Project # 1

Amir, Aroush

Completed Project, Science, Health & Medical

Determining the Mechanisms of Cancer Stem Cell Selection

Colon cancers begin with a genetic mutation in a niche or group of colonic stem cells (SC) found in all crypts, which are tube-shaped units forming the intestine. If a mutation were to occur in a niche, the mutated SC is selected and results in the spread of cancer, however, how these mutated SCs got selected is unknown. This project aimed to understand SCs' mechanism when they have been mutated and pushed out from the niche. It was hypothesized that if a mutation is acquired in the SCs, then these cancer SCs would outcompete neighboring cells. The independent variable of this experiment was the introduction of a cancerous mutation to SCs. The dependent variable was the rate of SC multiplication. Constants included the age of mice, mice littermates, the site of mutation, and where the mutation was introduced by the mentor. Nine days post-administration of the mutation, the mouse colons were dissected and cryofixed. The mentor took pictures of the cryosections under a fluorescent microscope and the student counted SC clones, calculated the average mitotic index (AMI) of both tissue groups, and conducted a one-tailed T-test. Results thus far suggest that the AMI is higher for tissues with tumors than healthy tissues due to an overexpression of BRAF E600 (genetic mutation), showing a selective advantage of cancer SCs because of increased proliferation rates. Once completed, this research could assist in the future development of colon cancer prevention treatments by identifying the presence of a selective advantage of cancerous SCs.

Amity High School

Teacher: Catherine Piscitelli

Project # 2

Arnold, Sadie

Completed Project, Science, Health & Medical

Determining the Best Drill Trajectories and Best Instrumentation to Conduct Core Decompressions to Treat Avascular Necrosis of the Femoral Head

Avascular necrosis (AVN) is a disease that results from temporary/permanent loss of blood supply to the bone. AVN is caused by injuries, alcohol consumption and certain medical conditions/treatments. Diagnosis in the femoral head is increasing. If left untreated, it can progress to secondary hip arthritis (osteoarthritis). There's 10,000-20,000 new cases in the U.S. annually. There are multiple surgical treatments, but no consensus on the most efficient type. Core decompressions are a type of surgery that removes the inside of bone to relieve pressure, allowing new blood vessels to form. The purpose of this project was to determine the best drill trajectory to conduct core decompressions to treat AVN of the femoral head. It was hypothesized that the volume of the femoral head and AVN will be correlated since a larger femoral head size allows for a larger AVN region. There are no variables since this is a comparison study. Scans of patients' hips with AVN were provided by the mentor. 3D models were created in ScanIP. The volumes were measured to categorize the stages of AVN. Surgeries were recreated in 3D. A statistical analysis was run to determine the most efficient drill trajectories. Results thus far support the volume of AVN region to the femoral head do not have a trend. However, the models provide an accurate view of the angle and depth needed for an efficient surgery. The findings of this project could help surgeons successfully reach the AVN region on the first try.

Amity High School

Teacher: Catherine Piscitelli

Project # 3

Bisset, Luke

Completed Project, Science, Environmental

<u>Researching the Effects of Microbursts On the Biodiversity In Local Ecosystems</u>

Microbursts are storms with really strong downward wind, and are very unique disturbances. They can be equal or stronger to tornadoes. It is Hypothesized that they can cause an increase in heterogeneity and an increase in diversity wherever they hit. Hundreds of microbursts occur in the US every year. They are very destructive and can uproot trees and churn soil. Microbursts have occurred in Connecticut, and a really powerful one hit Sleeping Giant State Park a few years ago. There haven't been many studies on microburst's impacts specifically, and they might cause an increase in biodiversity. The purpose of this project is to determine the effects of microbursts on the biodiversity of local ecosystems. Two sites at Sleeping Giant State park were chosen, one that was hit by the microburst and one that wasn't. A 10 ft by 10 ft area was marked off, and everything in them was recorded. Data was collected on these two sites, including the plant species, plant type, tree thickness, and estimated age. Using the data, the above and below ground biomass was calculated using similar taxonomic taxes from background research of the site. Using the biomass, the biodiversity of each site was calculated. The species richness was also calculated by adding up the number of each species present divided by area, which was just 100 square feet. The biodiversity in the impacted cite was found to be higher, supporting the hypothesis.

Amity High School

Teacher: Catherine Piscitelli

Project # 4

Brissette, Kaylin

Completed Project, Science, Health & Medical

<u>Hepatic Stellate Cells in Liver Regeneration</u>

Hepatic stellate cells, once described as Kupffer cells, are generally quiescent or inactive within the healthy liver. Once activated through injury stimuli, stellate cells transform from fibroblasts into myofibroblasts. Stellate cells' main role is in remodeling the cellular matrix and producing scar tissue through the synthesis of collagen and lamin. Thus allowing stellate cells to contribute to the maintenance of homeostasis within the liver but also makes them a large proponent in fibrosis. The fibrotic liver then becomes carcinogenic and is progressively linked to various cancers and tumors, such as hepatocellular carcinoma. Additionally, stellate cells have the ability to stimulate migration and transformation of nearby hepatocytes through the chemical secretion of chemokines. Gene expression analysis through UMAP(Uniform Manifold Approximation and Projection), a program similar to t-sne processing, could prove useful in identifying patterns of proliferation and production of proteins. UMAP is especially useful in reducing the dimensionality of data while having more simple parameters and operations. Data from pre-existing databases would be used for the software program. Patterns of proliferation capabilities would prove insightful in the aim of better understanding the delicate nature of stellate cells.

Newtown High School

Teacher: Timothy DeJulio

Project # 5

Burbank, Aiden

Completed Project, Engineering, Physical Science

Autonomous Ping Pong Robot Object Detection and Prediction

Can robotics be used as a replacement for human players in Ping Pong? I will find this out through creating a Ping Pong robot that will successfully return a Ping Pong ball hit by a human player. This is done through having multiple arm-like segments, each controlled by its own motor. The robot sees the ball with a multiple camera system that will track the ball and predict its location in real time. I first designed the Ping Pong robot in Solidworks, then 3D printed my design on a smaller scale. With the model, adjustments were made until the design had minimal and inconsequential flaws. With this complete design I will go to a metal manufacturer and have a full sized model made out of aluminum. A mix of ROS(Robot Operating System) and python coding will be used to control the robot. Basic functions like moving will be coded into the robot first, then more complicated things like tracking the Ping Pong ball movement will be completed. Object detection is done using faster RCNN. After all of the functions are incorporated improvements will be made to increase speed and efficiency for a better outcome. I expect that the robot will be incapable of the goal at first but I will keep making improvements until it does work. When the robot is successful I think that it will be capable of replacing a human player on a low level being able to return a ball back across the table.

Newtown High School

Teacher: Timothy DeJulio

Project # 6

 Cannon, Emma

Completed Project, Science, Environmental

Determining the Ability of Mosses and Plants to Remove Algae-Causing Phosphates and Nitrates From Water

When phosphates and nitrates enter bodies of water, algae blooms form, covering the surface and diminishing water quality by hindering sunlight for underwater plants. In addition, when the algae die, the oxygen in the water is consumed, making it extremely difficult for aquatic life to survive. This study assessed mosses and plants' ability to mitigate these pollutants due to their leaf and root structures. A fertilizer solution containing phosphates and nitrates was added to water and the initial levels of these nutrients were recorded, then a sample was set aside to be used as a control. Five mosses in triplicate were then exposed to the polluted water and the water was tested for the pollutants over periods of time. It was expected that the Polytrichum commune would remove a significant amount of the pollutants from the water. After testing, it was found to be successful, but the moss that performed best was the Fruiting Moss. Plants were also introduced in a separate trial. Five different species were tested the same as the moss. It was hypothesized that the plants would be able to use their roots to absorb the pollutants, similar to the moss's ability to absorb through their leaves. King's Choice Ivy was the most effective. This experiment implies that mosses, and possibly plants, can be used along the shoreline to remove the algae-causing pollutants before they enter the water. Water will become safer to swim in, and will become environmentally stable for the habitats of marine life.

Convent of the Sacred Heart-Greenwich

Teacher: Joyce Reed

Project # 7

Cardamone, Beatrice

Completed Project, Science, Health & Medical

Inhibition of Prion Protein Propagation

Transmissible Spongiform Encephalopathies (TSEs), or Prion Diseases, are a class of rare neurodegenerative diseases with no known cure or treatments. Though the understanding of their processes is lacking within the science community, some important pieces of information have been gathered. As shown by Prusiner et alia, no genetic information is responsible for their pathogenesis. Instead, the 'prion only hypothesis' states that the prion protein, a protein conserved in most mammals, and of which the exact purpose is unclear, is responsible for these diseases. In TSEs, the healthy prion protein, denoted PrPc, converts to a diseased isoform, denoted PrPsc. It is also known that the diseased prion isoform is capable of conferring its malformity to the healthy variant. PrPsc forms oligomers, fibrils, and amyloid plaques within the brain, the concentration of which is associated with a further course of disease. As shown by Collinge at alia, the removal of the prion protein from the brain via a monoclonal antibody has a stabilizing effect on the degeneration caused by Creutzfeldt-Jakob Disease -- a TSE -- in humans, as well as mice. This paper proposes a novel technique for the treatment of TSEs wherein an interfering peptide (IP) is designed in silico similar in structure to PrPc which is capable of binding to the diseased isoform, and inhibiting its ability to convert more proteins, via the interference in protein-protein interactions (PPI) therefore slowing or halting disease progression. The IP will be designed based on a 3D model of the prion protein, its structure tailored to bind to so-called hotspots, residues within the protein with higher binding energies than the remainder; these areas, therefore, are those with a higher likelihood to interact with other proteins, exactly what is intended to be inhibited, as this interaction is responsible for at least some portion of the disease. In doing this, the intention is to provide succor to both those suffering, and those whose families' have suffered, from TSEs, in the form of relief from the disease, as well as further progress and hope that one day such ravages will be cured in their entirety.

Newtown High School

Teacher: Timothy DeJulio

Project # 8

Chen, Rebecca

Completed Project, Science, Health & Medical

Determining the Similarities and Differences Among the Characteristics of Mitochondrial Proteins Found in Brains Affected by Alzheimer's Disease

Alzheimer's Disease (AD) is one of the most common types of dementia primarily found within people over the age of 65. The disease causes people to progressively lose their memory, cognitive skills, and the ability to accomplish simple everyday tasks. AD currently has no cure and the causes such as the build-up of proteins in and around brain cells are continuously being researched. Proteins have many unique characteristics and are thought to impact AD due to abnormal levels of proteins found in AD brains compared to healthy aging brains. The purpose of this experiment was to determine the similarities and differences among the characteristics of mitochondrial proteins found in brains affected by Alzheimer's Disease. It was hypothesized that there will be a correlation between the characteristics of proteins that have similar effects on AD brains. The independent variable was the ten proteins and the dependent variable was the protein characteristics. The mentor provided the protein names along with their ratio of expression and subcellular location. The other characteristic data were found through UniProt, a large database of protein information. Two characteristics were compared at a time with the use of excel. Results thus far support minor and major similarities among nearly all the characteristics with the exception of function, which seems to differ the most among the proteins. This research will provide more information on how protein characteristics are related and how they might be responsible for certain AD symptoms.

Amity High School

Teacher: Catherine Piscitelli

Project # 9

Cox, Lydia

Completed Project, Science, Environmental

Using Sunscreen as a way to distribute Beneficial Microorganisms for Corals (BMCs)

Using Sunscreen as a way to distribute Beneficial Microorganisms for Corals (BMCs). This project is trying to create a BMCs enriched sunscreen that will be used to distribute the BMCs to a natural reef environment. To do this a 2-section sunscreen compartment will be created. In half of the container freeze-dried BMCs will be stored, the other half there will be non-nano zinc oxide (the sunblock). The first question that will be tested is will the BMCs rehydrate in the zinc or in water. To see how effective the BMCs are at mitigating the effects of bleaching a heat stress simulation will be performed. There will be 12 fish tanks used in the whole experiment but only 6 tanks will go through the heat stress simulation. The water temperature in the 6 tanks will start at 26°C and be raised to 30° C over a period of 10 days. Then the water temperature will remain at 30 degrees Celsius for 10 days, before being lowered back to 26°C over 10 days. There will then be a 20-day recovery period. To avoid working with humans participants neoprene diving gloves will be used to inoculate the corals with zinc-oxide compound or just zinc. Farther down the road the sunscreen will be tested on humans. The other 6 tanks will remain at 26°C as a control. This sunscreen could be a way to distribute BMCs to natural environments.

Newtown High School

Teacher: Timothy DeJulio

Project # 10

 Dillon, Avery

Completed Project, Science, Health & Medical

Determining Whether or Not Using Certain Exercises in Physical Therapy will be More Effective

Physical therapy is the practice of treating diseases, muscle tightness, torn ligaments or tendons, inflammation, deformity, or other injury through exercises, massaging, and heat therapy instead of using pharmaceutical drugs or surgery. Focusing on treatment plans in physical therapy, physical therapists frequently provide different plans for individual patients, even if they have the same injury. This project's purpose was to determine whether using different treatments in physical therapy for the same injury would make recovery time faster. Building on the challenges faced in the previous year, where data collection was limited, this continuation project sought to expand and refine its findings. The researcher recorded therapies and exercises employed, addressing the gaps identified in the initial study. The hypothesis of this project is that specific treatment plans prescribed by physical therapists contribute to faster recovery times compared to alternative plans. Key variables in this study include the independent variable of treatment plans, the dependent quantitative variable of recovery time, and the dependent qualitative variable of pain levels. Constants involve lower extremity injuries and an age range of 35-65 years. Weekly visits to Amity Physical Therapy facilitated data collection through patient charts provided by the mentor. The recorded information includes patient demographics, injury details, surgical history, time since surgery, prescribed exercises, and massage techniques. Although meaningful trends have yet to emerge, there are many potential implications. The project aims to enhance the ability to tailor treatment plans, ultimately leading to accelerated recovery times for patients with specific injuries.

Amity High School

Teacher: Catherine Piscitelli

Project # 11

Fan, Janet

Completed Project, Science, Behavioral

Comparing the Tendency to Perceive Online and Offline Offending as "Violence" in Youth Victims of Online Offenses

The purpose of this study is to determine if a correlation exists between the extent to which a youth has been a victim of online offenses and the extent to which they consider various offenses "violent." The hypothesis is that if a youth has been a victim of online offenses to a great extent, then they will consider various online and offline offenses as "violent" to a much lesser extent than youths who have not been victimized because youths who view offenses as less violent may be more likely to commit them in the future, supporting the correlation suggested by past studies. The independent variable is the extent to which a youth has experienced online victimization, as measured by the number of times an individual has reported being threatened or verbally assaulted online in the past 12 months. The dependent variable is the extent to which a youth considers offenses "violent" as measured on a likert scale from 1-4. The control in this experiment was the average responses of individuals who have never been victim of a violent offense. Participants were asked if they had ever been a victim of a violent offense, and if so, how many times in the past year. Then, students ranked actions such as "threatening someone on social media" and "touching someone else on the shoulder, with or without his/her permission" as more or less violent using a Likert scale. Data was analyzed and a regression analysis was run. This study will help build a greater understanding of the link between online victimization and perpetration, and specifically how individuals move from the role of victim to perpetrator.

Amity High School

Teacher: Catherine Piscitelli

Project # 12

Gleason, Calista ; Speicher, Emma

Completed Project, Science, Teams (Completed Project)

The Effects of Golf Course Runoff on Rooster River

Algae blooms have harmful effects on aquatic ecosystems. We wanted to see if water with fertilizer, in comparison to water without fertilizer, had any effect on the growth of the algae. We started by collecting river water samples from before a golf course and after the golf course, along with plain distilled water. We used these three water samples to grow our algae, each in a different bottle. We grew the algae under a growth lamp and took observations with a light meter every other day for two weeks. By seeing the difference in the algae growth we're able to see how the amount of fertilizer affects the amount of algae in the water. The results ended with the water after the golf course having the most lux. The river water before the golf course came in second and the distilled water came in last with the least amount of lux. This demonstrated that the more fertilizer in the water resulted in more algae, causing more harm to the aquatic ecosystems.

Fairfield Warde High School

Teacher: Ryan Gleason

Project # 13

Gopal, Alesandro ; Liu, Adam

Completed Project, Science, Teams (Completed Project)

Designing a More Human-Like Non-Player-Character to Enhance Player Experience in Video Games

Artificial Intelligence (AI) has been rapidly integrated into various aspects of human life, highlighting a challenge: AI lacks human-like qualities. This is why, in the realm of video-games, playing with Non-Player Characters (NPCs), or AI robots, often results in less enjoyable experiences. To address this, researchers and game developers explored using machine learning to artificially mimic human learning. Long Short-Term Memory (LSTM) models are machine learning algorithms known for processing sequential data. The purpose of this project was to design a human-like LSTM-based NPC to enhance gaming experiences. The project was deemed successful if the NPC could exhibit human-like reactions and seamlessly blend with real players in 80% of testing scenarios. Training was split up into different skills required for the game: aiming, moving, and action-timing. Human participants, mainly 14-22 year olds recruited through convenience sampling, played small games in Minecraft to generate skill-specific data for training the LSTM model. The NPC was programmed using Mineflayer, a JavaScript library for Minecraft NPCs, and trained on Google Cloud servers. Following the Turing test approach, an online survey asked participants to distinguish between NPC and human players based on gameplay videos. Findings thus far show that the implemented machine learning based NPC does show resemblances to a human player but fails to be indistinguishable from them. The project aimed to enhance the Minecraft player experience and potentially extend these techniques to other fields like healthcare and education, fostering more engaging interactions between humans and AIs.

Amity High School

Teacher: Catherine Piscitelli

Project # 14

Greco, Bella

Completed Project, Science, Health & Medical

<u>The Effect of Morning vs. Night Exercise on Sleep Length and Quality</u>

When it comes to muscle growth and making your body more healthy, sleep is one of the most important aspects. Sleep is when your muscles are able to grow and your body can recover. So, to optimize sleep is to optimize athletic performance as well. In order to investigate this I tested the effect of morning versus night exercise on sleep length and quality. I did this through self experimentation using a fitness band called WHOOP. This band tracks sleep length and recovery. For 3 weeks, I exercised every day in the morning and slept at a constant time. Then the next three weeks I exercised every day at night and slept at the same constant time. I then studied and analyzed my results on the whoop band app.

Ridgefield High School

Teacher: Ryan Gleason

Project # 15

 Hayashi, Parker

Completed Project, Engineering, Physical Science

Clonal Evolution of Non-Small Cell Lung Cancer Reveals TP53/EGFR Maintenance and SETD2 Selection in Metastases

According to the World Health Organization, almost 10 million people die of cancer annually, equating to about one-sixth of all deaths. Approximately 90% of these deaths are a result of metastatic cancer, highlighting the importance of metastasis focused research. As cancer cells evolve over time, certain cells gain the ability to disseminate from their primary tumor and metastasize to a distant organ. Understanding which cancer cells metastasize and the routes they took to get there would aid in our understanding of metastasis and the development of novel therapeutics. We investigated the genetics of metastatic cells by identifying the genes that are selected for in metastasis. To do so, we inferred the clonal evolution and migration histories of non-small cell lung cancer (NSCLC) patients, the most common cancer type seen at Memorial Sloan Kettering Cancer Center (MSKCC). By preprocessing large datasets and utilizing recently developed machine learning techniques, we generated highly accurate clonal evolution trees that facilitate the search for mutations correlated with metastasis. By compiling the genes found in our results, lists of mutations were categorized by various data points, such as the anatomical site and mutation type (primary or metastasis). We identify one gene, SETD2, as significantly associated with metastasis, as well as possible explanations for this link. We've identified a previously unknown gene that could aid future researchers as a potential therapeutic target for metastatic NSCLC.

King School

Teacher: Victoria Schulman

Project # 16

 Hicks, Cate

Completed Project, Science, Health & Medical

<u>Caffeinated Energy Drinks Effects on Energy and Performance</u>

With a large amount of young adult athletes consuming highly caffeinated beverages, further research into their ingredients is extremely necessary. Creating awareness and helping to educate the public and athletes of all levels about the possible effects consuming caffeinated energy drinks may have. As well as increasing our knowledge of how these energy drinks and the herbs they contain may boost athletic performance. Main ingredients such as guarana, ginseng, and taurine are highly concentrated in these popular drinks. In this experiment, I focus on the possible stimulant effects of guarana on fruit fly behaviors as similar indicators to human athletic performance. I hypothesized that if given an herbal stimulant of paullinia cupana then drosophila melanogaster will experience little to no increased movement behaviors over a period of time. By performing a serial dilution and administering different concentrations of a water and guarana solution, I was able to see if there were different effects based on dosages. I then recorded the flies that were administered the different concentrations, as well as a control group who was given only water. When reviewing my data, I focus on the behavioral and physical indicators shown by the flies such as flight and response times. Initially, my data shows little to no differences between concentrations and between control and guarana-dosed flies.

Ridgefield High School

Teacher: Ryan Gleason

Project # 17

Huitron, Martha ; Krishnan, Ashwika

Completed Project, Science, Teams (Completed Project)

Quantify Microplastics in Shrimp Using Potassium Hydroxide and Nile Red Dye

Microplastics are extremely small pieces of plastic debris left in the environment. Plastics are not able to dissolve, instead, they break down into smaller and smaller pieces. Microplastics are miniscule but dangerous to terrestrial and oceanic ecosystems around the world. When microplastics break down from larger plastics, they become a different kind of threat to wildlife because of their small size, and the amount of microplastics is only projected to increase in the upcoming years. This research will serve to advance the study of how microplastics affect marine ecosystems and seafood consumption by humans. Plastic pollution is expected to double by 2030, so research towards the conservation of the environment is more vital now than ever. Additionally, this experiment will highlight the possible harm of consuming microplastics in seafood. The research question is: If microplastics are so prominent in oceanic environments, will they be found in marine organisms like shrimp? The hypothesis is: If microplastics are so prominent in oceanic environments, there will be microplastics found in marine organisms like shrimp because they would have consumed them in their natural habitat. The methodology is as follows: Acquire Nile Red Dye, Potassium Hydroxide, and marine organisms. We will get 4 large tiger shrimp Carefully remove all of the shrimp's digestive system and GI tract Separate the shrimp's intestine and stomach contents into 8 different test tubes. Weigh the materials and record data. Label each test tube. Pour 3-4 mols of potassium hydroxide diluted in distilled water into each test tube. Place test tubes in the oven and bake at 60 °C for 24 hours. This will allow for the biological components of the sample to be digested away by the chemicals. Take each sample, and put filter paper on a funnel on 8 new test tubes. Leave the solutions to strain. Introduce the Nile Red Dye Put leftover particles on a slide and examine them under a microscope (UV light). Examine and collect data

Ridgefield High School

Teacher: Patrick Hughes

Project # 18

Jerfy, Aadit

Completed Project, Engineering, Physical Science

AI Based Skin Cancer Detection System

Melanoma, the most severe form of skin cancer, is almost always deadly if left untreated. While it comprises a small minority of skin cancer diagnoses, it has the highest fatality rate. Current detection requires a visit to a clinic to receive a physical examination or biopsy, which some people don't have access to. I have created a detection method that will effectively be accessible to anyone with a phone, computer, or similar device. A user interface was made using PyCharm, and code written by Sasank Chilamkurthy, in which Python is utilized to identify whether or not an image submission is melanoma. The AI is trained on 6,000 images from the HAM10000 dataset from harvard.edu, which consists of 10,000 images of melanoma, to train the neural network for detection. The code considers variance in skin tone and crops the image so as to limit computing power needed. Transfer learning is utilized so that the data can be made into a more comprehensive imageset for the network. The AI iterates through the database, comparing it to the submitted image and picking up on similarities. If there are enough characteristics of melanoma in the submitted image, it is identified. The code will be incorporated into an application eventually, in which people can take a picture of a lesion for accurate and simple detection of melanoma. The AI is currently able to detect melanoma with an accuracy of 92.1%, tested on a set of 2,000 images.

Newtown High School

Teacher: Timothy DeJulio

Project # 19

 Kim, Yunah

Completed Project, Science, Environmental

<u>Determining the Most Effective Blend of Coagulants for Surface Water Treatment in Varying Temperatures</u>

Determining the Most Effective Blend of Coagulants for Surface Water Treatment Water scarcity is becoming more prominent, leading to the need for more efficient and cost-effective water purification methods. Coagulation is a chemical water treatment method that removes impurities from water through destabilization of suspended particles that make water disinfection difficult. The increased efficiency of blended coagulants in removing physicochemical parameters compared to individual coagulants has been observed. The purpose of this project was to identify the most effective blend of coagulants: alum, ferric sulfate, and Moringa oleifera seed powder in treating surface water. It was hypothesized that alum and ferric sulfate would be the most effective blend as they are both chemical coagulants and frequently used in purification industries. The independent variable was the different blends of coagulants. The dependent variable was the percentage removal of conductivity, water hardness, and total dissolved solids (TDS) from the water. The control was the surface water sample without any coagulants added. The experiment was performed outdoors at home. Water was collected from a local pond and the performance of eight different samples were recorded. Before coagulation, water hardness, TDS, and conductivity were measured. After coagulation, the water was filtered and measured again. Results demonstrated a decrease in water quality amongst most criteria, with an overall increase in conductivity, increase in TDS, and variation in water hardness. This research will provide more knowledge on how to improve the experimental process in the future and provide insight on coagulation as a purification method.

Amity High School

Teacher: Catherine Piscitelli

Project # 20

Kolb, Antonia

Completed Project, Engineering, Physical Science

<u>DETICKT IT: A Machine Learning-Based Application for Real-Time Tick Identification and Spatiotemporal Disease Risk Assessment</u>

There is an alarming increase in the population of ticks and tick-borne diseases (TBDs), with 475,000 cases reported annually, some of which are fatal. Due to limited training, healthcare providers and the public cannot always accurately identify ticks and their associated infections, leading to delayed diagnoses and treatments. Additionally, the prevalence rates of different disease-causing pathogens vary based on geographic locations. To facilitate the identification process and provide an expedited risk assessment of TBDs, a machine learning-based iOS application, DETICKT IT was created. The app features a ResNet50V2 (transfer learning) deep convolutional neural network (CNN) built in Python for combining real-time tick-species identification with a location-based tick-risk assessment by embedding the Centers for Disease Control and Prevention's (CDC's) spatiotemporal tick and pathogen surveillance statistics. With DETICKT IT, users can now receive an immediate and accurate analysis to determine whether they are at risk of contracting a certain TBD. The app is able to accurately identify the ten most common tick species in North and South America: American dog tick (Dermacentor variabilis, D. similis), Asian Longhorned tick (Haemaphysalis longicornis), Brown dog tick (Rhipicephalus sanguineus), Eastern blacklegged tick (Ixodes scapularis), Western blacklegged tick (Ixodes pacificus), Groundhog tick (Ixodes cookei), Gulf Coast tick (Amblyomma maculatum), Lone star tick (Amblyomma americanum), Rocky Mountain wood tick (Dermacentor andersoni), and soft tick (Ornithodoros). The overall accuracy is 97% with precision, recall, and F1 score metrics of 0.96, 0.97, and 0.96, respectively. This freely accessible app shows promise in assisting tick bite victims with their decision to seek further medical assistance, particularly those with underlying health conditions.

King School

Teacher: Victoria Schulman

Project # 21

Kompalli, Nidhi

Completed Project, Science, Health & Medical

<u>Determining The Correlation Between Various Types of Breast Cancer Treatments and Signs of Psychological Stressors in Breast Cancer Patients During Time of Diagnosis and After Treatment</u>

Determining the Correlation Between Various Types of Breast Cancer Treatments and Signs of Psychological Stressors in Breast Cancer Patients During Time of Diagnosis and After Treatment Breast cancer treatments are common treatments for breast cancer patients that help reduce and try to eliminate cancer cells in their bodies. Many patients, when first diagnosed, have doubts and are fearful of what is to come. Furthermore, it was recently discovered that many patients associate their treatment with pain or instability, hence resulting in many signs of psychological problems. These psychological effects can even result in poor health for these breast cancer patients, from the time they are diagnosed to after their treatment is completed. The purpose of this project was to determine the correlation between the breast cancer treatment types, and the stressors presented within each group. If a breast cancer patient is diagnosed and treated with chemotherapy, then they are more likely to show signs of poor psychological health, because chemotherapy has been shown to be one of the most painful and expensive types of breast cancer treatment. The independent variables in this project were the various types of treatments (chemotherapy, radiation, and hormone) and the dependent variable was the psychological health of the patient that was determined using the NCCN distress tool. There were no controls or constants in this experiment. The student gathered data from the mentor's database, and then the retrieved data was sorted into three different treatment groups: chemotherapy, radiation treatment, and hormone treatment. Then, within each treatment group, the patient data was sorted into groups based on their score using the NCCN distress tool.

Amity High School

Teacher: Catherine Piscitelli

Project # 22

Koola, Adrian

Completed Project, Science, Health & Medical

Analyzing the Impact of Low-Level Viremia on Treatment Outcome in HIV Infected People Living in Low-and Middle-Income Countries

Currently, research is lacking on HIV for people living in low and middle-income countries. Information is especially lacking on low-level viremia (LLV) when patients have 50-999 copies/mL of HIV in their blood. LLV is associated with higher risks of virological failure and drug resistance. The purpose of this research was to determine the impact of LLV on the treatment outcome for people living in low and middle-income countries. The independent variable was the initial viral load categorized as LLV or non-LLV, and the dependent variable was the treatment outcome. The control in this study was the people without LLV. It was hypothesized that if people in low-and middle-income countries with HIV have LLV, then they are more likely to develop virological failure because studies from high-income countries show that low-level viremia is associated with virological failure. For this research, several articles were collected by the mentor, and data was extracted from the articles by the student. Subsequently, the results of the study were recorded and analyzed by comparing the risk of virological failure between those with and without LLV. The results show that there was a 2.24 risk ratio for people with low-level viremia to develop virological failure. This indicates that low-level viremia increases the risk of virological failure, supporting the hypothesis. Since the hypothesis was supported, the researchers will join other researchers to recommend that the WHO revisit its criteria regarding HIV. This would increase awareness of the risks of low-level viremia and potentially decrease treatment failure.

Amity High School

Teacher: Catherine Piscitelli

Project # 23

Laryea-Adjei, Sowa

Completed Project, Engineering, Physical Science

Synthetic Intelligence In Motion: Building and Testing a Miniature Self-Driving Car

Self-Driving cars are becoming more relevant to society every day, but almost 70% of drivers are afraid of them, even though automated cars can be trained to be safer than even the average human driver. This made me curious about how automated cars are able to stay on the road and detect motion. I used the Engineering Design Process to prototype a Miniature self-driving car. Then I made an algorithm for it to move on its own, react to different colors, and stop when it detects an object, all on a self-made road with appropriate markings. I also attempted to make a cruise-control mode for the prototype, which lets it follow a moving object, such as a hand or a toy car. I discovered that in order for the car to turn around the road, the sensors need to detect the different colors for it to safely navigate the road. These results suggest that self-driving cars require many sensors and trackers for them to function while abiding by street laws. If I were to do this project again, I would try to refine the automatic steering of the car as much as possible, to the point of replacing the kit, so it would drive perfectly straight without any mishaps.

King School

Teacher: Victoria Schulman

Project # 24

Student is no longer participating in Fair

Project # 25

Louizos, Zachary

Completed Project, Engineering, Physical Science

Two-Dimensional Semiconductors: Characteristics and Usages of Graphene and Transition-Metal Monolayers

The properties of two-dimensional semiconductors are of high interest in recent years due to their potentially exceptional performance in optoelectronic devices. Graphene, already known for its exceptional performance as a conductor, is needed in its few-layer form for characterization through the use of Scotch-tape exfoliation. This method involves the thinning of a bulk lattice using Scotch-tape as a separating agent. The tape easily overcomes the forces that hold the graphene lattice together, so it is optimal for producing high-yield few layer graphene. Graphene is then placed onto SiO_2 wafers for contrast with the substrate. Few-layer graphene is identified through methods of 100x magnification, with the transparency of a bi/trilayer indicating the presence of few layer graphene. In addition to graphene, exfoliation methods are used on the TMD semiconductor WSe_2. In this case, however, gold exfoliation is used in which Au foil is placed on a bulk WSe_2 crystal and extracted onto a SiO_2 substrate. WSe_2 stacking methods are prevalent in exerting properties of Moiré superlattices, with our original method involving transfer of a monolayer to a substrate using a polymer. This polymer slides the monolayer onto the substrate and creates potential superlattices dependent on the twist angle. These superlattices and monolayers of both graphene and WSe_2 can be characterized through Scanning Tunneling Microscopy, in which doping levels and bandgap structures are identified using a piezoelectric tip on the atomic level of magnification and charge carrier mobility analysis within 2-D semiconductors and TMD materials. Overall, we aim to optimize and uncover new methods of production and identification within 2-D materials, with the goal being the enhancement of semiconductor properties that can enable materials to be efficiently utilized in optoelectronic devices.

King School

Teacher: Victoria Schulman

Project # 26

Lu, Nicholas

Completed Project, Science, Environmental

<u>Assessing the Potential Cost Effectiveness of Alternative Meat Sources at Improving Human Sustainability Using a Machine Learning Model</u>

Over the past few decades, increased land use for agriculture has grown to excessively unsustainable levels resulting in the industry accounting for 11% of all human greenhouse gas emissions and the destruction of vast areas of natural habitats. One potential solution to help address this problem is alternative meat sources. Alternative meat, such as lab grown and plant-based meat, produces almost 90% lower greenhouse emissions than conventional meat sources which can help reduce the overall carbon footprint of the meat industry and agriculture as a whole. While some studies have done meta-analysis on the potential benefits of alternative meat sources, this study was the focus on the long-term cost effectiveness of such sustainability solutions. The purpose of this project was to predict the overall impact of alternative meat sources on human sustainability using a machine model in order to assess its viability in reducing the negative environmental impacts of the meat industry. A prediction model was programmed in python to assess the future impact of meat production on human sustainability. The mentor provided guidance on the programming of the model. The model was able to predict future human sustainability based on the adoption rate of meat substitutes. The model predicted that meat substitutes have the potential to greatly reduce the emissions of the meat industry and have a noticeable impact on overall emissions. This model could help provide insight into the benefits of meat substitutes on human sustainability and more accurately map the effects of the adoption of meat substitutes.

Amity High School

Teacher: Catherine Piscitelli

Project # 27

Luciano, Nathaniel

Completed Project, Science, Environmental

<u>Determining Which Species of Plant Growth Promoting Bacteria in Combination with Fertilizer Has the Greatest Effect on the Plant Biomass of Cynodon dactylon</u>

The use of chemical fertilizers can cause negative environmental effects while being inefficient in providing nutrients to plants. Plant growth promoting rhizobacteria (PGPR) has been observed to be an effective biofertilizer by increasing nutrient uptake while being more beneficial for the environment. The purpose of this project was to compare species of PGPR in combination with fertilizer on the biomass of bermudagrass to suggest which species would be most effective. It was hypothesized that a treatment of 50% fertilizer in combination with a strain of PGPR will lead to comparable results to the full rate of fertilizer. The independent variable was the type of bacteria used and percent fertilizer combination, and the dependent was the biomass of the grass in grams. The positive control was 100% of fertilizer, and the negative was 50% fertilizer. The PGPR isolates to be used in the experiment were collected in the mentor's lab. Each strain was combined with a 50% fertilizer rate. The seeds were prepared and the correct treatments were added for ten replicates of each group. The biomass of the grass was measured. The student analyzed the data to determine the results. Results showed with a high level of significance that 50% fertilizer with PGPR is comparable to the full rate of fertilizer, with F. solisalsi, and B. sphaericus being the most effective. This experiment helps illustrate the effectiveness of PGPR supplemented with fertilizer. These bacteria can be used in biological products leading to greater crop production and a healthier environment.

Amity High School

Teacher: Catherine Piscitelli

Project # 28

 Maklad, Salma

Completed Project, Science, Behavioral

Investigating the Effects of Media Multitasking on Concentration in Mathematical Tasks

Media multitasking (MMT) is generally defined as interacting with two or more forms of media simultaneously or the usage of media while engaging in a non-media task. Studies have shown that MMT is linked to negative effects on academic performance, cognition, and executive functioning. These studies mainly investigate the link MMT has rather than its direct influence on attention and concentration. Given this, the purpose of this study was to investigate the effects of MMT on concentration in mathematical tasks for high school students. The independent variable of this study was the alternate media (video) scenario. The control trial was the alternate media being off. The dependent variable was the participants' time concentrating on the given task. It was hypothesized that if the background video is playing, participants would struggle more with concentrating on the given task because MMT has been suggested to negatively impact focus levels. Participants completed three six-question worksheets (one per trial) made with pre-algebra Kuta Software questions, all of similar difficulty. While completing the task, the background video was playing (trial 1), paused (trial 2), or closed (trial 3) on their computer screens. Focus was measured with Gaze Recorder, an eye-tracking software. After participants finished, the percentage of time concentrating was calculated for each trial. The student designed and executed the experiment while the mentor provided guidance accordingly. Results thus far are inconclusive. Once completed, this study could be applied in working environments by providing insight into MMT's effect on concentration.

Amity High School

Teacher: Catherine Piscitelli

Project # 29

 Maltese, Dillon

Completed Project, Engineering, Physical Science

<u>The affect of self-driving cars on the everyday world</u>

My grandpa and I share some of the best memories from our car rides together. However, he is becoming old, and his hands are too shaky to drive. The only way to solve this problem is with some sort of other driving, which self-driving cars can do. What my project aims to do is solve the question of whether self-driving cars are ready for the real roads or not. I attacked this problem by using the microcontroller of my choice, an Arduino. I decided to add four motors using a particular motor shield type from this selection. I also added an Iduino controller to make the control group, manually driving the car, and an ultrasonic sensor on a server to represent the test group, the self-driving car. Finally, I added code to move the motors toward where the controller is pointing or where the ultrasonic sensor detected the furthest away object. The part that helped me make it more realistic was adding a camera to the car and using a VR headset to make it feel like I was in the car. To test, I put the robot through a maze in my garage with the sensor and the controller and measured the times. Looking at the results, you can see that although it has been greatly improved over the years, our current technology is not quite ready to drive entirely on the roads. However, using Moore's law, it will hopefully be ready in the next couple of years.

King School

Teacher: Victoria Schulman

Project # 30

 Mannan, Zuhayr

Completed Project, Engineering, Physical Science

<u>Designing and constructing a bioreactor that utilizes an optimal ratio of Trichoderma harzianum and Trichoderma viride to Arthrospira Platensis for the repeated production of biofuel</u>

Fossil fuels have been criticized due to current climate concerns. However, biofuels produced from organic sources such as algae and fungi present an alternative. The only bottleneck is an affordable, consistent harvesting method. The purpose of this project was to design and construct a bioreactor that utilizes a ratio of T. harzianum/viride to A. platensis for the consistent production of biofuel. To begin, the different successful bioreactor models for both algae and fungi subclasses were researched, ending up with a stirred tank membrane bioreactor. A 3D model of what the bioreactor would look like when constructed was designed in FreeCAD, a modeling software specialized for engineering. Simulations were then run using this model, including tests for stress and interior pressure as well as an airflow test that replicated the harvesting process. The reactor was adjusted until it passed all tests. The adjustments made to the bioreactor design suggested that a cylindrical borosilicate glass tube with stainless steel end caps and a thin carbon fiber rod with plastic impellers in the center would be the most resilient design, in both sturdiness and successful execution of the harvesting process. The reactor was equipped with a simple water pump and aerator, as well as an air outlet near the membrane filter to release additional gases. An efficient bioreactor that utilizes an optimal ratio of T. harzianum/viride to A. platensis could make the production of biofuels economically feasible, allowing for the industrialization of biofuels and providing a feasible alternative to fossil fuels.

Amity High School

Teacher: Catherine Piscitelli

Project # 31

Mathew, Daniel

Completed Project, Engineering, Physical Science

Measuring Improvements of Physical, Thermal, and Mechanical Properties of Arrowroot Starch-Based Bioplastic Films Based on the Incorporation of Various Concentrations of the Plasticizers Fructose and Sugar Cane

Plasticizers, substances added to promote plasticity, are one method used to address insufficiencies in starch-based plastics. The sugar fructose, for example, has been seen to perform very well in wheat starch films at various concentrations with 35% w/w being its best performance. The type of sugar used has been known to impact the produced films, meaning a separate type of sugar, like sugar cane, could further impact the starch's properties. The purpose of this project is to measure the improvements in the physical, structural, and mechanical properties of an arrowroot starch-based film based on incorporating the plasticizers fructose and sugar cane at various concentrations. It was hypothesized that both substances should result in the improvement of the films with 35% w/w having the best performance. For this experiment different concentrations were established (0%, 35%, and 50% w/w) with two more groups being decided based on the results of the 35% and 50% (45% and 55% w/w). Films were produced outside of a lab by the student using a mixture of starch, distilled water, and plasticizer. The solution created from this mixture was casted in glass lenses and dried for 72 hours. After production, films underwent water absorption and solubility % tests before being sent to UCONN, where mentor performed differential scanning calorimetry and thermogravimetric analysis testing. Results of the experiment thus far support the initial hypothesis, although further testing is needed. The experiment's findings can be used to better understand the relationship between plasticizers and starch-based films.

Amity High School

Teacher: Catherine Piscitelli

Project # 32

Meier, Lucas

Completed Project, Science, Environmental

Mechanistic Analysis of the Driving Factors for Ventilation Dynamics within Macrotermes Michaelseni Termite Nests

The complex nest architecture of the fungi-cultivating Macrotermes termite species has been widely studied for its demonstrations of air ventilation. Mechanistic analysis of these ventilation dynamics within Macrotermes nests can provide insight into more effective ventilation systems for human buildings with the purpose of limiting the use of energy-intensive HVAC systems and their subsequent fossil fuel release. In this study, I isolated two different theories for ventilation within the African termite species Macrotermes michaelseni and replicated them within two respective models to take steps towards implementing termite architecture within human designs. The first model demonstrated a theory for ventilation driven by alternating day and night temperature cycles and the second model demonstrated a different theory driven by fluctuating wind patterns. Both models were tested under outdoor environmental conditions as well as indoor controlled conditions, with temperature and air velocity within the model measured over time. From the temperature and air velocity measurements of each model under several different testing setups, it was found that the It is expected that while each model will maintain the ability to circulate air, the model based on the diurnal temperature cycles will be more efficient with stronger airflow. Along with clearly demonstrating how the mechanisms of each theory function and showing which one is more efficient, this study also takes steps towards implementing termite architecture into human designs by presenting two baseline models for inspiration that could be adapted into actual human buildings.

Darien High School

Teacher: Guy Pratt

Project # 33

 Mejnartowicz, Mila

Completed Project, Science, Behavioral

Determining Trail Making Test B Accuracy in Predicting Driving Preparedness in Pre-Driving Age Adolescents

New adolescent drivers have the highest crash rates in the United States, largely due to underdeveloped cognitive and executive functioning skills. Adolescents' under-developed attention-switching (AS) and scanning skills make learning how to drive challenging. The purpose of this project was to determine Trail Making Test B (TMT-B) accuracy in predicting driver preparedness in pre-driving-age adolescents. It was hypothesized that the TMT-B would be an accurate predictor of adolescent driving preparedness. Participants reviewed a hazard list, completed one focused simulator (FS) and one distracted simulator (DS) on an online hazard identification driving simulator website, and completed the TMT-B. Changes in simulator scores were calculated by subtracting DS accuracy scores from FS accuracy scores. An R^2-test was used to determine the correlation between changes in simulator scores and TMT-B speed and accuracy scores. The data thus far shows a non-significant correlation ($R^2 = 0.150$), and the hypothesis was not supported. AS skills only correlate with 15% of decreases in hazard identification accuracy when distracted, meaning that people with low TMTB scores were not more likely to have lower scores on the DS than people with high TMTB scores. The data thus far does not support the hypothesis of the TMT-B as an accurate predictor of adolescent driving preparedness. This study demonstrates the need for tests that accurately measure adolescent attention-switching skills to aid them and their parents in the crucial decision of when to start driving.

Amity High School

Teacher: Catherine Piscitelli

Project # 34

 Miranda, Bernardo

Completed Project, Science, Health & Medical

<u>Effect of IC100 Antibody on Inflammasome Activation in Traumatic Brain Injury</u>

Traumatic Brain Injury (TBI) has generally unexplored mechanisms, biomarkers, and targets for treatment. The NLRP3 inflammasome has proven to be a major driver of neuroinflammation and neurobehavioral disturbances following TBI, a stage of TBI often referred to as a "secondary injury." The inflammasome adaptor speck-like protein containing a CARD (ASC) is involved in bridging the interactions between inflammasome sensors and caspase-1. Recent studies have shown that the inhibition of ASC through the anti-ASC monoclonal antibody IC100 can suppress the neuroinflammatory response in neurodegenerative diseases such as multiple sclerosis and Alzheimer's Disease. In this study, we aimed to see if treatment of post-TBI inflammation with IC100 will reduce inflammasome activation through the inhibition of ASC proteins. We started by inducing mice with TBI using an impactor and then treated them with IC100. The caspase-1 concentration in the mice brains directly correlates with inflammasome activation. We measured caspase-1 concentrations in the right cortex and right hippocampus of the mice using an electrochemiluminescence immunoassay (ECLIA). No significance was measured. We suspect that the mice brains were not stimulated enough for TBI's secondary injury to initiate, therefore yielding no measurable change in inflammasome activation.

Darien High School

Teacher: Guy Pratt

Project # 35

Nandy, Mihir

Completed Project, Engineering, Physical Science

Determining if Expansion Microscopy is a Valid Alternative to Electron Microscopy for the Purpose of Imaging Neurons for Connectomics

Connectomics is the study of connectomes, which are systems of neural pathways. The current method for imaging neural tissue for connectomics is electron microscopy (EM). This is unideal because there is a lack of people who have access to and can use an electron microscope. Fluorescence microscopy, a type of light microscopy, does not have sufficient resolution to resolve the structures of interest. Expansion microscopy (ExM) is a new method of light microscopy that uses a gel to expand the neurons. The purpose of this project was to determine if ExM is an effective alternative to EM for connectomics. It was hypothesized that ExM is as accurate as EM and is an effective way of imaging neurons for connectomics. The independent variable was microscopy type. The dependent variable was the accuracy of the microscopy. The images from the EM are currently accepted as a standard for connectomics and were treated as a control which the data from the ExM was compared with. The data for EM and ExM images of mouse neurons exists. The neurons imaged by ExM were annotated to create a 3D model of the neurons. The density of dendritic spines was used as criteria to determine the efficacy of ExM compared to EM. It was found that the ExM was not able to capture the same density of spines as EM. In order for ExM to have an impact in connectomics, research will have to be done on improving the process to preserve more of the neurons.

Amity High School

Teacher: Catherine Piscitelli

Project # 36

Olvany, Steven

Completed Project, Science, Environmental

The Economic Efficacy of Various Algae Strains for Biofuel Production

Producing fuel products from algae could provide a solution to the draining of fossil fuel reserves and help reduce the detrimental effects of fossil fuel extraction on the environment. This study determined what strain of algae is the most economical for biofuel production. The experiment compared the economic efficacy of 3 different strains of algae: Chlorella, Spirulina, and Scenedesmus. For all algae types, data for the elemental compositions was gathered from various literature and databases. After compiling this data, the values were entered into the NREL Algae farm model. This model produced an estimated cost per ton of biomass for each lipid. From this, the percent lipid compositions, which were also gathered from literature and databases, were used to determine the estimated cost per ton of lipids from each algae strain. This result serves as an indicator of which algae strain is the most cost-effective for biofuel production. Through this research, Scenedesmus was determined to be the most economically efficient algae strain of the three tested.

Darien High School

Teacher: David Lewis

Project # 37

Petrizzo, Allison

Completed Project, Science, Environmental

Detecting PFAS in Medical, School, and Delivery Uniforms

Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic chemicals that provide physical properties such as water repellency and stain resistance. As such, they are widely used in consumer products. The focus of this research was to investigate medical, delivery, and school uniforms for the presence of PFAS. First, as an initial test for PFAS, a water and oil droplet test was completed. In the samples, if the droplet did not absorb into the fabric, this would indicate that the sample was likely to contain PFAS. In particular, the water and oil beaded for five-plus minutes in one sample. Subsequently, samples were tested at the University of Notre Dame to undergo particle-induced gamma-ray emission spectroscopy (PIGE), a surface technique used to measure total fluorine concentrations. Based on the total fluorine values measured, conclusions could be made regarding whether samples contained intentional fluorine. Most of the school uniforms were found to contain intentional fluorine, meaning that PFAS was added to promote stain resistance or water-proofing. A possible reason why school uniforms contain PFAS is that students may be more susceptible to stains than delivery workers.

Convent of the Sacred Heart-Greenwich

Teacher: Joyce Reed

Project # 38

 Qin, Bo-Jun

Completed Project, Engineering, Physical Science

Simulating CMB temperature signal to analyze the effects of noise

As cosmologists probe the early universe to understand its nature, the development of precise ground-based telescopes has become increasingly important. The cosmic microwave background (CMB) is radiation redshifted from the first light in the universe. It may contain primordial gravitational waves, which would provide evidence for inflation, the theory that the universe started as a tiny, dense ball of matter that expanded rapidly. This project analyzes the effects of environmental and instrumental noise on the precise measurement of the CMB, with the final result of simulating a realistic CMB temperature signal. A raw CMB temperature map from a power spectrum is generated from the NASA Code for Anisotropies in the Microwave Background. Foreground maps of point sources and the Sunyaev-Zeldovich effect are added. A noise map comprising beam convolution, white noise, atmospheric noise, and 1/f noise is created and overlaid to complete the simulated CMB temperature signal. In the process, each type of noise is overlaid individually onto the signal at three different values to examine its independent effects. The resulting simulated CMB signal's power spectrum is found to be biased high compared to the accepted power spectrum from the Planck satellite. A better understanding of the noise affecting ground-based telescopes will enhance current and reveal new measurements of the early universe, specifically the energy level required to induce inflation and thus available in the universe. The next steps of this research would be to investigate how to reduce noise in large ground-based telescopes with thousands of detectors.

Darien High School

Teacher: Christine Leventhal

Project # 39

Rutkowski, Sophie

Completed Project, , Health & Medical

Using Defibrinated Sheep's Blood To Predict Endometrial Cancer

In scientific literature there exists a significant gap in menstrual health research. Numerically quantifying menstrual blood volumes allows patients to objectively track significant changes in menstruation over time, serving as a potential indicator and early diagnostics-tool for endometrial cancer. The purpose of this study was to determine the volume capacity, in milliliters, of the five different sizes of Tampax tampons when different volumes of defibrinated sheep's blood were added. This research is the first of its kind, using defibrinated sheep's blood as a substitute for menstrual blood as a result of both substances lacking the ability to clot. Fitting the tampons into glass vials, volumes of defibrinated sheep's blood were added to induce the tampon to $1/6$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{5}{6}$, and maximum capacity of its defibrinated sheep's blood holding volume. Each trial was repeated three times, and a picture of the tampon was taken after each trial. Six images were designed for each of the five tampon sizes to accurately portray the visual pattern when a given volume of blood was added. When Tampax tampon size and induced volume of blood increased, the tampon held a greater volume of defibrinated sheep's blood, in milliliters. Menstrual health, though stigmatized and under-researched, remains highly relevant to doctors seeking to take into consideration new indicators of difficult to diagnose illnesses and diseases. Quantifying menstrual blood output numerically aids in removing bias in patients and doctors, and serves as a new metric for reproductive health as a whole.

Weston High School

Teacher: Christopher Gamble

Project # 40

Rathjens, Anton

Completed Project, , Behavioral

Mood Congruent Musical Preferences in Adolescents: An Exploratory Study

Mood congruence is the matching of the mood displayed in a song, painting, or other art piece with the mood of its audience. Mood can be measured on the PAD scale, a 3d plane that uses pleasure, arousal, and dominance of an emotion to define a mood. There is little data regarding mood congruence and music, and it is a new field of research. The purpose of this project is to determine any relationships between variables in the lives of adolescent participants and their preference for mood congruent or mood incongruent music. It is predicted that there will be some notable connections from musical mood congruence preferences in teens. There will be multiple independent variables outlined in this study, but the dependent variable (as measured on the PAD scale) will be the difference between the mood of a participant and that of the song that they would like to listen to. A greater difference indicates less congruence. Each participant is given a survey, which asks them a series of basic questions about their life (the independent variables). Then, they are asked what song they would most like to listen to when experiencing specific moods. The PAD score of each song is determined, and the difference between the value of the songs and that of a participant's moods is recorded. The personal answers from each participant will then be scrutinized individually to determine any outstanding relationships. The results of this project could be used to develop hypotheses for later research.

Amity High School

Teacher: Catherine Piscitelli

Project # 41

Roche, Tyler

Completed Project, , Environmental

Determining the moisture percentage and water absorbency of various potential litter substrates, to determine which is opitmial for keeping birds dry

Many different litter substrates are used in the rearing of commercial broiler chickens. The water holding capacity of litter affects how clean broilers are and ammonia production. The purpose of this study was to find the best litter substrate to keep broiler chickens driest. It was hypothesized that if pine wood shavings, chopped straw, hemp bedding, and shredded paper are tested to determine % of moisture and water absorbency, then straw will have the least % of moisture and will absorb the most water because straw is typically pre dried to become edible for animals. The independent variable was the type of litter used. The dependent variables are percentage of moisture and how much water is absorbed by each litter. The first part of the experiment was done by heating 125g of each litter substrate in an incubator at 55°C for 48 hours. After heating the litter was reweighed to find moisture percentage. The second part of the experiment was done by stirring each litter substrate in 1000mL water. The litter was then drained, the amount of water remaining was measured. Straw had the highest moisture percentage of 8.6%, followed by paper with 6.8%, then hemp with 6.56%, and pine shavings with 4.4%. Thus far, the second part of the experiment which suggests that hemp absorbs the most water, followed by paper, then straw, then pine. Hemp is shown to be the best substrate as it absorbed the most water. A healthy litter substrate for broilers was found.

Amity High School

Teacher: Catherine Piscitelli

Project # 42

Santomaro, Sophia

Completed Project, , Health & Medical

<u>The Effects of Temperature and Diet on Mutated Drosophila Melanogaster to Reduce Familial Migraines</u>

A large percentage of people in the world, including me, suffer from familial migraines. For my project, I aimed to rescue a common mutation (occurs in TRPM8 gene) that leads to these genetic migraines. I tested different diets as well as environment temperatures on fruit flies, Drosophila Melanogaster to see the effects of these factors. Drosophila Melanogaster were selected for my research because they are 70% genetically similar to humans, therefore indicating that the methods used on these flies, if effective, can likely be used to help humans suffering the same problem. I first had to create the mutation, by crossing two types of the fruit flies to create the same mutation commonly seen in humans who suffer from those migraines. This in total took about 1-2 months. I tested both a relatively cold (18°C) as well as a relatively hot (around 24°C) environment on the mutated fruit flies. I additionally examined the reactions of the non-mutated fruit flies as a control group. I also created a high sugar diet (diet with 20% added sucrose) in order to see the effects that this had on both the mutated and non-mutated flies. In order to determine whether or not I had rescued the mutation, I assessed the movements of the flies. Flies with the mutation that had been "turned on" were supposed to move in a jerkily fashion, therefore making this movement pleiotropic with the migraines. Therefore, when examining the effects of the altered temperatures and diet, I can assume that if the jerky movements have stopped, the migraines have also gone away.

King School

Teacher: Victoria Schulman

Project # 43

Scanlon, Madeline

Completed Project, , Behavioral

Assessing the Public's Willingness to Accept Cancer Vaccines

In the U.S. alone, each year more than 64,000 people will be diagnosed with pancreatic cancer, and about 50,550 people will die from this disease. The Pancreas is concealed behind multiple abdominal organs, resulting in difficulty for scanning methods - for instance, computerized tomography scans - to diagnose Pancreatic Cancer. Additionally, awareness of this disease is low; for example, 74% of the UK does not know a single symptom of this form of cancer. Provided with these challenges, it is clear that a proactive approach - such as vaccination - is needed to prevent Pancreatic Cancer. Furthermore, with the advancements in the vaccination field provided by the mRNA-based COVID-19 vaccine developments, the scientific community has a new tool to induce immune responses. One challenge with vaccines is that there has been an increase in hesitancy due to misinformation propagated through social media. Thus, before embarking on creating a ground-breaking pancreatic cancer vaccine, through the creation of a survey I aimed to gauge the public's interest and determine whether those hesitant towards vaccines could be convinced to accept an mRNA-based cancer vaccine. Furthermore, I aspired to determine if hesitancy towards vaccines is regionally based in the U.S. and abroad. It was discovered that the public's awareness about vaccines was relatively high. Additionally, although there was no significant change in the public's openness to vaccinations in a majority of the U.S., in the South there was a decrease in Pancreatic cancer vaccination hesitancy, after providing the participants with statistics on vaccinations.

King School

Teacher: Victoria Schulman

Project # 44

Shah, Layla

Completed Project, , Health & Medical

Gender-Related Differences in a Murine PCSK9 and HFD Model of Atherosclerosis

Cardiovascular diseases are the leading cause of death worldwide, taking an estimated 17.9 million lives annually. Although these stats are frightening, there are several predictors and known risk factors to aid in identifying diagnosis early on. One such cardiovascular condition, atherosclerosis, is the buildup of fats, cholesterol, and other substances in and on the artery walls called plaque. There are several factors that can induce atherosclerosis including high cholesterol and triglyceride levels, and gender, which also affects the intensity of atherosclerosis. It is hypothesized that males are more prone to developing atherosclerosis, especially at an early age. In addition to susceptibility, gender also affects the characteristics of the plaques, cholesterol levels, and body weight. To test this, male and female C57BC/6 mice were sacrificed and the heart tissues were isolated, sectioned, stained, and imaged at the aortic root to assess the plaque buildup. A total cholesterol and triglyceride assay was performed to assess the makeup of the plaque. The results show the male mice had a stronger onset of atherosclerosis in terms of lesion area, cholesterol, and triglyceride levels. The purpose of this work is not to explain why there is a difference between the sexes, but to highlight that there is a difference in plaque characteristics between the sexes. With this new knowledge on the gender differences in atherosclerosis, we can begin to develop personalized therapies that can be applied to either males or females, and can be safely and effectively used in the entire population.

King School

Teacher: Victoria Schulman

Project # 45

Sidhartha, Aditi

Completed Project, , Health & Medical

Identification of a DNA Enhancer For CCR5

Tens of millions of people have died because of HIV, and about 39 million people are living with HIV, but there is still no cure. C-C chemokine receptor type 5, also known as CCR5, is an HIV co-receptor, which is a binding protein on a cell that can connect viruses to cells. Removing CCR5 is an important aspect to curing HIV, and DNA enhancers are what increase the transcription for reproduction of viral cells, which is why it is important to identify one. When identified, it can be removed with CRISPR-Cas9. The purpose of this experiment is to identify a DNA enhancer for CCR5. The independent variable was the different enhancers identified, and the dependent variable was the FFLUC activity after the cells were electroporated. First, enhancers from healthy blood donors were cloned, and plasmids were electroporated into cells. If an enhancer was identified, it was removed with CRISPR-Cas9. Data was sent to the student, and the student analyzed the graphs to see how successful each enhancer was. Graphs sent show that almost all of the enhancers' expression was low compared to the control. The data collected so far shows how none of the enhancers show increased expression as compared to the positive and negative control, meaning an enhancer for CCR5 still has not been found. However, more enhancers are to be tested to see if any match CCR5. This study can help with understanding CCR5 and finding a cure for HIV.

Amity High School

Teacher: Catherine Piscitelli

Project # 46

 Sifrovich, Mark

Completed Project, Science, Physical Science

<u>Designing a Video Game to Boost Performance in Algebra I</u>

Education today doesn't engage and immerse students in the subjects getting educated. As such, many students are not interested in what's getting taught and therefore aren't learning. On the contrary, video games have exploded in popularity over the past few years, with millions of people spending their time playing them. What video games have to their advantage is the ability to attract and immerse people. Gamification is known as the combination of video games and education or using video game features in non-recreational environments. This project aims to create a video game to teach high schoolers Algebra I using a game with gamification features such as currency and difficulty upgrades. Last year, a game was created that could supposedly teach Algebra I, but did not have Graphics and was not tested. This year, the graphics for the game were made and all the bugs were fixed. When running it, all menus and gameplay features worked as intended. The next phase of this project would be to give the program to a group of Algebra I students for a week and compare their change in skill to another group that was given a traditional study packet. If this game is effective at teaching math skills, it can be used in a classroom to teach Algebra I in an immersive and engaging way.

Amity High School

Teacher: Catherine Piscitelli

Project # 47

Stannard, Charlotte

Completed Project, Science, Health & Medical

<u>Investigating If There Is a Correlation Between Maternal Age At Time Of Pregnancy Loss And The Number Of Trophoblast Inclusions In The Placenta</u>

Approximately 23 million miscarriages occur each year worldwide, equating to 44 pregnancy losses every minute. Rates of miscarriage and stillbirths increase with maternal age but often the cause of pregnancy loss is unexplained. Trophoblast inclusions (TIs) are microscopic morphological abnormalities of the placenta due to atypical infolding of the trophoblast bilayer into the villous core and have been identified in pregnancies with adverse birth outcomes. The purpose of this project is to investigate if increased maternal age impacts the number of TIs found in the placentas of lost pregnancies. It is hypothesized that increasing maternal age corresponds to a greater number of TIs, thus contributing to pregnancy loss. The independent variable is maternal age. The dependent variable is the number of TIs. Data from the Yale University School of Medicine Reproductive and Placental Research Unit was obtained. The student worked with Dr. Harvey Kliman to sort and analyze data from 1,256 cases of pregnancy losses from 922 patients that demonstrated 878 (69.6%) miscarriages and 378 (30.4%) stillbirths. A regression analysis was performed yielding a weak positive correlation between maternal age and number of TIs. The hypothesis can be refuted because there is not likely an age dependent correlation to number of TIs. This data demonstrates that pregnancy losses are due to random genetic problems that may occur at any age.

Amity High School

Teacher: Catherine Piscitelli

Project # 48

 Stoltenberg, Ian

Completed Project, Science, Environmental

Developing Thermodynamic Models to Accurately Predict the Performance of Solar Powered Desalination Systems for Concentrated Brine Solutions

Finding a way to desalinate water is becoming an important issue in many places because of constant droughts and lack of water. Also, there is an increased need for systems like this to be powered by renewable energy because of the climate crisis. The purpose of this project is to develop thermodynamic models to accurately predict the performance of solar-powered desalination systems for concentrated brine solutions. The model was created using the Julia programming language. Previous related models were used as a starting point for the creation of the new model. The models were then developed further to be made more specific for the project, and then they were tested in different locations along the East Coast of the United States. The model looked at the different effects desalination has on the economy of the region, energy usage, and how well it can make potable water. The results of these tests determine the optimized desalination method for certain areas and certain needs. Data was analyzed by compiling and comparing the results of the different tests run by the computational models. It was found that overall, the model's optimized renewable desalination plan could save regions up to millions of dollars if implemented correctly. The implications for this project are helping find reliable ways to desalinate salt water using renewable energy, which could greatly help regions' economies and well-being.

Amity High School

Teacher: Catherine Piscitelli

Project # 49

Storeygard, Jacob

Completed Project, Engineering, Physical Science

Optimizing an Algorithm Used for 3D Printing on Uneven Surfaces for Commercially Available 3D Printers with TPU Filament

Conventional FDM (Fused Deposition Modeling) 3D printing is a method of additive manufacturing in which melted plastic is extruded layer by layer onto a flat print bed. 3D printing on uneven surfaces involves altering the G-code file in order for the extruded material to lay correctly on an altered surface. Various algorithms already exist to transform G-codes to be able to print onto these uneven surfaces; however, they are not optimized for standard home-use printers or for printing PLA (Polylactic Acid) filament. The purpose of this project was to modify and test a current algorithm used for non-planar 3d printing so that it is optimized for home use and PLA filament on Uneven Surfaces. To optimize the algorithm factors such as the temperature of the nozzle and bed, print speed, and fan speed needed to be adjusted. The new code was tested on a variety of uneven surfaces to measure the effectiveness. If the objects were printed onto the surfaces using the altered G-code file without any complications such as warping, layer shift, or bed adhesion issues, it was considered a successful trial. The original algorithm printed successfully 80% of the time, however, the modified algorithm, however, printed successfully 100%. In addition to a 25% increase in successful prints, the modified algorithm showed a significant improvement in print quality indicating that the modifications were successful. The results from this project could help people with standard 3D printers create more complicated projects with less wasted material.

Amity High School

Teacher: Catherine Piscitelli

Project # 50

Trudel, Evelyn

Completed Project, Science, Behavioral

An Investigation of Stone Reusual Construction Techniques Used in the Anasazi Community From 800-1200 AD In Southwestern United States Based on Stone Length-Width Ratios

The American Southwest has a rich history with the Ancestral Pueblo. They lived in Great Houses, which consisted of many rooms and kivas, which are religious semi-subterrane structures and served as centers for politics and economics. This study focuses on the reuse of stones in these structures, a concept passed down orally in the American Southwest and briefly explored in a few articles. It aims to quantify the concept. We turned to the classic archaeology term for stone reuse, Spolia, to delve deeper. We predicted that length-to-width ratios in stones at the Haynie Archaeological Site would show evidence of Spolia construction techniques in ancestral pueblo. Haynie is located in southwestern Colorado and is maintained and utilized by the Crow Canyon Archaeological Center. Then, a data set was compiled with different length and width measurements (cms) of stones within the site. A total of 8 structures were documented, which were broken up into 11 more focused structures, seven based on room walls and four based on kivas. The earliest stones were from Middle Pueblo I(800-850 CE), and the latest were from Late Pubelo II(1100-1140 CE). Box and whisker plots were created and provided means and medians of varying structures, which helped establish interpretations. The results indicate that stones with similar length-thickness ratios were used in Pueblo I and Late Pueblo II kiva and room walls. This interpretation suggests possible stone reuse between these two periods. Further analysis using a more comprehensive range of attributes could enhance this interpretation.

Darien High School

Teacher: Guy Pratt

Project # 51

 Tsai, Michael

Completed Project, Engineering, Physical Science

Preventing Catastrophic Forgetting in Continual Learning by Controlling Node Gradients

Sequential task learning without forgetting is a critical challenge in deep learning, often referred to as continual learning or lifelong learning. While existing regularization-based methods primarily emphasize node importance evaluation, they often overlook optimization strategies for neural networks, potentially hindering performance and underutilizing network capacity. To address this, we propose a novel optimization framework that synergistically combines node importance evaluation with gradient descent regularization. This framework leverages a regularization-based method to assess node importance, which subsequently dictates the determination of optimal gradient directions for all neural network nodes. Experiments conducted on the CIFAR-100 dataset demonstrate that our approach effectively enhances regularization-based methods and maximizes the utilization of fixed-capacity neural networks.

Ridgefield High School

Teacher: Patrick Hughes

Project # 52

Twitchell, Nathan

Completed Project, Science, Environmental

<u>The Effect of Road Usage Frequency on the Quality of Soil</u>

In the use of automotive travel, many factors contribute to particulate pollution in the local environment. Fuel consumption releases trace amounts of heavy metals, such as nickel, into the local air, which then settles in the soil due to surface runoff. Other parts of automotive travel release heavy metals, such as tire and brake wear, oil consumption, and road abrasion. In addition to this, leaking oil or any other petroleum based product is also distributed into the environment by some cars. The deposition of such metals and pollutants into our soil is highly detrimental for the local environment, and can negatively impact other important resources, such as drinking water due to leaching. Because of its constant growth and development, automotive traffic load is increasing day by day, thus increasing the amount of metals and other pollutants being distributed into the environment. In order to view the impact of increasing traffic load on soil composition, studying the soil on roads with varying usage would simulate this development. In this simulation, we are given information of how the further increase in road traffic could affect the quality of soil.

Newtown High School

Teacher: Timothy DeJulio

Project # 53

 Vivanco, Lucia

Completed Project, Science, Environmental

Assessing Coral Bleaching Resilience with Additives

Coral reefs are known to be essential organisms to the global marine environment, but they are in severe jeopardy due to anthropogenic environmental changes, such as rising ocean temperatures, which can disrupt the symbiotic corals share with zooxanthellae, a classification of dinoflagelletes. Several studies in the past have successfully explored probiotics consisting of different marine bacteria as a way of mitigating the effects of coral bleaching, highlighting Dimethylsulfoniopropionate (DMSP) as an essential compound for understanding the complex microbial interactions of the coral holobiont. This this study, I hoped to discover how multiple compounds related to DMSP affect coral's ability to resist bleaching under temperature stress. I hypothesized that increasing the concentration of tropodithietic acid (TDA), copepods, and dimethylsulfide (DMS) in the coral's environment would increase the coral's resilience to bleaching and result in a lower percentage of mortality because these additions to the microenvironment would support microbial health and increase pathogen resistance. Testing by simulating a marine environment and adding these compounds resulted in the finding that TDA could partially mitigate the effects of bleaching at 32°C over the course of 20 days when compared to control groups and other experimental groups. The corals treated with TDA bleached after an average of 13 days under stressful conditions, whereas the control group bleached after an average of 9 days. With the addition of future research, these findings could result in a way to prevent and mitigate coral bleaching microbially.

King School

Teacher: Victoria Schulman

Project # 54

 Walsh, Gianna

Completed Project, Science, Behavioral

<u>The Effects of Long Term Immersion in Character on Sense of Self and Empathy in Experienced Versus Novice Adolescent Actors</u>

The study sought to investigate the impact of complete immersion in a character on the sense of self and empathy levels among novice and experienced teen actors. Limited research has delved into the long-term effects of character immersion, particularly in the context of teenagers. Given the developmental vulnerability of teens to character-centric pressures, there exists the potential for a distortion in self-perception. The experiment utilized online surveys, ethically approved by the Institutional Review Board (IRB), to assess the self-perception of teen actors both before and after their performances. Two distinct groups were examined, consisting of trained and novice actors across varying age ranges. Employing the ESSS and modified empathy scales, the study aimed to measure the sense of self and empathy experienced by these actors. While initial expectations anticipated a deeper connection with characters among experienced actors, the results revealed an unexpected outcome. The analysis demonstrated an increase in empathy levels for both groups, accompanied by a decrease in the sense of self when comparing pre- and post-performance data. Although these findings deviate slightly from the initially hypothesized outcomes, they consistently support the overarching theory that complete embodiment of a character, whether in movies, shows, plays, or musicals, carries inherent risks.

Convent of the Sacred Heart-Greenwich

Teacher: Joyce Reed

Project # 55

Wang, Leon

Completed Project, Science, Environmental

Exploring new realms of renewable energy by harnessing the electronegative properties of bacteria

In today's world, renewable energy solutions come at a high cost. According to a recent study by Yale School of the Environment, transitioning the United States power grid would cost more than four trillion USD (Schwägerl, 2019), which is more than ten times the US government revenue in the 2024 fiscal year (Fiscal, 2023). This alarming statistic points to one of the biggest key issues facing the transition towards renewable energy, especially in developing countries. The initial investment in constructing renewable energy infrastructure is simply too expensive for many developing countries, and that is because traditional forms of renewable energy like nuclear plants and wind farms rely on advanced mechanical systems. However, in this project, a new domain of renewable energy is explored: the harnessing of energy through bacteria via microbial fuel cells. By harnessing common bacteria readily found in wastewater, and the greater environment, this method has the potential of greatly reducing the cost to consistently generate renewable energy, thereby encouraging developing nations to transition to renewable forms of energy. Thus, this project seeks to explore how the chemical energy converted by bacteria can be utilized as a carbon-neutral way to power electrical devices. More specifically, this project examines the role that the gram stain of a bacteria has on its capabilities to transform its chemical energy into electrical energy via a microbial fuel cell. Due to the fact that gram-negative bacteria have a much thinner layer of cell wall, more than 80% thinner than gram-positive bacteria (Mai-Prochnow, 2016). Thus this experiment hypothesizes that gram-negative bacteria would generate more electricity, due to the thinner cell wall in gram-negative bacteria. This hypothesis will be tested with four types of bacteria: E.coli, S.marcescens, P.fluoresens, and M. Luteus, three of which are gram-negative, and one gram-positive bacteria. To effectively carry out this experiment, one needs Four agar plates, Two incubators, Sterile incubation loops, Four microbial fuel cells (sciencebuddies.com), Microwave (for sterilization), Distilled water, Potting soil, Parafilm, and the starter bacteria for S. marcescens, E. coli, P. fluorescens, and M. luteus.

King School

Teacher: Victoria Schulman

Project # 56

Wijesekera, Soumya

Completed Project, Science, Health & Medical

Determining an Individual's Typing Efficiency while Injured

Wrist pain is the third most common work-related injury, affecting 19.1% of the adult population. The wrist is a joint that connects the radius and the ulna to the carpals in the hand. A splint is commonly used when a wrist injury occurs. Short arm splints immobilize hand and wrist joints and long arm splints immobilize the upper extremities. The most common wrist rotations when typing are wrist extensions and ulnar deviation. The purpose of this project was to determine an individual's ability to type while being injured. It was hypothesized that if an individual is placed in a short arm splint, they will be less efficient while typing than if they completed the typing task with the long arm splint, or no splint at all. The independent variable was the type of splint, and the dependent variable was the typing score and speed. Constants included the typing test and the splints. The control was the trials performed without splints. A short arm splint was placed on the participant's dominant hand. The participant completed a typing test and score and speed was recorded. The same procedure was repeated for the long arm splint and the no splint trial. The order of the splints tested was altered to ensure no extra variables were included. Results thus far support the hypothesis. The mentor provided the splints and advice during the project. The findings of this project can help gauge one's ability to return to activities that require typing movement.

Amity High School

Teacher: Catherine Piscitelli

Project # 57

Wempen, Ryan

Completed Project, Science, Environmental

<u>Utilizing Ground and Space-Based Sensors to Track Trajectories of Vehicles/Dangerous Objects and Monitor Climate Change/Environmental Issues</u>

As the number of satellites in low and high earth orbit increases beyond the 10,000 mark and the concentration of space debris increases exponentially, the risk to satellite launch and orbital operations is similarly increasing. This strains the ability of existing systems and algorithms to analyze the data, even before taking into account orbital drift and errant meteorites. Nevertheless, recent sensor technology leaps are poised to make a permanent change in this landscape, resulting in an immediate demand for new and updated simulations to apply the technology to existing problems. To address this demand, a simulation was developed to design an appropriate satellite launch trajectory and orbital path based on chosen mission and operational parameters, and then track a simulated launch from liftoff to final orbit within the designated satellite constellation. After successful orbital positioning, the simulation then continues operating on a designated mission to track evidence of climate change on the ground, from identifying wildfires to tracking flooding, while utilizing its sensors to simultaneously protect the satellite from external threats, including other satellites in decaying orbits, space debris, and exo-orbital threats including meteors and asteroids. As additional simulations working together come online utilizing existing data gathered by satellites, projects such as this one have the potential to both significantly benefit communities threatened by wildfires and flooding by creating an early warning system and to provide the scientific community with an additional tool against the threat of climate change.

King School

Teacher: Victoria Schulman

Project # 58

Womer, Molly

Completed Project, Science, Environmental

<u>Determining a Correlation Between the Seasons and Florida Zooplankton Community Biodiversity to Help Protect Endangered Manta Rays</u>

Manta Rays were designated a threatened species under the Endangered Species Act in 2018. A large part of a Manta Rays diet is zooplankton, and different species of zooplankton offer different nutrients when consumed. The purpose of this research was to analyze how temperature trends associated with the seasons affect the biodiversity of zooplankton communities in Florida. It was hypothesized that there would be more zooplankton biodiversity in the spring and summer compared to the fall and winter, because of the increased temperatures commonly observed during the spring and summer seasons. The independent variable of this project was the season in which the zooplankton was collected, while the dependent variable was the zooplankton community's Simpson's Diversity Index. There was no control, as this was a comparison project. Data on temperature was collected by the student from a NOAA buoy, and the biodiversity was analyzed using the Simpsons index. The highest average temperature was seen in the summer of 2022, with the lowest average temperature seen in the winter of 2022. The highest average Simpson's index occurred in the winter and fall of 2022, while the lowest occurred in the summer of 2021; furthermore, the highest Simpson's Index occurred in the summer of 2022, while the lowest occurred in the summer of 2021. The mentor supplied the student researcher with the zooplankton data, as well as provided general mentorship. Work from this project can help to understand how the endangered Manta Rays prey population changes between the seasons, which can help to protect the endangered species.

Amity High School

Teacher: Catherine Piscitelli

Project # 59

Yan, Iris

Completed Project, Engineering, Physical Science

<u>Creating a Novel Decision Tree-Based Change Point Detection Machine Learning Algorithm Employing Unsupervised Learning for Real-Time Earthquake Detection</u>

Earthquakes occur when tectonic plates release energy and move suddenly, causing devastating damages to surrounding areas. Resulting seismic waves provide valuable information for detecting earthquakes and their locations. Because of the variability and large amount of data, human labeled detections are incomplete and subject to bias, highlighting a need for unsupervised learning. Current models are not sensitive enough and do not provide real-time detections. This project created a decision tree-based machine learning algorithm that used unsupervised learning for detecting earthquakes in real time. The algorithm was trained on seismic wave data from the STanford EArthquake Dataset (STEAD). The decision tree-based algorithm, which used a hierarchical tree structure to categorize data, automatically detected changes within the distribution of data itself, removing the need for learning from labels. The multidimensional data were split at each node of the decision tree based on projected values along the principal direction, which resulted in a sorting that exposed the distribution of data points. When new data was analyzed continuously, significant differences in the distribution of data indicated change points of earthquake occurrences. A machine learning classification model was created to learn distribution patterns resulting from the procedure described. It was tested on different magnitude earthquakes in different locations to determine accuracy and sensitivity. The algorithm was more accurate and more sensitive than existing research, while providing detections in real time. By accurately detecting earthquakes in real time at a high sensitivity, this algorithm can help experts understand natural phenomena better and significantly mitigate earthquake damages.

Amity High School

Teacher: Catherine Piscitelli

Project # 60

 Yee, Emily

Completed Project, Science, Health & Medical

The Effect of Plant vs. Animal Protein: Soy Protein vs. Beef Protein on Sleep Quantity

Plant based proteins have shown association with increased sleep quantity and quality in previous research. This research seeks to directly compare the effect of plant based protein (soy) with animal based protein (beef) on sleep quantity in drosophila. Plant based proteins typically contain more tryptophan, than animal based proteins making them more effective in increasing sleep quantity. Tryptophan is an essential amino acid that also serves as a building block for melatonin, a neurotransmitter responsible for sleep and regulating the sleep cycle. Previous research shows that plant based proteins, especially in combination of fiber, are successful in increasing sleep quantity and sleep quality. Drosophila has been proven to be an effective model organism to measure sleep in humans as they share the same circadian rhythm patterns. Sleep can be measured by analyzing video data by hand over the course of 24 hours (if there is no access to a Drosophila Activity Monitoring, DAM, system). This research analyzed video data of drosophila with their respective diets over a course of 24 hours (in each of the 3 trials). This research is important because the amount of people adopting vegetarian or vegan diets has increased significantly in the past 30 years, and there is limited research regarding plant based diets, especially its effects on sleep.

Ridgefield High School

Teacher: Ryan Gleason

Project # 61

Zhang, Tony

Completed Project, Science, Behavioral

How Working Memory Load Affects Decisions Under Uncertainty in Highschool Students

The tendency to take risks is influenced by how people perceive and treat uncertainty, possible rewards or punishments. Their perception is also influenced by outside factors such as what they are doing at that moment. Risky decision making (DM) is one where outcome probabilities are known. Working memory (WM) is a limited capacity store for retaining information for a brief period while performing mental operations. The purpose of this project was to investigate the effects of working memory load on decision-making under uncertainty. It was hypothesized that if working memory (WM) load is present, there is an increase in risk aversion and an increase in consistency. The independent variable was the working memory load- none, low, and high. The dependent variables were choice proportion, the number of times the risky option was chosen and the consistency of which each lottery was chosen. The control was when there was no WM load. Participants from Amazon Mechanical Turk completed two tasks simultaneously in a program, a dot memorization task and then a risk decision making task. For the control, participants were given the complete dot task and the DM task separately. The mentor collected the data, while the student analyzed the data. The overall trend was that participants were more consistent without WM load and they chose the risky choice more without WM load. This partially supported the hypothesis. This suggests that although WM does affect risk DM to some extent, there are outside factors that affect an individual's decision making.

Amity High School

Teacher: Catherine Piscitelli