts where the results can be predicted within one polling place, but only when the results are extremely one sided. When there is an extremely close race, almost all polling places are needed to predict a winner. When 50% of polling places have reported, the winner can be projected if the results are 52-48 or greater, but it is too close to call if the margin of victory is smaller than this margin. Similarly if 10% of polling places are reporting and results margin is 57-43 or greater, the election can be called.

THE ULTRA-LOW THERMAL CONDUCTIVITY OF THE THERMOELECTRIC MATERIALS GETE AND SNSE

Oliver Rancu
Mentor: Apparao Rao (Clemson University)
GSSM Advisor: Mark Godwin

This study examined the reasons behind the ultra-low thermal conductivity of two materials, SnSe and GeTe. The efficiency of thermoelectric materials is given by the dimensionless figure of merit ZT, defined with thermal conductivity in the denominator; the ideal thermoelectric material therefore has a low thermal conductivity. Specifically, the flow of heat in a lattice can be represented by the interactions of phonons, or quantized lattice vibrations. Using temperature-dependent Raman Spectroscopy, the peak phonon frequency shifts of 4 modes in a lattice of SnSe and 2 modes in GeTe were examined. This shift was attributed to a combination of quasi-harmonic volume expansion and anharmonicity. Anharmonicity was dictated by so-called 3-phonon and 4-phonon processes, whereby in the simplest case, a phonon decays into 2 and 3 other phonons, respectively. Experimental data of the frequency shifts as a function of temperature were fitted using code developed in MatLab and previously derived equations, and the fitting parameters showed the relative strengths of the processes in their contributions to the frequency shifts. The 3-phonon processes dominated the shift in the modes for SnSe, but the fits for GeTe demonstrated either a mix in their relative contributions or complete domination by 4-phonon processes. These findings give a better understanding of the poor thermal conductivity in these materials in an effort to better understand the ideal thermoelectric materials. Research will continue to examine more materials to further our understanding of thermoelectric materials and their properties.

USING CUBESATS TO DETECT OCEAN DEBRIS

Madeline Robertson
Mentor: Rebecca Arenson (Massachusetts Institute of Technology - Beaver Works Summer Institute)
GSSM Advisor: Paul Dostert

When plastic finds its way to the ocean, it quickly degrades into microplastics. These microplastics are difficult to clean up and are easily eaten by sea life. This project was to look into the feasibility of using cubesats to detect large pieces of plastic before they degrade, in order to assist clean up efforts. Previously, the same concept of plastic identification was applied using an airplane to sweep segments of the ocean. Over two sweeps of a segment of the pacific garbage patch, 1600 items were detected, and 120 were positively identified as plastic. A cubesat could do the same job as the airplane, but with a much larger range and for a longer time. A model cubesat was constructed. To test the cubesat, three poster boards were set up and colored pieces of plastic were placed on them. A ten orbit cycle was simulated by moving the cubesat in a circle over the poster boards at a speed of one orbit per minute. The cubesat was able to take pictures of each poster board. From there, the image processing code was able to crop the poster board and identify the amount of plastic. It was determined that using a cubesat was viable to identify ocean waste, however, a more precise attitude determination module, a higher quality camera, and more solar panels would be needed.

SOIL ANALYSIS OF THE RARE RHODODENDRON EASTMANII (MAY-WHITE AZALEA)

Mattie Rumfelt
Mentor: Charles Horn (Newberry College)
GSSM Advisor: Cara Roberts

Azaleas are a widespread species of plant and in 1999 a rare species of azalea, the Rhododendron eastmanii (May-white azalea), was discovered to be native and populated in South Carolina. While the species has been studied over the last twenty years, many characteristics of the May-white and its ecological niche are unknown, including its preferred soil type. Insight into the plant's unique properties can be obtained through a greater understanding of the physical and chemical characteristics of soils where May-whites flourish. In this study, we investigated the soil texture and pH best suited for the species. We acquired soil samples of May-white populations identified at seven sites across five counties in South Carolina. Even with a variety of textures and pH values found, our results indicate May-whites thrive in acidic, sandy loam soils, supporting previous theories about the habitat of Rhododendron eastmanii. A greater understanding of the range of conditions that support May-whites will help preserve this rare, endemic species and allow researchers to focus their monitoring on optimal sustainable habitats.

AUTOMATED FIBER PLACEMENT AND CONVOLUTION NEURAL NETWORKS

Benjamin Sale
Mentor: Subramani Sockalingam (University of South Carolina)
GSSM Advisor: Lance Riddle

The Automated Fiber Placement process creates composite architectures that are used for a multitude of structures. The new way that the Automated Fiber Placement process is being used requires it to use different and more precise angles, as well as different widths of fibers. This research will try to determine which composite architecture is ideal for toughness and strength from this new process. To determine the ideal composite architecture, we used Convolution Neural Networks, a type of deep learning network mainly used for visual images. We created a program that would construct composite architectures from unit cells and show the properties of that composite architecture. Unfortunately, due to time constraints, the Convolution Neural Network program was not finished. Therefore, we could not find the best composite architecture. However, if we were to have finished the program, the findings would be theoretical and would have targeted two composite architectures. The first composite architecture we would have wanted to find would be the ideal composite architecture for toughness and strength. The second composite architecture we would have liked to determine would be the most practical one. The most practical composite architecture would be the one used in mass production, so it would need to be cheap enough for mass production but also strong and tough enough for structural integrity.

THE SYNCHRONIZATION OF HEADING ANGLES USING PULSE COUPLED OSCILLATORS

Soumit Sarkar & Jackson Self
Mentor: Yongqiang Wang (Clemson University)
GSSM Advisor: David Whitbeck

Pulse coupled oscillators are devices that only transmit and receive binary pulses on a select frequency. They send data-less pulses at designated intervals to communicate with other units. This investigation was conducted to find a way of utilizing pulse coupled oscillators to synchronize heading angles on multiple raspberry pi robots connected to the same network. An algorithm was developed by testing multiple ways the heading angle would be changed. It was intended to run on fully equipped robots. However, due to restrictions from the pandemic it had to be tested in a simulation. The most efficient was one that based its changes on percentages of the difference between the heading angle and 360 degrees. Each simulated device executed the same script, and each responded to receiving a pulse in a way that would cause them to synchronize there simulated heading angles. Ultimately, each of the simulated "robots" were able to synchronize their heading angles, within a 40 second time interval. This technology will eventually be used for encrypted communication, hive-mind control, and cyber security.

MICRORHEOLOGICAL ANALYSIS OF COMPLEX BIOLOGICAL FLUIDS

Jacob Shaw
Mentor: Paula Vasquez (University of South Carolina)
GSSM Advisor: Nicole Kroeger

Physical properties and behaviors of biological fluids have remained relatively unexplored until recently. This study aims to introduce knowledge of these properties in viscoelastic (complex) fluids, as most biological fluids are, and how they respond to applied forces. Four mock-up complex fluids were used in place of real biological fluids, while still maintaining similar properties. Microrheology avoids the problems of larger scale rheology by reducing needed sample sizes, and providing a microscopic understanding of the material. Through fluroescence imaging, the motion of fluorescent particles inserted in mock-ups of biological fluids was observed and recorded. Algorithms were designed to track the motion of the particles throughout the frame, and to select which particles in each recording were most likely to be representative of the characteristics of its fluid. After clean data on the particles was obtained, analysis of their trajectories could begin in order to glean new information about the flow of these complex fluids. Using the Stokes-Einstein equation, evaluating the diffusion coefficient, and then the mean squared displacement (MSD) leads to discovering the mode of displacement of particles in each fluid. This can be either freely diffusing, transported, or bound and limited in movement. Further analysis is required to draw conclusions about specific properties of the biological fluids. Once more is known about biological fluids, advancements in medical technology can be made, such as improving the efficiency of artificial hearts pumping blood, as well in other biological fields.

IMPROVING THE ABSORPTION OF ICOSAPENT ETHYL IN THE GASTROINTESTINAL SYSTEM

Andrew Sherburne
Mentor: Christopher Roberts (South Carolina Governor's School for Science & Mathematics)

As the leading cause of death in the U.S., pharmaceutical companies have developed and continue to develop preventative treatments for heart disease like Icosapent Ethyl, also known as Vascepa. Due to Vascepa's abnormally large dosage and limited information about its mechanism of action, the study examined how to improve the solubility of Vascepa in water using emulsifiers to improve absorption with the goal of reducing required dosage. Taurocholic acid, Glycocholic acid, and Polysorbate 80 were examined as emulsifiers to improve Vascepa. After docking each emulsifier to Vascepa using PyRx and examining their interaction using VMD, Taurocholic acid was selected as the best candidate. Models of Vascepa with 0-5 molecules of Taurocholic acid were simulated in water. The results were quantified by examining the average total energy of each simulation. The results showed that as more molecules of Taurocholic acid were added to Vascepa, its solubility increased. Vascepa alone had a total interaction energy with water of -27.75 kcal/mol and Vascepa with five molecules of Taurocholic acid had a total energy of -42.85 kcal/mol. While the numbers show an improvement, the 3D model of the simulations showed that Vascepa was still exposed to water when it should have been surrounded by Taurocholic acid molecules. This suggests that more research needs to be done in determining the optimum ratio of emulsifiers to Vascepa, the stability of emulsifiers with Vascepa, and the best emulsifier. Overall, the experiment was a success and has opened the door for further lifesaving research into heart disease treatment.

THE ASSESSMENT OF VALENCE AND AROUSAL THROUGH NARRATIVE

Savannah Stremlow, Caroline Strinsky & Gracen Anne Thompson
Mentor: Svetlana Shinkareva (University of South Carolina)
GSSM Advisor: Gary Salazar

In psychology, affect refers to the positive or negative feelings experienced in reaction to stimuli, whereas hedonic valence is a characteristic used to describe its pleasantness or unpleasantness. These terms were used consistently throughout our part in the Aging Brain Cohort Study. This study was prompted by the changes in brain health as people reach advanced age. This has the potential to make them more susceptible to age-related problems such as Alzheimer's disease. Valence can be researched in a variety of controlled ways like audios, visuals, or narrative. Because valence is not a physical object, scientists are trying to understand how it operates biologically in our brains. Through experimental psychology we investigated the question of how valence is affected by narrative and how it is displayed in the brain. In this study, we divided 23 texts into segments, following grammatical rules as well as natural pauses. We then moved our newly divided segments, called offsets, into spreadsheets and recorded their start and end time for each speaker of each story. These timestamps are used to play each audio segment aloud for a group of senior research participants. Participants will undergo fMRI scans while listening to our offsets. We want to determine if there is a relationship between the active parts of their brains and the ratings of the texts in order to provide us a better understanding of the way an aging brain works.

TESTING A MULTIFUNCTIONAL INTERLOCK MATERIAL THROUGH COMSOL MULTIPHYSICS

Tetiana Tymoshevska
Mentor: Sourav Banerjee (University of South Carolina)
GSSM Advisor: Mark Godwin

Over the last couple of decades, there has been great interest and progress in the design of several artificially engineered composite materials called metamaterials[1] (Links to an external site.). They can manipulate acoustic waves in a unique way not present in natural materials, making them more suitable for various practical scientific applications. When metamaterials are shaped in periodic structures, they exhibit features such as wave focusing, acoustic transparency, superlensing, and negative refraction. In this study, a new interlock structure made out of PMMA and silicon rubber was tested and as well as a more elongated exciter. The metamaterial structure explored in this paper applies to man scientific areas, including biomedical ultrasonic imaging, cloaking, and aerospace functions. This was accomplished using Comsol Multiphysics V4.3 software[2] (Links to an external site.) which is a simulation program. Preliminary studies were done, including finding natural frequencies through eigenfrequency and mesh sensitivity. In the eigenfrequency study, a dispersion curve was constructed, which revealed band gaps from ~190 kHz to ~240 kHz and from ~300 kHz to ~350 kHz and a linear behavior below ~100 kHz. This indicates the possibility of acoustic transparency and vibrations, which is promising. Before these characteristics could be tested through frequency domain, a mesh sensitivity study was done to achieve accurate results. The settings were calculated to be 1.32 mm for PMMA and 0.02 for silicon rubber. Computational power was too limited to apply the settings so this particular study ended there.

PREDICTING MECHANICAL PROPERTIES OF NANOCOMPOSITES USING SUPERCOMPUTER

Sydney Weeks
Mentor: Zhaoxu Meng (Clemson University)
GSSM Advisor: Fatemeh Salehikhoo

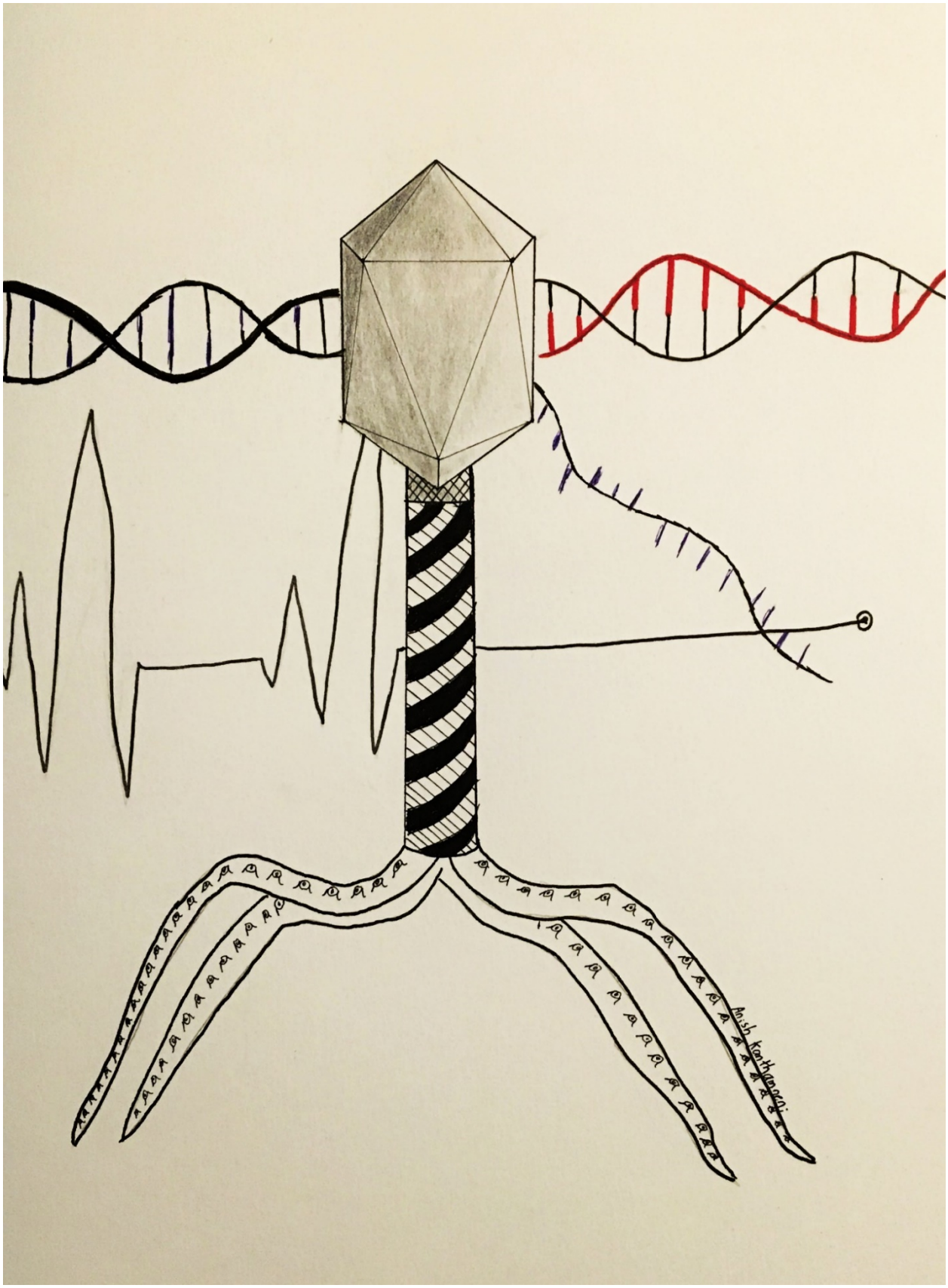
New technologies and innovations have created a high and unmet demand for more advanced materials. In many cases, the solution to this demand has become nanocomposites. Nanocomposite materials are created through the combination of two or more materials with distinctive mechanical and physical properties. The properties of the resulting nanocomposite will be superior when created with the correct ratio of each constituent. This research will look at graphene-polymer nanocomposites and work to find the ideal ratio of each material. A polymer is a type of plastic, in this research polymethyl methacrylate (PMMA), while graphene is a one-atom-thick layer of carbon atoms densely packed in a honeycomb crystal lattice. The ideal combination of these materials results in improved mechanical, thermal, electrical, and gas barrier properties. Additionally, because graphene occurs naturally, graphene-polymer nanocomposites are considered bio-inspired structural materials. Inspired by nature and complimented by technology, the material is tougher, stronger, and more lightweight. While the demand for graphene-polymer continues to increase, there are still numerous unknowns regarding the ideal ratio of graphene to polymer to reach the desired properties. This research will focus on dissecting the mechanical properties of seven variations of graphene-polymer nanocomposites using computer simulation to provide insight regarding the ideal composition and application of this material.

COMPARING MICROBIAL COMMUNITY STRUCTURE BETWEEN MFC AND AD

Winnie Zheng
Mentor: Sudeep Popat (Clemson University)
GSSM Advisor: Stephen Kaczkowski

Wastewater treatment research is pivotal to optimize the treatment and end products of wastewater technology systems. Additionally, understanding the structures and changes in microbial communities allow for more efficient control of these systems. The overarching question focused on during this research was "Does chemical oxygen demand (COD) or pH have a greater effect on the microbial communities in microbial fuel cells (MFC) and anaerobic digestion (AD) co-digesting municipal wastewater sludge with rendering wastewater (RW) or fats, oils, and grease (FOG)?" After extensive research, it was hypothesized that pH has a greater effect on the microbial communities because both waste systems have similar ending COD values. A system called RStudio Cloud (R) was used to analyze the microbial communities from two different systems (MFC and AD) co-digesting two different types of waste: fats, oils, and grease (FOG) and rendering wastewater (RW). RStudio Cloud was used to perform a series of tests: using the ggplot2 library from R, and then performing shannon alpha diversity, beta diversity with NMDS (non-metric dimensional analysis) ordination, the Mantel and ANOSIM (Analysis of Similarity) tests, and the Indicator test. It was concluded that neither pH nor COD have a significant effect on the microbial communities. Rather, waste type and systems have the greatest effect. In the future, analysis of the metagenomic sequencing data for this sample could be performed, which would allow us to gather information on the potential functions of the communities. Additional variables could be observed, such as organics, solids, and nutrients.

Jack Aragon (Class of 2021)



Anish Kanthamneni (Class of 2021) - *COVID-19 may not change our DNA, but it does change who we are. It's inevitable. However, we can choose how it changes us: we can let it break us or make us stronger.*