

Senior Division Animal Sciences

Kandice Eastwood

SR-AS-001

Can Crickets Handle the Heat?

Can Crickets Handle the Heat? has tackled the issue with chemical repellents for crickets. Chemicals can be toxic and harmful to people using them as well as the environment. This project uses whole peppers and natural solutions made from crushed peppers and water to repel the crickets. The crickets were successfully repelled by a jalapeno solution and whole habanero peppers; therefore, chemicals can be replaced with natural solutions. This can benefit society by preventing harm to the environment and people who use products to repel pests in their homes and gardens.

Sierra Allen

SR-AS-002

Catnip's Effect on Different Cats

To introduce this project, cats were being tested to see how cats react to catnip differently. Overall, the goal of this experiment was to see the different results from each cat. It will help owners of cats know what the common reactions could be of the cat when introduced to catnip. This is important because knowing the common results of catnip will help owners of cats be more cautious of their cat's stomach, especially because the cat can become sick. Since some reactions have worse consequences than other reactions, it is important to have an understanding of what could possibly happen and how to prevent damage to the cat. The reactions varied between the cats, with five out of six cats showing a more noticeable reaction to the catnip.

Taylin Harthun

SR-AS-003

Keep Your Cool

The purpose of this experiment was to see what pad could keep horses the coolest for riding. I hypothesized that the thin Pro pad will do the best with maintaining my horses' temperatures. It is the thinnest pad that I like, because I think it is very reliable. This experiment involved collecting a variety of different horse pads, and then using a vernier surface thermometer to measure temperatures. I put the vernier surface thermometer four inches into the pad to measure temperatures. I repeated this four times in four locations along the same path for each horse. I recorded this on four horses, and repeated this step with three different pads for each horse. I repeated this experiment with all three pads on all four horses three times for efficiency. I then averaged this data to get my results. I concluded that my data supported my hypothesis. Though the results were close, the Pro pad kept my horses the coolest. I found that the outdoor temperature was even the highest with the Pro pad then all of the other horses. So even with it being the hottest days when I had the Pro pad, it kept the horses the coldest while I was riding them. These findings have led me to believe that Pro pad does the best job to keep your horses cool while riding them.

Senior Division Animal Sciences

Tonya Rothbauer

SR-AS-004

The Effects of Plant-Based Meat Alternatives on the Development of Drosophila

The purpose of this project was to determine if there are ingredients in plant-based meat alternatives that are harmful to consume. The hypothesis was that there are harmful ingredients in plant-based meat alternatives that would affect drosophila. This was tested by placing 4 males and 2 females in each of 5 vials for each of the 3 groups. After one week, the same amount was placed in another set of 5 vials for each of the 3 groups. Each vial had medium provided but there was 2g of beef alternative for the alternative groups and 2g of beef for the meat groups. To place the drosophila into new vials, they were first anesthetized with FlyNap®. The data showed an average 5% decrease in the control group, an average 63% decrease in the meat group, and an average 100% decrease in the alternative group. This may show that an ingredient in plant-based meat alternatives is harmful and proves the hypothesis correct.

Senior Division Behavioral & Social Sciences

Diego Santoyo

SR-BSS-001

Cheating in Basketball?

Most basketball players want to get better at shooting a basketball and landing it in the basket. Ever since Allen Iverson wore an arm sleeve in 2001 (Kang C. Jay 2014), basketball players have debated whether wearing an arm sleeve on their shooting arm actually improves the chances of scoring a shot. This sports project answers the question of, "Do arm sleeves improve the chances of players scoring a basket in basketball?" A shooter wearing the arm sleeve will have a higher chance of scoring a basket from both the free-throw and the 3-point line than without wearing the arm sleeve.

Tyler Sunahara

SR-BSS-002

Do You Remember the Time? Testing the Effects of Stress on Accuracy of Eyewitness Accounts

Identifying the accuracy of eyewitness accounts matters for many reasons. For one, there would be fewer innocent people imprisoned for crimes they did not commit. This experiment aims to demonstrate how stress plays a role in a witness's memory and that if a situation is deemed very stressful, the witness's account should not be taken as an accurate fact. When humans experience stress, they release stress hormones that impact memory creation and recall from said memory. Humans can intermix internal and external stimuli to create what they see. In this experiment (with a sample size of 42 participants split into three groups of 14), each participant watched videos beforehand to induce low, medium, or high stress. Afterward, participants viewed a presentation of faces, and then they selected the one they saw from a group of 4-5 similar faces (like a lineup) to measure accuracy. I recorded heart rate and blood pressure to measure stress since releasing stress hormones can increase heart rate and narrow blood vessels (raising blood pressure). Five days later, participants filled out the same form without seeing the faces again. I found the level of stress did affect memory, with a p-value of 0.021137; and after conducting a Tukey HSD test, I found a significant difference between the low and medium stress groups, as well as the low and high-stress groups, but no significance between the medium and high-stress groups. There appears to be a significant link between stress and memory.

Serenity Foutz

SR-BSS-003

Ethical Controversy of Horse Training

Horse training has been a controversy since the dawn of time. Many people have experienced different ideologies that seem to work for them. Finding common ground is hard among horse trainers. But nonetheless it's important. I researched the 5 most controversial training methods or ideas and created a survey asking participants what they deemed ethical and unethical (an option was also given for unsure). I surveyed 102 teenagers ages 14-19. Demographics were not needed seeing I was not focusing on those specific fields. Results like predicted varied considerably. I conclude that these results will help to draw horse trainers together to activate change in methods and ideologies.

Senior Division Behavioral & Social Sciences

Jamie Hume

SR-BSS-004

How Do Beauty Standards Affect Children in Middle School?

Did you know that over 40 percent of the images or other activities on the internet are fake or edited? I am testing children's ability to observe differences between a set of images. There are 8 people that I'm showing to the subjects and 16 images. This is because the 8 people have two images of themselves, one is real and the other is filtered. The subjects' impressions of the images will be recorded and compared on a scale of 1-10. The Instagram images were perceived as people with higher confidence levels as I expected. But the surprising thing is the kids I interviewed thought the reality images were more approachable and trustworthy. The results were shocking as well, as it was assumed the reality photos would get super low ratings but some of those ratings were surprisingly better than the filtered photos. The hypothesis was wrong as the real images scored a whole percent better than the filtered images. The results were like this because my interviewees could relate to the images well and understood what was asked of them. The sad thing learned from this project is that most kids are oblivious to the fact that most of the images they see on a day-to-day basis are fake or changed beyond recognition.

Gabriella Rodriguez

SR-BSS-005

How Do Fears Change with Age?

The purpose of this investigation is to see how people's fears change with age. By surveying different age groups, people can learn how fears can change with age. If the participants are surveyed based on fears, then the fears and how the fears change will be determined by age group. On the first table for ages 5-12 years old the most common fear was the fear of the dark. The least common fear was the fear of mountain lions. On the second table for ages 13-21, the most common fear was Heights and insects. The least common fear was the fear of pregnancy. From the ages of 22- 32 the biggest fear was the fear of kidnapping the least common fear was the fear of heights. From ages 39-84 years old, the most common fear was the fear of insects and dementia. The least common fear in this age group was the fear of fire. Fear is a human emotion that alerts danger or harm. My hypothesis was correct because I was able to determine what the biggest fears were within each age group. This investigation is beneficial in the real world because it makes people more aware of the possible fears that can come with age. If I were to do this project again I would increase my sample size from an average of 13 participants to at least 25. I would keep the type of questions I asked my participants the same, since they were easy to comprehend.

Senior Division Behavioral & Social Sciences

Henry Westfall

SR_BSS-006

Investigating Political Polarization Through Human Experiments and Agent-Based Simulation

Ideological polarization in the United States has grown substantially in recent decades. Recent research establishes that this newfound polarization is eroding American democracy — a similar process as has occurred recently in Hungary, Venezuela, and Turkey — but there is little consensus on its primary causes. Polarization is well-established to occur in single-issue contexts. Here I investigated polarization in multi-issue contexts with models of opinion dynamics explored through human experiments and agent-based social simulations. I specifically sought to understand (i) how ideologies evolve in social networks and (ii) how partisan actors in a population affect the group's polarization. The experiments and simulations revealed that individuals in dense communities rapidly develop a consensus ideology when abstract issues are presented as binary choices — notably, this ideological consensus is not equivalent to ideological polarization. Interestingly, however, I found that small minorities of partisan agents exacerbate polarization of larger populations in social networks with clique-based topologies. Networks of 250 adaptive-opinion agents fluctuated between slightly polarized and depolarized. The introduction of just two partisan (fixed-opinion) agents increased the stability of this polarization, and the introduction of just 50 agents increased both the stability and magnitude of this polarization. These results suggest that social networks are highly sensitive to partisan influencers and that social network topology is a critical factor in whether a social network will polarize and the nature of this polarization. Understanding and modeling the root causes of polarization is crucial for understanding how to combat the harmful effects polarization has on individuals and societies.

Claire Seger

SR-BSS-007

Is a Pandemic Academic?

The purpose of this experiment is to see if there are statistical trends that exist with student's GPAs before and after COVID-19. Deidentified data was collected from the Monte Vista School District from the classes of 2025, 2024, 2023 and 2022 including students' GPAs, ethnicities, gender, and income level. The results showed that out of the classes analyzed, the class that had the most decrease in average GPA was the class of 2025, then the class of 2024, followed by the class of 2023 and finally the class of 2022 who increased in average GPA over the last four years. T-test values showed that for the majority of the classes and years the students who are female, on subsidized lunch, or white had the least amount of decrease in GPAs. In conclusion, as a whole, the students of Monte Vista high school have had lower academic success rates since the start of COVID-19. While the classes did not have the same decreases in average GPA, and the class of 2022 has improved as a whole, the pandemic definitely had an effect on the education system and the students within the education system.

Senior Division Behavioral & Social Sciences

Ethan Gavin

SR-BSS-008

Measuring the Effects of Sleep Quality on Multi-Modal Cognitive Functions

The purpose of this experiment is to determine the impact that sleep quality has on brain function in a wide variety of applications. I hypothesized that participants who had the lowest quality sleep would have increased stress, decreased memory performance, and increased emotional volatility. This experiment involved having participants take a variety of tests meant to measure perceived stress, emotional volatility, and memory. The participants also wore an O2 sensor while they slept, to monitor oxygen levels and heart rate to supplement the sleep-quality calculations. The data collected did support the original hypothesis. These findings lead to the conclusion that sleep quality does have an impact on multi-modal cognitive functions. This experiment also highlighted an easy way to potentially improve overall mental health, as individuals who received lower-quality sleep had both higher stress levels and higher emotional volatility scores.

Riley Luttringer & Shaneiry Eufrazio

SR-BSS-009T

The Hints in the Prints: Fingerprint Analysis

The purpose of this experiment was to determine the best at home, easily accessible powder to lift fingerprints. The control of this project was an ink fingerprint that would be used to compare ridges from each print. It was also to determine if oil or lotion did better. The process was started by applying oil or lotion to the fingertip. Then, the fingertip was pressed onto a microscope slide where it was dusted with different home powders. The slide was labeled then pictures were taken of the print. The ridges from the pictures were traced with Procreate application and counted for full and partial lines. Charts were created to determine which powder and base did the best. The project determined that flour and oil did the best out of all the other prints.

Wendy Eller & Jon Paul Manguso

SR-BSS-010T

What Affects Handwriting

The purpose of this project was to see what factors affect handwriting. We hypothesized the environmental factors would affect it more, because handwriting is something learned and that can be improved upon. This experiment involved giving participants a 10-question survey as well as writing an excerpt for 1 minute. The survey consisted of 5 questions regarding genetics and 4 regarding environment. The genetic factors we tested were hand size, being left or right-handed vision, gender, and age. The environmental factors we tested were how many languages someone speaks, if they have taken handwriting classes, if they play any instruments, and their occupation. After we collected the data we rated the handwriting. The data collected in the aforementioned experiment did not support the hypothesis. Genetics affect handwriting more than environment. Upon evaluating the data, we saw that there were really only 4 variables that affect handwriting. Left or right handed, male or female, neatness and whether participants had played an instrument. Males scored an average of 20.4 and the females scored an average of 24.83. In the left or right section, the left scored an average of 19.2, and the right scored an average of 24.5. Next is whether the person had played an instrument, the scores of "no" were 24.56, and the scores of "yes" were 21.12. Overall, neater handwriting also tended to be faster.

Senior Division Behavioral & Social Sciences

Maria Sears

SR-BSS-011

What Do You Have to Fear?

The purpose of my project was to see if there was a direct correlation between traumatic events and phobias, as well as to investigate the impacts of meditation on the fear levels of participants. To get my data I interviewed 20 people and had them fill out questionnaires about their phobias, and the possible causes of them. They were asked before the experiment about how they felt about their fear. I then talked to them for 3 minutes about their phobia. I asked them one more time about their phobia after I had them meditate for 5 minutes. I then had them assess their state of fear using a scale of 1 to 10. After comparing data, I found that the mediation did help relieve some of the fear and helped the participant cope with their fear. It also showed that there was a relationship between traumatic events and phobias. This project taught people that phobias don't just happen and that meditation can be a way to help with their phobias.

Senior Division Chemistry & Biochemistry

Aryan Roy

SR-CB-001

A Novel Liquid Embolic Agent to Treat Brain Aneurysms

Brain aneurysms are weak-walled pathological dilations occurring at cerebral vasculatures. If left untreated, they can easily rupture, resulting in stroke or even death. This project aims to improve patient outcomes through the development of a novel liquid embolic agent (LEA) comprised of the hydrogel F127-DMA, a reverse thermo-responsive, easily injectable, cross-linkable, and shape-conforming polymer system with proper mechanical strength; a catalyst consisting of ammonium persulfate (APS), ascorbic acid, and FeCl₂, which gives the polymer long term stability by allowing chemical crosslinking; and the biocompatible contrast agent iohexol. Rheology tests showed that 29% F127-DMA hydrogel exhibited an elastic modulus of 202.1 kPa after chemical crosslinking, and the average wall shear stress of the carotid artery— 0.85 ± 0.2 Pa—was within the gel's linear viscoelastic region. These results prove that the LEA will be able to withstand blood flow pressure. DSC tests accurately measured the ordering temperature in which the micelles of gel were able to form an FCC lattice. This lattice formation found through DSC corresponds to the drastic rise in modulus found through rheology. In this manner, the LEA composition could be tailored to achieve the desired modulus during the injection. It was found that once cross-linked, the F127-DMA was able to support cell adhesion. This indicates that the LEA can support the migration of endothelial cells required for the healing of aneurysms. Future development will involve monitoring the long-term performance of the agent within animals, enabling the LEA to promote endothelialization, and implementing biodegradability.

Jaxson Monks

SR-CB-002

Gel Electrophoresis: Homemade vs. Manufactured

When DNA is injected into gel agarose topped with buffer solution, it has the tendency to move seemingly on its own when an electrical current passes through the gel. As a result of this quality, gel electrophoresis chambers have oftentimes been used in recent history to test DNA for a variety of purposes. But what makes a gel electrophoresis chamber effective and what factors, such as the variant of the agarose, determine how accurate the results are? That is what this project aims to investigate. During the trials, both a manufactured electrophoresis chamber that can be found in stores and a homemade one constructed out of materials found around the house were used for testing. In addition, two different types of gel agarose were used: an expensive store-bought bottle and a homemade sample created from agar powder, buffer solution, and distilled water. The results showed that the dyes move further with the homemade gel, yet the store-bought chamber was seemingly more reliable and safe.

Senior Division Chemistry & Biochemistry

Nicholai Hagemann

SR-CB-003

Isolation Extraction and Identification of Unknown in Friedel-Crafts Acylation of Biphenyl

Acylation of biphenyl with acetyl chloride is a commonly used Friedel-Crafts reaction. Side products observed between the reactant and the acetylating agent are often due to incorrect stoichiometric quantities. Fluorescent complexes were observed and made the focus of this project, while a lack of interest and funding in these byproducts by traditional industries was the motivation. Isolating, extracting, and identifying these develops a methodology to separate compounds with comparable properties. The procedure, proven reproducible, was scaled up to yield a quantity of product sufficient for analysis. Thin-layer chromatography (TLC) determined the product's transition into a mobile phase could be favored in polar liquids. Including a slightly less polar solvent increased the difference in retardation factors. The efficient solvent system, repurposed to column chromatography, was run through a pipet and buret. Fractions were analyzed qualitatively via TLC to assess which contained a single compound. Crystals, collected from creating an oversaturated solution, were transported to the Air Force Academy, which had the technical equipment necessary for quantitative analysis. Nuclear magnetic resonance (NMR) indicated fourteen carbon atoms with eight hydrogen atoms. Infrared spectroscopy (IR) exhibited the possibility of the presence of chlorine. Additionally, gas chromatography to mass spectroscopy (GC-MS) characterized possible fragmentation for biphenyl and acetyl chloride derivatives, labeling a possible molecular mass as 279 amu. Collective interpretation alludes to the unknown containing [1,1'-Biphenyl]-4,4'-dicarbonyl dichloride. Recrystallization, a cost-effective alternative for the extraction, and X-ray crystallography, a more conclusive route in identification, were considered in plans to continue experimentation.

Anastasia Diener

SR-CB-004

Sequentially Photostiffening a Hydrogel: Redshifting Tetrazoles for Long-Wavelength Activation

My research question is "Will adding on end groups of aniline, naphthylamine, and aminopyrene to a tetrazole at the end of a PEG molecule shift the photo stiffening properties of the molecule?" The three modifications would increase the length of wavelengths that the gels can be photo-stiffened at. This would open up the possibility of non-invasive tissue replacement procedures, as longer wavelengths of light are able to pass through tissue better. The light would therefore be able to actually reach the gel when shined outside the body. The extent to which the 3 tetrazoles modifications actually red-shifted the PEG tetrazoles was tested using the extinction coefficients of the molecules. As expected the benzene modification redshifted the molecule the most, with naphthyl red-shifting it the second most, and pyrene red-shifting the tetrazole PEG molecules the most. After this my mentor and I looked at the gel's rheology to confirm that the gels were actually suitable for use in tissue engineering and that the gels could be deformed and still spring back to their original shape. Using the storage and loss modulus I confirmed that the gels were suitable for use in tissue engineering. Finally, we looked at the possibility of a dual writing system using the difference in Naphthyl and Pyrene's absorbance and fluorescence emissions. However, this was later discounted due to the differences in the absorbance not being enough to stiffen the mixed gel and hit only the naphthyl and pyrene independently of each other.

Senior Division Chemistry & Biochemistry

Ryan Young

SR-CB-005

The Bismuth Dipper

I first got the idea for a bismuth experiment in 6th grade middle school from a show I was watching at the time; but that experiment, disheartened, proved to be a failure as I, being young, did not do the proper research in order to make proper crystals. I would later learn more about bismuth to find out what I did wrong. So, when I was placed with an opportunity to make a new experiment with bismuth with the knowledge I have accumulated over the years, I was more than excited. I used the bismuth from my past failed experiments (1lb), with a sample of three pounds gained by my teacher. Along with samples of sulfuric acid. The first parts of my experiment were fairly straight forward, aside from having to alter the speed in which the bismuth cooled. I would melt, cool, separate a crystal before oxidation, dip in the variable, and repeat. And for the acid side of the experiment I planned to do at school. First, I prepared three bismuth crystals, in sizes according to the time they would be dipped in acid (Small 1s, Medium 2s, large 3s). Then dip, let sit for 5 seconds, and then neutralize the acid. I first tried to melt bismuth at school with a 30 min time frame, but I severely underestimated the time frame needed to melt bismuth chunks of larger size. So, I opted to make the bismuth at home, dip the safe variable, and come back with pre-made crystals for the acid section. The first few melts were failures, as I cooled too fast (small crystals). I fixed this by turning heat down slowly in 10 intervals for bigger crystals as the slower bismuth cools the larger the crystals. Before the crystals oxidized I dipped the largest crystals I would separate a crystal then dipped in the safe variable being Pop, soap suds, water. No dipped crystal came out normally. I ended up making three base crystals so a sense of consistency among crystals can be made before seeing the alterations of the test samples. When it came to the pop variable an unexpected thing happened, A thick layer of contaminant formed on the crystals surface. Even oppo remelts the containment remained as spread to the surface layer of the molt meale become contaminated leading me to having to remove the entire surface layer in order to completely remove the contaminant. With water the only change was that the crystal lost all color. When dipped in soap suds the crystal gained bronze colored spots. A portion of the metal splashed on my skin when I was tripped by my dog running between my legs leaving minor burns. I should have made sure that the dogs were in the backyard before melting occurred. I then made Three samples for the acid test in three sizes small, medium, and large On the last day before the due date I was able to get in the building to do the acid dip part of the experiment. My instructor prepared the acid under a ventilation hood along with the baking soda water solution to neutralize the acid. Then I had my instructor time each acid dip. I then neutralize the acid on the crystal, and set it aside to dry. I thoroughly enjoyed this experiment even during the frustrating parts. The only grievance I had when doing this was that the bismuth sample size was not large enough to get substantially sized crystals, being Four pounds compared to the desired Ten pounds. This however is to be expected as this substance is a costly one, being a bit more than ten dollars a pound.

Senior Division Chemistry & Biochemistry

Shelby Dunlap & Siena Parr

SR-CB-006T

The Burning Question: Homemade or Purchased Fire Retardants?

With rising temperatures and increasing drought in many parts of the world, people are experiencing the threat of wildfires more often than in past decades. One of the biggest challenges facing populated areas exposed to recent wildfires is wind-blown embers that hold the ability to ignite housing developments and their surrounding communities. A possible fire preventative measure for structures could be the use of a fire retardant on roofs or other exposed areas. The purpose of this project was to test the durability of a purchased commercial fire-retardant compared to a simple homemade version made of boric acid, borax, and water. Our hypothesis was that the commercially made retardant would perform better than the homemade one. Miniature versions of a wooden structure with a shingled roof and fabric samples were used to represent real-world objects that might be exposed to fires. A house fire was simulated, and each product was exposed to flames. Time to combustion was measured for each of the samples versus a control. The results did not support our hypothesis and showed that the homemade fire retardant was more effective than the store-bought counterpart. The homemade version was also substantially less expensive and did not contain as many potentially harmful chemicals as the commercial retardant, providing a possible low cost, more environmentally friendly alternative for consumers who wish to use fire retardants in the hopes of preventing catastrophic damage in the event of a wildfire.

Shreya Sethuramalingam

SR-CB-007

A New Water Generator; The Effects of Calcium Chloride and Silica Beads on Humidity Adsorption Rates

Many humid and tropical regions struggle to obtain water supply due to inadequate resources and electricity, which introduces the necessity to figure out a way to generate water by utilizing inexpensive materials. I experimented to determine the effects of calcium chloride and silica beads on humidity adsorption rates by placing the same surface area of these materials under a relative humidity level of seventy percent for one hour. Then, I would heat each material for thirty minutes to identify the amount of moisture adsorbed (in grams). Throughout the experiment, I observed how the glass plates, containing calcium chloride formed water crystals that eventually melted into water droplets. Similar to my prediction that calcium chloride would release more than triple the weight of water (in grams) than silica gel, the average data from my results concluded that calcium chloride had significantly produced a higher amount of water than silica beads due to its hygroscopic properties of attracting moisture that is several times greater than its weight. By understanding whether calcium chloride or silica gel adsorbs water vapor the fastest, scientists could potentially implement the chemical in the real-world application as a prominent element that can develop purified water from these accessible materials through exposure to heat and condensation. In that way, there would be a chance for all populations to receive a convenient solution that can be implemented in humid and hot areas without electricity.

Senior Division Earth & Space Sciences

Arlene Price

SR-ESS-001

In Search of the Astronomical Holy Grail

Anyone with decent eyesight can observe that lights seem dimmer with increasing distance. We can possibly use the inverse square law to determine distances to those light sources, the holy grail of astronomy. Under ideal viewing conditions, one observes about 2,500 stars. What are those spots of light? How far are they? Well, they are stars of varying size, color, age; and now astronomers may have a method of measuring their distance from Earth. The research and experimental question are whether there is a mathematical relationship between the apparent brightness of a light source and their straight-line distance from Earth. It is the purpose of this project to understand distances to stars in relation to the Earth using the inverse square law formula. The hypothesis is if different light source colors are used then the only effect on the results is the shifting of the curves upwards or downwards. A similar experiment performed at the school showed that white light generally followed the inverse relationship; therefore, white light was chosen as a control. Light intensity was measured at varying distances from one to ten meters. Light intensity and color-controlled LED light source were used to represent stars of different spectral classes. Light intensity was measured in units of Lux and compared to mathematical figures calculated to determine if the experimental data follows the inverse square law.

Abigail Ross

SR-ESS-002

Detecting Flares (Part 4)

“Detecting Flares (Part 4)” is about solar flares that can affect humans through damage to radio signals, power grids, satellites, and radiation. The problems were: “how does the number of sunspot clusters affect solar flare strength?”, “how does the number of sunspots affect solar flare strength?”, “how does the speed of the solar wind affect solar flare strength?”, and “how does the speed of the solar wind affect the time solar flares reach Earth?” The hypotheses were: the more sunspot clusters there are, the stronger solar flares will be; the more sunspots there are, the stronger solar flares will be; the faster the solar wind is, the stronger solar flares will be; and the faster the solar wind is, the sooner it will arrive at Earth. Two antennas were used to detect flares through radio interferences. This data from daily graphs was compared to GOES data about sunspot number, clusters, solar wind speed, and time of flares. Changes in clusters and flare strength correlated for 65% of the data. Changes in sunspot number and flare strength correlated for 75.5% of the data. Changes in solar wind correlated with flare strength for 67.5% of the data. Changes in solar wind correlated with the time the flare arrived at Earth for 66.7% of data. These results show changes in these variables affected flares. The results could have been affected by noise interference and human error interpreting graphs. These findings can help scientists use different indicators to predict solar flares.

Senior Division Earth & Space Sciences

Natalie Pujet

SR-ESS-003

Modeling Triton's Seasonal Atmospheric Change: Applications of the VT3D Model to Triton

The seasonal cycling of volatile nitrogen, methane, and carbon monoxide ices from pole to pole causes significant changes in Triton's atmospheric pressure. The ability to model these changes is crucial for planning missions to Triton and understanding more about planetary bodies with volatile cycles. For my research, I adapted a simple analytic model called VT3D that was originally developed for Pluto and used it to investigate how Triton's atmospheric pressure evolves over time. I then compared my results to those of Bertrand et al. (2021), who used a general circulation model, or GCM. Using different models to investigate Triton's atmospheric change is critical in verifying that the results do not depend on the type of model used. I performed two experiments with the VT3D model: one where I investigated the effects of varying volatile ice distribution, and another where I conducted a parameter space search to determine which geophysical parameter values were needed to best match a range of telescope observations of Triton's atmosphere. In both experiments, I analyzed the similarities and differences between the predictions of VT3D and the GCM. I found many similarities between the results of the two models, including similar minimum and maximum pressures and responses to varying the northern volatile cap extent. The shared predictions are now supported by more than one model, which is evidence that they are not model-dependent. Overall, my research gives us more confidence in our predictions of the atmospheric dynamics of Triton and other planetary bodies with volatile cycles.

Nathaniel Ellis

SR-ESS-004

Moon-Opoly: Using In-Situ Resources for the Construction of Lunar Concrete

The colonization of space is important to the future of mankind. Our nearest celestial body is the moon, and having a suitable method of building habitable structures on the moon will be critical to maintaining a colony there. To build these structures, one requires a building material. My proposed solution is to create a type of Lunar-Crete; a mix of lunar regolith (moon-dust) and elemental sulfur refined from lunar rocks. When these two materials are blended and heated above 140 degrees C - they will bind to each other. To test my Lunar-Crete concept, I purchased a lunar regolith "simulant" and elemental sulfur, and combined them in various ratios. I then heated the mixtures and poured them into a mold in order to shape them in a form conducive to stress testing. Finally, my goal was to test each brick for compressive and shear strength, and compare those results to conventional concrete. The mixture of elemental sulfur and lunar regolith successfully combined and made a solid casted brick of homogenous material. The materials were tested and found to be weaker than traditional concrete, with a strength roughly 1/10th of what reference studies achieved. In conclusion, by extracting sulfur from lunar rocks, subsequently recombining the sulfur with lunar regolith, heating the mixture and allowing it to cool for several hours, a useful structure was successfully created. The Lunar-Crete was nowhere near as strong to conventional concrete, disproving my hypothesis. Further study of methods and materials are required.

Senior Division Earth & Space Sciences

Allison Inge & Langley Nakari

SR-ESS-005T

Characterizing the Altitude of the Martian Mesopause over the MAVEN Mission

The mesopause in the Martian atmosphere is the point in which the temperature is the coldest. It also divides the upper and lower atmospheres. In order for scientists to land spacecrafts on Mars, they need to be able to understand where the mesopause occurs. However, the exact altitude and variability of said mesopause is unknown. In order to discover more information about the mesopause, we wrote a computer program using the software IDL that would be able to interpret data received from the EUVM that is located on the MAVEN spacecraft. The EUVM takes wavelength measurements of the sun through the Martian atmosphere that can be converted into temperature data points using several equations. Our code organized the data into arrays and then compared temperature and altitude of the mesopause on several different graphs, accounting for different latitudes, local time, and season. We found that there is distinct trending during aphelion and perihelion in the northern hemisphere. This suggests that the mesopause altitude increases at temperature during perihelion due to the global dust storms that occur along the surface. Additionally, we found that at aphelion, the altitude of the mesopauses decreases with temperature because of adiabatic cooling and distinct air circulation patterns. There did not seem to be any trending along equinoxes, which may suggest that mesopause temperature could be related to pressure. We have also found that the mesopause occurs between 90 and 150 km across the board, with more specific parameters depending on season, local time, and latitude.

Ada Pence & Hannah Shelton

SR-ESS-006T

Observing the Relationship Between Sand Temperature and Ambient Air Temperature on Different Slopes

Have you ever worried about burning your feet at the Great Sand Dunes National Park? If not, you probably should! With sand temperatures reaching 150 °F in the summer, we hypothesized that if we could identify a relationship between ambient air temperature and sand temperature then we could develop a mathematical formula, or set of formulas, to predict sand temperature by measuring ambient temperature alone. We measured sand temperature and ambient temperature at 3 points on each of the 4 faces of a selected dune and found that there is a consistent relationship between temperatures. This allowed us to define at least one mathematical formula on the north, east, and south faces that could be used to predict sand temperature based on an ambient temperature at a point 50 and 150cm, or at the crest of the dune. We also predicted that the position of the sun, represented by time, and slope of the incline would have an effect on sand temperature. As predicted, sand temperature increased throughout the day, was coldest on the north and hottest on the south. We also found that slopes closer to zero did not absorb more heat, as predicted. In conclusion, based on our findings, we can confidently say that with continued data collection we could generate a formula to predict sand temperature based on ambient air temperature so you don't burn your feet.

Senior Division Energy

Wilson Moyer

SR-ET-001

Analyzing Non-Chemical Storage Solutions for the Grid-Scale Energy Problem

Grid-scale energy storage systems are an integral part of a clean future. Some sources of renewable energy cannot consistently produce electricity, leading to gaps between electricity supply and demand in what is called intermittency. Energy storage systems fill these gaps to consistently deliver sustainable energy when it is needed. Although lithium-ion batteries are efficient and compact, they have a number of disadvantages, the most alarming of which is environmental damage due to mining. This experiment is designed to prototype three types of alternative energy storage systems: hydroelectric, gravitational potential, and elastic potential. These systems were evaluated for feasibility and applications. These storage systems could overcome the weaknesses of chemical batteries, promoting a cleaner and more sustainable energy grid. Prototypes of the three types of energy storage systems were created and tested to compare their strengths and weaknesses. The experimental design reviewed factors like energy capacity, power output, round-trip efficiency, and discharge rate, while keeping in mind potential biases in order to thoroughly investigate the potential benefits of each type. The experimental results suggest that each of the tested prototypes could fulfill a different energy need. The hydroelectric storage system had a high storage capacity, making it potentially feasible for massive-scale implementation. The elastic potential energy storage system had a swift discharge rate, indicating its viability to support power surges. The gravitational potential energy storage system was versatile for all of the criteria, suggesting that it could fulfill many generic energy needs.

Shrey Rohilla

SR-ET-002

Electrify Your Step: Converting Foot Traffic into Renewable Energy

In order to decrease reliance on non-renewable energies that greatly pollute the earth, people need more renewable energy sources, such as piezoelectric energy harvesting, that can generate electricity from everyday actions. The essential design criteria included the following: (1) prototype must produce electricity when stepped on, (2) prototype must be able to store the electricity it produces, (3) prototype must be durable enough to withstand much pressure without any signs of damage, (4) prototype must be wheelchair accessible, (5) prototype must function after water is poured on it, (6) prototype must cost less than \$15. All prototypes met all of the stated design criteria with the exception of being able to withstand much pressure without any signs of damage. After being under 200lbs of pressure for 10 minutes, prototype # 1's circuitry housing was permanently compressed and its piezoelectric transducers were cracked and deformed, rendering them useless, but prototype #2 was completely unharmed both internally and externally. Both prototypes were designed to charge a 1.2v NiMH battery using only foot traffic and both succeeded in doing so, but prototype #2 was far more efficient than prototype #1 and charged a 1.2v NiMH battery 0.011v, while prototype #1 charged the battery 0.004v. Based on the analysis, the next prototype would be thinner, wider, and have more piezoelectric transducers, allowing for far more electricity produced and more comfort with each step.

Senior Division Energy

Braxton Dennison

SR-ET-003

Home Made Hydrogen Fuel Cell

For the 2022 science fair I did a continuation of last year's work and created a homemade hydrogen fuel cell. My goal for this project was to be able to engineer a fuel cell from scratch and measure the amount of electricity it created. Based on my last year's project and research I had done, I needed to combine hydrogen and oxygen back together and measure the chemical energy. To test, I did everything to test last year's project but added my fuel cell to the end of the flame arrestors. After waiting for some time and watching a voltmeter attached to the fuel cell, voltage began to show up. This was proving that the fuel cell was doing its job perfectly. In conclusion the continuation of my work has proved a success and I will continue down the path of creating an RC to be powered by hydrogen.

Alec Mallinger & Oliver Schmitz & Davis Cutforth

SR-ET-004T

Hydrogen Fuel Cell Vehicle/Station

Hydrogen fuel cells are the future of the transportation industry, yet they are very under-utilized. This project aims to create a proof for the Hydrogen fuel cell vehicle and subsequent refueling station. These cars and refueling stations will be able to replace both gasoline and electric cars, all the while being zero emission, and the only by-product being water. We started by collecting data from online sources of premade fuel cells. We then ordered a fuel cell and collected data from that. This data was used to calculate the size for our own theoretical fuel cell. This theoretical cell is then shown to fit in a model of a modern sedan. The refueling station was then calculated using the same data, in which it was found that only one acre of solar panels can be used to power multiple fuel cell cars per day. All of this data and calculations combined shows the overall feasibility of hydrogen fuel cell cars as a whole, along with showing how they can be utilized in a manner entirely off the grid from harmful greenhouse gasses.

Anna Lucas

SR-ET-005

How Half the Water in your Toilet Flush Could Power your Home

Fossil-fuels currently support 80% of the world's energy and have been powering economies for 150 years. While there are pros to using fossil-fuels, such as our deep understanding of how they work powering our communities, their reliability, and their efficiency; cons include how when fossil-fuels are burned, they release nitrogen oxides into the atmosphere, contributing to the formation of environmental pollutants, or how fossil-fuels aren't renewable and if we continue to use them at the rate we are, then all fossil-fuels will be depleted by 2060. Because of the dangers of continued use of fossil-fuels, use of them needs to be discontinued or cut down drastically. But, the Earth also needs energy. So, I propose the use of hydrogen energy, specifically through the use of miniaturized hydrogen-reactors, to replace fossil-fuels. As opposed to fossil-fuels, hydrogen energy is renewable and readily available as these fuel cells can run on salt-water. Hydrogen energy is also more energy-efficient than fossil-fuels as hydrogen has three times the gravimetric energy density of diesel, and hydrogen has almost zero emissions, meaning it won't pollute the environment. The hydrogen I promote is fuel cells of my own design. My fuel cells are low cost, and have an output 5.21 kilowatt-hours of electricity per liter of water, meaning it could power the average home for about 4 hours on a single liter. Because of all mentioned facts and reasoning, I think my design of hydrogen fuel cells could have a large positive impact on the energy crisis.

Senior Division Energy

Wyatt Guthrie

SR-ET-006

Recharging Car Batteries with Epsom Salt

This project is about figuring out if you can recharge car batteries with Epsom salt. In order to figure out if this works I have to completely empty and clean an old car battery to make sure only the Epsom salt is charging the battery. With the process of the experiment you have to do multiple tests in order to figure out if charging a battery with Epsom salt actually works. After doing multiple tests it is true that you can recharge car batteries with Epsom salt.

Chinmay Jayanty

SR-ET-007

Reversing Climate Change with Direct Air Capture

Direct Air Capture (DAC) is the capture of CO₂ from atmospheric air through technical chemical processes. DAC technologies have been developed to remove past emissions and reduce atmospheric CO₂ to an optimal level below 350 ppm. Amino acid sorbents are environmentally friendly and alternative to toxic and corrosive substances like aqueous alkaline sorbents (NaOH, KOH, and Ca(OH)₂) and amines. The aim is to improve the surface area relative to the sorbent volume, which limits the overall CO₂ uptake. The loading of CO₂ with the humidifier filter method and a bubbler method using 1 M and 0.5 M aqueous solutions of glycine and sarcosine has been tested. The CO₂ absorption was monitored by pH measurements and ¹H Nuclear Magnetic Resonance chromatography (NMR) to quantify the formation of carbonic acid and carbamate. The CO₂ capture experiments were carried out over a 24-hour period. There was a drop in the pH of glycine and sarcosine solutions after 24 hours at both concentrations and methods. The decline in pH is due to increased levels of carbamate and carbonate. In proton NMR analysis, the intensity of the proton at 3.8 decreases, while the intensity at 6.4 increases with time during CO₂ absorption on glycine. Similar changes in peak intensity and shift occurred with sarcosine at 24 hours.

Senior Division Engineering

Augustus Miller

SR-ENG-001

AccessiMouse: Using Arduino to Design and Build a More Accessible Computer Mouse

My engineering goals are 1) Successfully build a fully functional, more accessible, computer mouse using Arduino components that use motion 2) Develop fully functional left and right-click buttons 3) Use new code along with existing code to program the device, and; 4) Develop an easy and intuitive gesture system to allow the average and limited user to use the device. This device is to allow people who previously might have struggled with the use of traditional computer mice. The device was prototyped and improved repeatedly to meet the success criteria. Once the final device was finished the device was tested to see if the device met all of the success criteria. After the final evaluation of the device, 100% of the criteria for success were met. All the criteria were rendered successful due to proper function and each of the features being intuitive and easy to use. Due to the modular aspect of Arduino and 3D printing this device can be adapted to meet anyone's needs. The device can be configured to help and solve many problems that prohibit someone from using a standard computer mouse or traditional computer trackpad. The device could also be used for someone who simply does not like the ergonomics and form factor of a standard computer mouse. The possibilities and modifications of this device are boundless and are what allow the device to be so remarkable and influential.

Peyton Golliher

SR-ENG-002

To Infinity and Arduinos

This project sought to find a way to make an infinity mirror using an Arduino. Arduinos are a type of open source electronic prototyping platform that uses its own programming language. The Arduino was used to power LED lights that lead to the infinity mirror. The infinity mirror is two mirrors that has one that is one way, that way people can see in but the other mirror cannot reflect out. The tests performed were: while moving the Infinity mirror at different angles, the number of lights that could be counted by the naked eye were tallied. Combining them developed a wonderful project that everyone can enjoy as art and science combined.

Ana Alarcon Palacios

SR-ENG-003

B.O.B. (Building On Blocks)

Microcontrollers are programmable mini-computers that enable an object to follow a predetermined set of instructions. The engineering goal of Building On Blocks (B.O.B.) was to learn the basics of programming microcontrollers, build a rover with building blocks and wiring components, and program it to drive a specified time. The prototype was built and coded. Then, different wheels and gearmotors were tested to determine the rover's functionality on different terrains. It was hypothesized that wheels not compatible with the gearmotors would perform better (go a longer distance) on rough terrains, but the compatible wheels would result in the rover going in more of a straight line. Terrains tested included asphalt, hard-packed snow, polished concrete, low-pile carpet, and non-polished concrete. The code was set for the rover to go to its maximum speed and steadily slow down. Hypothesis one was rejected since compatible wheels were more accurate for all terrains except the carpet. It supported hypothesis one, as it went in more of a straight line with the compatible than the non-compatible wheels. Its total deviation was 128.54 cm less than the non-compatible wheels. Hypothesis two was rejected for all terrains except the non-polished concrete. It supported the hypothesis as it went farther with the non-compatible wheels rather than the compatible wheels. It traveled 38.1 cm more than compatible wheels.

Senior Division Engineering

Rhys Hanson

SR-ENG-004

To Apogee and Beyond

Model rocketry and high-powered rocketry have become stagnant fields over the last few years. Innovation is seemingly restricted to only actual aerospace engineers who have free time and the resources to develop new technologies. Thus, my goal through this project is to experiment and redesign the industry norms which rocketry hobbyists have been told to work within. I want to create unique and more highly performing launch vehicles and systems than are currently suggested to students to use and in the process, make them cheaper, more efficient, and more powerful than current commercial options. My theory going into this project is that High Power Rockets can be made to go far higher and faster while not compromising stability and with advanced payloads. Throughout the last few months I have designed and built 2 primary technologies, a Cold Gas Thruster and a Level 1 High Power Rocket. My cold gas thruster, while not being fully refined and reaching its maximum efficiency yet, still has about 4 times the total thrust of the Estes B6-4 Engine it was tested against. The high-power rocket meanwhile is able to fly over twice as high as commercial models for a far lower price point, launch mass, and with a far more advanced payload bay.

Samuel Law

SR-ENG-005

The Optimization of the Sonic Fire Extinguisher Using a Conical Collimator

Fire extinguishers are important safety equipment in most homes and offices. They primarily use three different methods to extinguish fires: chemical, foam, water, and carbon dioxide. These methods can cause a multitude of issues such as cold burn, property damages, and general cleaning hassles. The use of sound waves to extinguish fires will eliminate these problems, thus the goal of this project is to redesign and optimize the sonic fire extinguisher. We built a prototype by replacing the cylindrical collimator in the existing design with a conical-shaped collimator. This was done because we hypothesized that a conical-shaped collimator would focus the soundwaves better than a cylindrical collimator to extinguish fires more efficiently. Our results indicated that 45 to 55 hertz was the optimal frequency range for putting out fires and that outputting square waves worked better than traditional sine waves. Additionally, we found that all variations on the conical collimator, on average, worked four to five times faster than the cylindrical collimator. Finally, it was determined that neither the aperture diameter nor the taper of the collimator had any effect on the performance of the extinguisher. This project would result in an updated and improved version of a sonic fire extinguisher that could extinguish fires cleanly and non-destructively.

Senior Division Engineering

Geo Raguraman

SR-ENG-006

InvisiEye - Design and implementation of an Assistive Suit for Blind and Visually Impaired People

Independent mobility is a challenge for blind and visually impaired people (BVIP). The World Health Organization (WHO) reported that there are 285 million visually-impaired people worldwide. Among these individuals, there are 39 million who are completely blind. Assistive technology for the blind is a field of research that is gaining importance due to the challenge we have in finding the right assistive device. There have been several systems designed to support visually-impaired people and to improve the quality of their lives. Unfortunately, most of these systems are limited in their capabilities. This research aims to demonstrate the application of a systematic design approach in the development of a novel product 'InvisiEye'. InvisiEye, determine obstacles around the user body from the surroundings. Providing information about the distance between the user and the obstacle with essential directional instructions. The proposed system relies primarily on 6 ultrasonic sensors, a real-time processing board, and a user interface, suit. It uses sensor data as inputs and provides the desired safety orientation to the BVI P. The user is informed about the decision based on the vibration motor interface. The sensors calculate the distance of the object and feed the data through an Arduino system which is connected to a vibration motor to indicate the user how far and in which direction the obstacle is located. The InvisiEye Suit blows all the competition out of the water, and it revolutionized the assistive technology industry by the comfortability and the maneuverability of the suit.

Teagan Archer

SR-ENG-007

The Perfect Pan

I made a backpacking pot that keeps your water warm longer, and is multi-purposeful, so your backpack isn't as heavy. My engineering goals were for the new pot to be, smaller and weigh less than the old pot, be able to keep food warm for 8-10 minutes at a temperature slightly lower than boiling, to be easily assembled and disassembled, and for the peltier, which runs on temperature differential, to get 3-5 volts. I used a silicone bowl, an aluminum pot, and PLA as my main materials. I made some iterations to a few things, but the biggest problem was that the peltier wasn't getting a big enough differential. The first test was to determine which device would deflect heat best off the peltier, the second tested the temperature of the polyimide heater over time, and the last determined the difference between the polyimide heater and no polyimide heater. The small heat sink with snow was the best heat deflector by 0.2 volts over the big heat sink with snow. The polyimide heater reached 262°F in 10 minutes, which was 10°F higher than no polyimide heater. I met my first goal because it did weigh less, and was smaller. My second goal was met because it took only 60 seconds to take it apart and put it back. My third goal was met because it did keep the water warm for 10 minutes at 20°F below boiling. For my last goal it wasn't able to get to 3-5 volts.

Senior Division Engineering

Zachary Weiner & Zachary Porter

SR-ENG-008T

Designing an Energy Efficient Home for Climate Control Using Passive Solar and Wind Technology

This project examined the effectiveness of two passive solar architectural features, a Trombe wall and a window overhang, in order to identify which was more effective and efficient at maintaining a stable temperature throughout changing weather conditions and evaluate what could be improved. In order to test this, three models were constructed, and the conditions of winter and summer solstices were simulated with a heat lamp, fan, and evaporative cooler. Three trials were conducted with each model in each condition, and both the interior house temperature and roof surface temperature were recorded at regular intervals. The data revealed that the window overhang model was the most effective in both conditions, maintaining a relatively low temperature in hot summer conditions, and a consistently warm temperature during the colder winter conditions. In the winter tests, the interior temperature of the Trombe wall model remained within 1°C from its initial temperature, and the overhang model remained within 2°C. In the summer trials, the Trombe wall model's interior temperature increased by approximately 8°C each trial, and the overhang model's temperature increased between 4-6°C, each compared to the control model's increase of approximately 5°C each trial. Anova analysis confirmed that these differences were statistically significant. Additionally, it is very interesting to note that even on this small scale (approximately 12.5cmx12.5cmx13cm), very significant differences were shown between the three models, indicating a need for further experimentation on a more realistic scale.

Elia Lowe & Samantha Abate

SR-ENG-009T

Eco-friendly vs Store-bought Water Repellent

In this experiment, we attempted to redesign water-repellent product using all-natural substances to create a more eco-friendly substitute to store-bought water-repellent spray. We researched the water-repellent properties of lotus leaves and based our design on the way the plant is formed and the waxy cuticle substance on its leaves. We attempted to compare the effectiveness of the products based on their chemical makeup to show the benefits of the all-natural substance compared to the store-bought product with respect to environmental concerns. By combining melted beeswax and avocado oil, we created a water-proof substance and spread it thinly over various surfaces. This design provides an alternative to store-bought chemical water repellents. It is important to lessen the environmental impact of water repellents that are currently available. It creates an alternative to chemical based water repellents and is an effective solution that is environmentally friendly. It is a simple and functional product that reduces the harmful effects of store bought chemical water repellents. The results showed that the eco-friendly water repellent substance worked just as well, if not better than the store-bought spray on various surfaces.

Senior Division Engineering

Kelly Yang

SR-ENG-010

Under Pressure: Piezoresistive Pressure Sensors for Electronic Skin

The WHO states that 30 million people need prosthetic devices globally. While prosthetics achieve many mechanical functions associated with biological limbs, adding skin-like capabilities could improve the quality of life for users. One way to achieve this is electronic skin, which is a thin layer of sensors, such as pressure, temperature, etc., that mimics the properties of human skin. In this project, I'll be working with piezoresistive pressure sensors for electronic skin, which contain layers of conductive material. The material and design of the sensor play a critical role in its performance, particularly sensitivity. For my design, I used a simple block design with electrodes on the top and bottom and the active material in the middle. For my material, I used Polydimethylsiloxane (PDMS) with added carbon black (CB) in various ratios. My project aims to answer three questions regarding CB-PDMS sensors: (i) How does pressure affect resistance?, (ii) What's the sensitivity of the sensor?, and (iii) How does changing the sensor material composition affect performance, especially sensitivity? To mimic human skin, the design criteria were that the sensor was flexible, soft, inexpensive, and sensitive. I concluded that the sensitivity of the sensor increases when the weight ratio of CB is below 10%, but further increases of the CB weight ratio do not improve sensitivity. Additionally, increasing the mixing ratio of PDMS results in a lower modulus and improves sensitivity. I hope this work contributes to a better understanding of the composition of CB-PDMS films, allowing for better tactile sensing ability in future prosthetics.

Trent Donley

SR-ENG-011

Universal Gateway Valve

Throughout the United States cities, and counties, often have their own special fire hydrant thread, this causes problems when fire agencies from outside cities try to use them on mutual aid incidents. When fire hydrants first started to be made in the 1700's by blacksmiths, each blacksmith would make them their own causing them to have different threads. Over time some cities adopted their own threads like Pueblo, Denver, and Chicago. To help combat the problem of different cities have different fire hydrant threads I am creating a universal gate valve that can connect to any fire hydrant. The only other solution to this problem is that new cities use Nation Hose or "fire thread" on their hydrants so all departments have the proper threads however cities that already have their own thread often do not change over due to having to replace every hydrant in their city. Local governments do not see the need to spend all the money on replacing hydrants. Only 18 of the 48 most populated cities in the United States have installed Nation Standard Fire Hydrants. An Universal Gate Valve would help solve the problem of fire agencies not being able to connect to a fire hydrant with a special thread. This would increase their efficiency on mutual aid fires and potentially save more buildings.

Senior Division Environmental Sciences

Marissa Martinez

SR-ENV-001

A Habitat Assessment Protocol to Determine Suitability for Southwestern Willow Flycatcher Occupancy in the Northern Rio Grande Watershed

The goal of this study is to create a diagnostic “suitability” tool to assess potential habitat for southwestern willow flycatcher (SWFL) sites in the San Luis Valley, Colorado. The tool defined key parameters critical to the life stages of SWFL living in the Upper Rio Grande watershed based on insect forage, habitat structure, and occupancy data collected from known occupied vs unoccupied willow sites. Habitat was assessed with transects to collect height, canopy cover, and leaf gap data. Vegetation coverage was ground-truthed and drawn as polygons using Google Earth Pro. Terrestrial insect forage was sampled from available habitat within and surrounding the willow patches and analyzed for insect Order and amount of biomass. Occupancy was confirmed using data collected by field technicians during summertime SWFL surveys in 2021 and previous years. Habitat and forage characteristics of both occupied and unoccupied sites were compared and statistically analyzed, and significant differences of the above parameters defined the “cut score” for each parameter, creating a diagnostic tool by which to measure suitable habitat against poor habitat. Some parameters were found to have more “weight” than others, but in this initial model, scores for each parameter were not weighted until the tool can be field tested to a greater extent. The intent is to use this tool to assess other potential Southwestern Willow Flycatcher areas in the upper Rio Grande watershed; both to identify deficiencies and recommend management actions to improve sub-standard habitat based on parameter analysis with the "diagnostic" scoring tool.

Elton Cao

SR-ENV-002

The Effect of Oil and Gas Production on Tropospheric Ozone and Air Quality Emissions

Emissions from oil and natural gas (O&G) wells such as nitrogen dioxide (NO₂), volatile organic compounds (VOCs), and ozone (O₃) can severely impact the health of communities located near the wells. Indeed, with the O&G industry growing sharply, 17.6 million people already live within a mile from an oil and gas well. In this study I used O&G activity and wind carried emissions to quantify the extent to which O&G wells may affect the air quality of nearby communities. I created a computer model and determined the prevalence of O&G activity, then used linear regression based on monitoring site data to verify the accuracy of the model and predict emissions. The model revealed that NO₂, NO_x, NO, and ozone are correlated to O&G activity and oil producing wells produce higher NO₂ levels than gas producing wells. The model I created makes it possible for a community, or even a family or individual to determine the effect that O&G has on their homes. Given the growing O&G industry in the U.S., it is crucial that the public is educated on the effect that the O&G industry has on their daily lives and has the tools to monitor these effects.

Senior Division Environmental Sciences

Morgan Ashcraft

SR-ENV-003

Algaecide Success Rates

The purpose of this experiment was to test multiple algaecides in hope to find which one would work best. Originally it was hypothesized that the copper sulfate would work the best. The treatments were measured out to treat a 200-milliliter beaker that contained dechlorinated water and algae; two doses were applied to each container and results were recorded. The chemical solution worked extremely well compared to the other home remedies. Over time the copper sulfate solution showed some progress but results were extremely minor. Triticale and cornmeal showed no changes at all and did not seem to affect the algae in any exceptional way. Cornmeal appeared to have an opposite reaction and almost seemed nutritional to the algae, making the algae more green and vibrant. Finally, the chemical brand appeared to work the best. It appeared to destroy the algae's chloroplasts, draining the color to a milky white, and the overall amount of algae in the container seemed to lessen. Overall, the hypothesis was partially incorrect; it was hypothesized that the copper solution would be more effective, whereas it was only somewhat effective.

Grace Wahl

SR-ENV-004

Firewater

In my project "Firewater" I tested how different waters affected the growth of Timothy hay. I chose this project because the many hay meadows get flood irrigated by the East Troublesome Creek. Late 2020 the Troublesome Creek fire burned 187,964 acres. The headwaters of the creek start in the burn scar. Bringing sediments from the fire down-stream which disperses to the hay ground. My hypothesis stated that the fire water would kill the grass. I believed that with the Pre-fire water it would grow nicely, and with the distilled water it would not grow well. Finally, I thought the current water would make the hay grow worse. This experiment proved my hypothesis wrong. The experiment involved me growing Timothy hay in planters with a growth lamp. I monitored and watered them when needed. The growth lamp was on for 14 hours a day. I watered them every 2-4 days as well as measuring the grass everyday seeing how it progressed. My findings led me to believe that the current water grew the best, the fire water grew the second best, the distilled water made the hay grow the third best, while the pre-water made it grow the worst. I also had sent water to a Servitec laboratory to gather what molecules are in the water. That data came that the molecules were low, then rose, and now is leveling back out.

Senior Division Environmental Sciences

Emily Hume

SR-ENV-005

How Can Algae be Utilized in Nitrate Reduction

In my science project this year, I am looking to find the best way to utilize algae in providing an eco-friendly, yet effective solution to nitrate removal. Algae removes nitrates through the biological process of photosynthesis. Algae is often used in aquatic systems like fish tanks to reduce the nitrate content of the tank and improve the quality of the water. I wanted to take advantage of this process in my experiment. The variables I chose for this project were light availability, temperature, CO₂ content, and type of light. I believe that the algae will produce similar results through all changes in percentages of light availability, an increased drop in nitrates under CO₂ fertilization, an increased drop in nitrates under natural light, and an increased drop in nitrates under heat. In this experiment, the type of light that lowered the nitrate content to a safe level the fastest was artificial, 24-hour light. My hypothesis for this variable was wrong, as I predicted that natural light would do better than the grow lights. The results of this project were able to give us insight on how algae reacts to the variables that most heavily influence its growth. Implementing this research into creating a large facility similar to biofuel plants or other renewable energy sources is absolutely the goal of this experiment. I believe that this experiment is only the beginning of using algae in nitrate reduction.

Cesar Varela

SR-ENV-006

How Efficient Are Mealworms at Decomposing Different Types of Plastics?

Since the development of plastics, global production of plastics made from petroleum has increased by substantially. Scientists have been looking for different methods to decompose plastics. Yellow mealworms (*Tenebrio molitor*) can have a constant diet of styrofoam and the chemical hexabromocyclododecane (HBCD), which is found in everyday plastics. The mealworms contain bacteria in their gastrointestinal tract that degrades styrofoam. It is hypothesized that the mealworms will be able to reduce the amount of plastic by 40% over the course of four weeks. For the experiment, five containers containing different plastics (two with styrofoam, two with plastic bags, and one with plastic milk jug pieces) were set up. Fifty mealworms were added to each container. The worms in the container and the remaining plastic were weighed every five days for thirty days. After the first 30-day testing period, it was found that the mealworms who consumed the styrofoam from Container 1 gained an average of 0.01 grams. The mealworms who consumed the styrofoam from Container 2 lost an average of 0.02 grams. The mealworms in Container 3 who consumed from the plastic bag lost 0.01 grams per mealworm. The mealworms who consumed from the plastic bag in Container 4 and the plastic milk jug remained at the same weight. The hypothesis was rejected, as the mealworms only consumed up to 27% of the plastic instead of the hypothesized amount of 40%.

Senior Division Environmental Sciences

Lilly Figueroa

SR-ENV-007

Investigation of pH Levels in Relation to Northern Leopard Frogs

The purpose of this research project is to determine if the pH levels in public reservoirs or private agricultural ponds are in range to provide an ideal habitat (6.1-7.0) for Northern Leopard frogs. The Colorado Division of Wildlife (2016) states that pH levels are the number one habitat variable for Northern Leopard frogs. This research has the potential to increase awareness of herptile ecology in southwestern Colorado while also distinguishing the importance of agricultural areas. Research Question: Do the pH levels of public reservoirs, or private agricultural ponds, prove to be more neutral (6.1-7.0) and thus in range for Northern Leopard frogs? Hypothesis: The hypothesis states that private agricultural ponds will provide a neutral pH environment for Northern Leopard frogs, as opposed to public reservoirs, because of minimized pollutants and other noxious elements produced by roadways and recreational sites. Methods: Begin by testing the pH levels in five public reservoirs and five private agricultural ponds. The Apera Instruments electrode was used as well as a 7.000 pH buffer solution. Results: After completing both tests, it was concluded that the average pH of public reservoirs was 7.8 whereas the pH of private agricultural ponds was 7.0 (in range for the ideal habitat of Northern Leopard frogs). The hypothesis was accepted as the pH level in agricultural ponds was neutral and an ideal pH level. I will continue to test throughout the spring to confirm my results.

Benjamin Wells

SR-ENV-007

LD50 Investigation with Brine Shrimp: Comparing the Effects of COVID Disinfectants with Water Dilution and Brine Shrimp

In the last two years, COVID 19 has drastically increased the use of household disinfectants across the world. Is the increase of chemicals negatively affecting our environment more than we know? I conducted a toxicity test on Brine Shrimp exposing them to various concentrations of bleach, Lysol, and hand sanitizer. I used 48 petri dishes using 10 brine shrimp in each dish, different water dilutions for each type of chemical, using 3 petri dishes for each dilution and 4 control groups. Every five minutes for a total of 25 minutes, I checked the death rate of the brine shrimp and documented my results. The data collected supported my hypothesis: bleach used as disinfectant was more harmful than the other chemicals tested. Using my data, I created several "dose- response" curves. The Lethal Dose for 50% of the brine shrimp was at around 15 minutes for each chemical but at different chemical doses. The overall average death rate with bleach was 9 brine shrimp, 8.3 brine shrimp for Lysol and 7.4 brine shrimp for hand sanitizer. This experiment is significant because it proves that the COVID chemicals we are using are harmful to our environment. Choosing new or limiting chemicals will help save our environment, ecosystems, terrestrial environments, exposer to humans, and potential impacts to human health and safety. Long-term health risks and environmental risks should be furthered studied.

Senior Division Environmental Sciences

Keira LaRose & Maya Lowe

SR-ENV-009T

The Sticky Solution: Water Soluble, Eco-Friendly Fruit Sticker

All fruits and vegetables sold in grocery stores around the world are required to have a fruit sticker on them so that the store can identify the price of the produce. This causes lots of plastic to be wasted and thrown away which pollutes the environment. We attempted to create an eco-friendly, water-soluble fruit sticker that was biodegradable. We made the film by combining corn starch, corn syrup, agar-agar powder, and water and then bringing the mixture to a boil. We then spread out the substance and left it to dry for two days. To stick the film to the fruit, we made an all-natural sugar and water substance to use as an adhesive. When the fruit was washed, the water dissolved the sticker and removed the sugar substance. The sticker washed off somewhat easily and didn't damage or change the fruit in any way.

Amanda Castillo-Lopez

SR-ENV-010

Reducing Grass Irrigation Using Sugarcane Bagasse as Soil Amendment

Using water efficiently is vital to combat water scarcity challenges imposed by global warming. In the US, landscape irrigation accounts for one third of residential water use, therefore it is important to look for sustainable ways to reduce this specific water consumption. Sugarcane bagasse (SCB) is a byproduct of the sugarcane industry that in recent years has been studied as an organic soil amendment that improves the water retention capability of soils, however, it has not yet been researched in regards to grass growth. This project analyzes grass samples that grew in soil mixtures with different percentages of SCB (2%, 4%, 6%, 8%, 10%, 15%, and 20%). Soil humidity was measured daily and pictures of each sample were taken every three days. These pictures were compared to the initial image to evaluate the effects of non-irrigation on the color of the grass using the CIELab color space (L, a*, b* coordinates). By comparing a*:b* ratios from the different samples after two weeks without watering, it was concluded that grass growing in soil with 6%, 8%, and 10% of SCB maintained a relatively high green intensity (a*:b* values were -0.75, -0.78, -0.85, respectively). These results suggest that the optimum percentage of SCB to be used as a soil amendment for grass growth is near 10%, which retained 19.8% more moisture than the control while causing less of a negative effect on grass appearance than the other samples.

Senior Division Environmental Sciences

Amrita Saini

Using Algae to Create Photosynthetic and Bioluminescent Textiles for Sustainable Lighting and CO₂ Removal

Climate change continues to be an issue, driven by high carbon dioxide emissions. Additionally, electric lighting is essential for safety and productivity but is unavailable to large percentages of the population. There are species of marine dinoflagellates that perform photosynthesis and bioluminescence, two processes that can be applied to remove CO₂ emissions and provide sustainable lighting sources. This project's purpose was to test if the organism could be applied to functional textiles. This study tested different textile types' ability to sustain the algae. It was hypothesized that natural fiber textiles would best support the dinoflagellates because these fabrics can absorb water to replicate oceanic conditions. This was tested by applying a species of bioluminescent dinoflagellates, *Pyrocystis fusiformis*, to 6 different sterilized fabrics, as well as a control group with algae growing without fabric. The fabric trials were divided into 4 different groups, with each group being measured over different time periods. Measurements were taken with spectrophotometry and fabric mass after growth. Mass measurements showed that a fabric blend of linen-viscose and the control group repeatedly had the highest mean masses after 5, 10, and 20 days. Comparatively, the rayon-polyester-cotton fabric blend had lower masses for these same periods. The mass dataset was analyzed with ANOVA and Tukey post-hoc testing. The spectrophotometer data displayed variability due to the organism's sensitivity and technical error. Due to this study's limitations, the data is insufficient to support or reject the hypothesis. In the future, this experiment should be repeated using different methods of measurement.

Senior Division Math & Computer Sciences

Adam Rolander

SR-MCS-001

Analyzing the Effects of Non-Generative Augmentation on Automated Classification of Brain Tumors

Due to the devastating effects that brain tumors have on the body, early classification is crucial in reducing cancer mortality, improving quality of life, and developing a treatment plan. Although biopsies are often used for diagnosis, brain tumors can be classified using techniques like MRI, a process that can be automated. In this study, I developed a Convolutional Neural Network (CNN) model to classify four classes of brain tumors – gliomas, meningiomas, pituitary tumors, and no tumors. I then observed how different methods of data augmentation affected my model's capabilities when used individually and in combination with each other. Data augmentation plays a crucial role in classification tasks as it diversifies a dataset and helps prevent overfitting, which can increase a model's accuracy. This study sought to discover which method of augmentation was most effective at doing so. I tested several of the most commonly used methods of augmentation, including horizontal and vertical translations, reflections, rotations, and zooming, in different combinations over six trials. In doing so, I found that the model using no augmentation obtained a classification accuracy of 93.02%. The most successful trial, however, utilized random horizontal and vertical translations, which resulted in a classification accuracy of 95.80%. These results demonstrate the efficacy of augmentation in improving CNN models and show that translations were most successful at improving my model. Further research should seek to optimize the parameters of the augmentation methods I used, as well as continue to test the efficacy of augmentation on different datasets.

Morgan Holien

SR-MCS-002

Attempting to Define Tetration of Non-Integer Heights

Tetration is a fundamental mathematical operation that follows in the sequence of addition, multiplication, and exponentiation. x^n is defined as x to the power of itself, n times. Naturally, the question arises: What happens if n is a non-integer? Many generalizations to non-integers have been produced over the history of tetration, all of which fall short in one way or another. As such, there is no universally accepted definition of non-integer tetration. A viable non-integer extension is crucial to the physical application of tetration, as the real world so rarely involves pure integers.

To address this shortcoming, I am attempting to define an extension for non-integer heights that meets all ideal extension requirements. Using the known functional square root of $\ln(x+1)$, I was able to show that $(e^{1/e})^{(-3/2)} \approx -1.289$. Using basic identities, I then calculated $e^{1/e}$ tetrated to other heights, which are consistent with the values produced by other non-explicit methods. Because this derivation was discovered incredibly recently, I have yet to generalize this method to other bases or heights, though I have many ideas on how to do so. Additionally, I discovered several never-before-published tetrational identities, which may be used to further characterize the behavior of tetration. With the framework laid, it is only a matter of time before I can derive a complete extension for non-integer tetration. This may ultimately allow the operation to be fully integrated into the study of the natural world.

Senior Division Math & Computer Sciences

Gryphon Patlin

SR-MCS-003

Binary Synthesis: Applying Philosophical Principles to Artificial Neural Networks

As machine learning becomes increasingly important across all fields which process data, it is necessary to investigate new models of machine learning. The goal of this project is to create a software framework which effectively incorporates the principles of Binary Synthesis, a modified Hegelian Dialectic, into the calculations of an Artificial Neural Network. As Hegelian logic can aid humans in philosophical pattern recognition, it is possible that it can aid Artificial Neural Networks in pattern recognition. The primary design criteria for the prototype was to meet or surpass Artificial Neural Networks. The variables for measuring this included training time in seconds, model accuracy in percentage of correctly identified images, and model efficiency in training sample size. Notable prototypes include those based on the philosophies of Socrates, Aristotle, and Hegel. The Socratic network developed antitheses networks which, on average, shared 40.2% of original thesis errors. Normal processes generated networks which shared an average of 81.9% of original thesis errors. The Aristotle network, given Socratic inputs, increased accuracy by an average of 0.7%. The Hegelian network was unable to complete tests due to excessively long processing times. While the Aristotle network was capable of slight optimization, it was unable to surpass the efficiency of neural networks in training time or accuracy given the same training sample. The accuracy of Binary Synthesis remains undetermined due to a lack of adequate modeling. Future development should focus on the accuracy of the representation of Socratic dialogues, Hegelian synthesis, and Binary Synthesis paradoxes.

Yicheng Teng

SR-MCS-004

Convolutional Neural Network Based Gesture Recognition Application System

Gesture recognition has been a widely studied area since machine learning has been worked out. Different methods have been experimented to make computers detect and analyze people's gestures. Although this can lead to higher accuracy, there are still many limitations in daily life. Therefore, the purpose of this study is to explore a model that uses a relatively small data set, a simpler network, but still maintains a high recognition accuracy rate. During the process of researching, I chose to use the environment of The AudioPipe framework for the bases of the project. The model locates the hand by using 21 points, (four for each finger, and one for the palm) in a three-dimensional space and has 63 variables in all. With the data collected, I built up a Convolutional Neural Network (CNN) with three layers of convolution followed up by a max pooling function to simplify the data and identify features for the gestures. Finally, the data is put into a Fully Connected Feedforward Network (FCN) to calculate the result. After 100 epochs, the accuracy of the model improved to about 97.11%. With the recognition model, a snake game is designed to show the result. It is important to have gesture models that can be personalized for each individual with less data and easier network for better application in our life. In all, personalized data sets will make devices more receptive to people's commands, make human-computer interactions smarter, and allow recognition systems to adapt well to different people's habits.

Senior Division Math & Computer Sciences

Alexander Marsh

SR-MCS-005

Finding a Better Way to Parameterize the Symmetric Orbit of $\{X^3, XYZ, X(Y^2 - Z^2)\}$

Parametrization is the process of converting standard functions from implicit to parametric. Implicit equations are the normal ones. This is important because parametric equations are more useful for some things, while implicit ones are more useful for others. For example, physics usually handles equations in the parametric form, but it is much easier to find a clear intersection with the implicit form. This is why I will be attempting to solve the implicitization problem with a consistent faster method. The implicitization problem is merely a fancy name for finding how to convert between parametric and implicit. Let k be a field. Let $\varphi: k[x_1, \dots, x_n] \rightarrow k[y_1, \dots, y_m]$; $\varphi(x_i) \rightarrow f_i(y_1, \dots, y_m)$ is a map, where f_1 through f_m are all homogeneous polynomials in $k[y_1, \dots, y_m]$ of the same degree, D , let $V = \text{im } \varphi$, and $I = \text{ker } \varphi$. We can then find polynomials $p(x_1, \dots, x_n)$ such that $p(f_1, \dots, f_m) = 0$. From this, we can construct a candidate ideal, J , generated by these $p(x_1, \dots, x_n)$. We will then show that $J = I$. Finally, we will conjecture and attempt to prove that every ideal generated by the symmetric orbit of $x^3, xyz, x(y^2 - z^2)$ is equal to the ideal generated by the symmetric orbits for 7 variables and higher:

Ruoxi Hu

SR-MCS-006

Quantum Attack on Elliptic Curves

Elliptic curves over finite fields are widely used in modern cryptography. Cryptosystems based on elliptic curves are commonly deemed more secure than RSA for a given key size. However, Shor's famous quantum algorithm has enabled attacks on elliptic curve cryptosystems with comparable number of steps to those on RSA. On the other hand, elliptic curves over Z_n for a composite integer n are being considered recently by researchers on information security. I investigated quantum attacks on cryptosystems based on this new system and studied the effectiveness of Shor's algorithm (or its variation) on such systems.

Ethan Lou

SR-MCS-007

Solving the Three-Body Problem with Physics Neural Networks

The three-body problem is a classical unresolved question in physics that seeks to determine the end position of three celestial objects acting under gravitational force. With numerous applications in many diverse fields such as astrophysics, structural biology, and quantum mechanics, resolving this question has been a chief goal in the scientific community for centuries. However, the three-body problem's chaotic properties render a closed form analytic solution impossible and oftentimes even leave numerical simulation impractical. In this project, I develop a neural network to sidestep these computational and numerical issues to help resolve the three-body problem. The network is built to respect the physical properties of the three-body problem system, an inductive bias which is crucial for speeding up and improving training. As a result, the neural network is able to make very accurate predictions for the three-body problem in a fraction of the time required by traditional numerical solvers. I hope that my solution will help accelerate applications of the three-body problem in the natural sciences.

Senior Division Medicine & Health

Gitanjali Rao

SR-MH-001

A Novel Approach to Early Directional Diagnosis for Prescription Opioid Addiction - Phase II

Prescription opioid addiction is a national health crisis. Today, patients or physicians don't have a way of diagnosing if a painkiller given for relief causes addiction. Current approaches for diagnosis are based on self-assessment or psychological evaluations. Using genomics, the proposed solution uses the measurement of variations in the Mu Opioid Receptor protein produced by the OPRM1 human gene. The research and experimentation included the behavior of the OPRM1 gene in response to exogenous opioids such as prescription drugs (oxycodone and fentanyl). In addition, the increase in protein levels due to agonist were mapped to a user-friendly scale for physicians to take action. The research output also included design, fabrication, and testing of a portable prototype tool to directionally indicate the onset of opioid addiction in patients. My work involved simulating the behavior of human genes addicted to opioids in a lab environment using the human OPRM1 gene on a *Saccharomyces Cerevisiae* host. The methods used included yeast strain preparation with CRISPR/cas9 expressed with OPRM1. The portable solution was enhanced with a machine learning algorithm and calibrated to substitute the colorimetry process of protein detection of a spectrophotometer, with neural network-based image processing algorithms. The results are sent over Bluetooth to a custom-developed mobile app, where they are mapped to a user-friendly scale and displayed for further action by the user. The results were able to support that OPRM1 protein levels can be measured in the presence of an agonist, and are proportional to the levels of opioids in the system. Apart from science, I expanded my work as an intern for the Colorado Department of Law, Attorney General's office, and researched campaign management and target demographics to create a successful opioid response plan for the state of Colorado. My future work includes testing using mammalian models for the research, calibrating the prototype further for accuracy, and working with the Attorney General's office to implement opioid response plans and influence genetic-based research grants from the State. This incremental solution that focuses on diagnosis rather than treatment will save lives.

Daniel Lin

SR-MH-002

Discovering Biomarkers for Breast Cancer Subtypes with Gene Expression Data using Machine Learning

Breast cancer is the most commonly diagnosed cancer in the world and accounts for the fifth most cancer deaths globally. Breast cancers are generally categorized into five main subtypes, namely basal-like, HER2+, luminal A, luminal B, and normal-like, which are differentiated by their gene expression signatures. The identification of breast tumor subtypes with genomic information is critical to determining treatment options for patients. Elastic Net Regression, a regularized regression model that combines the penalties of both lasso and ridge regressions, is very useful for feature selection when there are groups of highly correlated independent variables in the data, like gene expression data. Here I employed elastic net regression on breast cancer microarray data to identify signature genes for the breast cancer subtypes. The selected signature genes were verified using publicly available tools. Functional analysis on selected signature genes revealed that hormone therapy is not suitable for basal-like breast cancer, as suggested by the identified steroid-related terms. The results also suggest that immunotherapy may work best for luminal A and luminal B breast cancers, and RNA-polymerase could be a potential target for HER2+ and basal-like breast cancer treatments. This study identified important and novel breast cancer biomarkers for different subtypes and established a framework for identifying disease-associated genes. These biomarkers shed light on breast cancer diagnostics and treatments and the framework established in this study can also be used on other diseases.

Senior Division Medicine & Health

Aditi Avinash

SR-MH-003

Quantitative Methods to Analyze the Synergism of Digestive Enzymes for Gluten Breakdown

Millions of people in the USA alone suffer from celiac disease or gluten intolerance. In previous work, I identified three fruit-derived enzymes that when combined have an efficient effect in gluten breakdown (Papain, Bromelain, and Actinidin). This year, I pursued quantitative identification of a combinatorial ratio of these three enzymes that are synergistic and efficient in gluten degradation. For experimentation, gluten was extracted from wheat using a commercial kit. Wheat and fish gelatin were treated with purified enzymes (either commercially available or extracted fresh in the lab), and gluten was measured by ELISA absorbance at 450nm, using G12 antibody-coated 96-well plates. The gluten protein breakdown was visualized by Western blotting. The results of the present study indicate that: 1) Treating wheat with the combination of three different enzymes displayed more efficient gluten degradation than single-agents; 2) The effective combinatorial ratio of Papain, Bromelain, and Actinidin was found to be 1:2:3 (Units) respectively; 3) A complete loss in the 33-mer gliadin peptide and other gluten proteins was visualized at this enzyme ratio using immunoblotting; 4) Combining any two of these three enzymes was also efficient in the breakdown of gluten but at an increased concentration suggesting that the combination of the three can be synergistic and 5) Alcohol and preservatives hinder the function of the enzymes. These results suggest the enzyme combinations needed to develop the “Glu-relief” pill. The current/future goal is to take this idea from bench to bedside in the form of a pill.

Fatima Duran

SR-MH-004

Shining Lights: How Curing Lights Polymerize Different Thicknesses of Pigmented Dental Fillings

Composite dental fillings (CDF) are used to repair teeth. Initially, in the form of a paste, CDFs are polymerized using curing lights. Curing lights use different wavelengths that interact with the photoinitiators in the CDFs, which causes them to become solid. The depth of the polymerization varies on the color and quantity of the CDF being used. The research question being investigated was, which factor plays a bigger part in the efficiency of the depth of cure within a composite? It was hypothesized that for the same amount of curing time the lighter shades will cure more efficiently than the darker shades regardless of the initial depth. Experimentation consists of three curing lights. Each curing light was used to polymerize two different depths at 4mm and 6mm. Curing light exposure was recorded in increments of 5, 10, 15, and 20 seconds. After data collection and analysis, the general trend of the statistics inclines to reject the hypothesis. Both initial depth and type of curing light used seem to have an impact on the efficiency of cure on the composite. The statistical significance of the impact was not found. A formal conclusion cannot be given without more statistical evidence.

Senior Division Medicine & Health

Dyhlani Perez

SR-MH-005

The Difference Between How Piloerection Occurs Within the Body Before & After a Spinal Cord Injury

Piloerection, or goosebumps, are activated through the stimulation and coordination of the hair follicle, the Arrector Pili muscle (APM), and the sympathetic nerve. Any external stimuli can raise any activity from the sympathetic nerve that allows drastic changes in the body's physiology. The sympathetic nerve and the APM's work together to stimulate Hair Follicle Stem Cell activity or HFSC. Sympathetic nerves connect to form a structure with HFSC and regulate the HFSC with norepinephrine, a neurotransmitter that sends signals between the nerve cells. Without this signaling for norepinephrine, HFSC represses the cell cycle metabolism and enters deep inactivity. The researcher wanted to determine if there are internal or external changes that occur when piloerection is stimulated before and after a Spinal Cord Injury. It was hypothesized that because a spinal cord injury damages the nerve signals reaching up through the spine to the brain to activate the muscles, there must be some changes within the body considering nerve signal strength response. A questionnaire was given to both able and injured participants based on history. Then, a bioamplifier was attached to electrode pads that stuck onto the participants arm. What this does is non-invasively measure and detect the electrical activity from the test subjects' muscles from the surface of the skin. The researcher tested the difference in pitch from the bioamplifier before and after flexing both stimulated and not stimulated for piloerection and found that there is a difference in how much electrical activity is functioning which aids in the hypothesis.

Sarah Grube

SR-MH-006

The Role that Differentially Expressed Genes Play on the Variable Phenotype of Klinefelter Syndrome

One out of every 600 males struggle with the symptoms of Klinefelter Syndrome (KS), oftentimes without even knowing that they have it. KS occurs due to an extra X chromosome in males (XXY). The symptoms of KS include cognitive, motor, emotional, and social deficits, testosterone deficiency and infertility, metabolic syndrome (obesity), insulin resistance, diabetes, and cardiovascular disease. Other than testosterone therapy, very little has been done to find treatments for these symptoms, so I pursued novel ways to cure some of them. It is known that the extra X chromosome causes these symptoms, but we don't know why. Using the dataset created by my mentor, I identified the most significant autosomal dysregulated gene, called Pro-opiomelanocortin (POMC), and investigated its role on the symptoms of KS. By looking at expression levels of genes that affect POMC expression, correlating them with POMC expression via linear correlation, and conducting a literary search for the physiology of the symptoms of KS and their relationship to POMC, I concluded that there is a weak correlation between POMC expression and obesity in males with KS, confounded by a young cohort and small sample size. Further, I found that polyunsaturated fatty acids (PUFAs) directly increase POMC expression. My current goal is to propose two new studies, one still correlating POMC expression and obesity but with a larger sample size and older cohort (ex. ages 30-50), and one to determine the effects of introducing PUFAs into the diets of males with KS.

Senior Division Medicine & Health

Madisyn Dudek & Samantha Maher

SR-MH-007T

Creating Animal Models to Study Childhood Brain Tumors

Pediatric high-grade gliomas (PHGGs) are the most deadly form of childhood brain tumor and are responsible for approximately half of all deaths caused by pediatric brain tumors. Diffuse midline gliomas (DMGs) are the most prevalent forms of pediatric brain tumors. Pediatric DMGs have specific gene drivers that make these tumors particularly unique. Mutations in Histone 3 (H3K27M) cause widespread dysregulation of gene expression, mutations in Trp53 cause cells to lose the ability to undergo apoptosis, and mutations in PDGFRA cause cells to gain growth advantage in response to growth factors. High-grade gliomas are notoriously difficult to study in humans. We are in need of a novel way to study these tumors through the creation of animal models. Our hypothesis is that expressing these three specific oncogenes during embryonic brain development leads to DMG formation, which provides an animal model more similar to human gliomas. We utilized techniques including DNA Cloning, In Utero Electroporation, Brain Dissections, and Tumor Characterization to create mouse models to study PHGGs. Through the course of the experiment, we were able to successfully develop diffuse brain tumors in mice by expressing three specific oncogenes during embryonic brain development. Our hypothesis was supported because the brain tissue expressed the correct color during microscopic observation. We have established a promising animal model to study these devastating pediatric brain tumors. In the future, we aim for these animal models to be utilized to identify ways to prevent or treat the tumors in mice and then transfer those strategies to humans.

Lluvia Alvarado & Gabriel Enriquez

SR-MH-008T

How Can You Help/Harm Your Sleep?

The purpose of this experiment was to test the effects that melatonin, technology, and nature audio have on an individual's sleep. We hypothesized that melatonin would be the most effective in improving our quality of sleep and energy throughout the day while 30 mins of technology would harm our quality of sleep while decreasing our energy throughout the day. The experiment involved 3 participants using melatonin, technology, and natural audio for 30 min before going to sleep over the course of 3 weeks (Mon-Thurs). A fourth week was also recorded to be used as a control to compare against the other three weeks where we did not take or do anything 30 mins before bed. Over the course of each week, each participant would fill out a scale of their vividness of dreams, quality of sleep, number of waking up during the night, and energy throughout the day. The data we collected supported our initial hypothesis. Melatonin was the most effective in improving the quality of sleep by an average of 76%. Nature audio was the second best with a quality of sleep average of 72%. Technology, as expected, had the lowest quality of sleep with an average of 40%. These results led us to believe that taking melatonin in moderation was more effective than other methods. Technology caused the most harm for the average quality of sleep and energy throughout the day.

Senior Division Medicine & Health

Chezne Woelk

SR-MH-009

White and Bright

Bright and white smiles are desirable in society today. There are different ways to attain this, but the most economical and commercially available is by using toothpaste whiteners. There were multiple toothpastes that are on the market for whitening that were purchased and used over two weeks to determine which one whitened the most. The brands used in this experiment were Sensodyne Extra Whitening, active ingredient hydrated silica; Arm and Hammer Whiten and Strengthen, active ingredient sodium bicarbonate; Crest 3D White, active ingredient silica; Colgate Optic White Advanced, active ingredient hydrogen peroxide; and Burt's Bees Purely White, active ingredient hydrated silica. After performing the experiment, the hypothesis was not proven. It appears that the toothpastes that contain mild abrasives that lift particles and polish the surface produced the most whitening during the process.

Senior Division Microbiology & Molecular Biology

Margaret Arthur

SR-MMB-001

Ab-GAN: A Novel Approach to Create 3D Antibody Paratope Models Using Antigen Epitopes

Monoclonal antibodies have become an increasingly important method of treatment for a variety of diseases including COVID-19 and HIV. This rapidly growing usage warrants a more streamlined antibody development pipeline. I have created a novel in silico method for the generation of the structure and composition of the binding regions of antibodies (paratopes) based directly on the structure of given antigen-binding regions (epitopes). My approach uses a generative adversarial network composed of a convolutional neural network that produces sample paratope structures and a deconvolutional neural network that determines if such structures are true, viable paratopes. I developed an intermediary step of docking the generated structure to a specific epitope to confirm effective binding. I utilized 50 antibody-antigen complexes from the Protein Data Bank which I separated into individual paratope and epitope files. After fifteen hours of training and testing the model, structures were compared to true paratopes using a Euclidean distance score that produced a mean accuracy of 75.31%. These results were further confirmed by converting the structures into amino acid sequences which produced identical accuracies. To date, my research has been performed on a small scale due to limited storage and computing power. With the addition of GPU, TPU, and supercomputing implementations, this exciting in silico method is a promising initial step to a novel approach of monoclonal antibody generation for use in a clinical setting.

Clara Kursinski

SR-MMB-002

Analyzing Ancient Mitochondrial DNA to Infer Human Migration Patterns

In June 2020 a group of geneticists and anthropologists led by Fernandez et al. published research on ancient Caribbean peoples based on the largest ancient DNA data ever studied for that region. Previously, fewer than five ancient genomes existed for the Caribbean, and none were from the island of Hispaniola. My research looked at a subset of that data, specifically the Mitochondrial DNA (mtDNA), which was collected but not analyzed in 2020. Analysis of the data through the use of phylogenetic networks, shows a large diversity of indigenous maternal lineages on the island of Hispaniola, which likely served as a launching point to other islands, including the Bahamas and possibly Puerto Rico. Distinction through isolation and genetic drift among regions followed the original island settlement. Further, comparison between modern and ancient mtDNA in the Dominican Republic (nation that occupies the eastern half of Hispaniola) suggests a nearly complete demographic change since 15th century European colonization, including centuries of Spanish immigration and forced movement of peoples from Africa to Hispaniola through the slave trade and the genocides of Indigenous peoples.

Senior Division Microbiology & Molecular Biology

Emma Seliskar

SR-MMB-003

Bee Yeast

About 40% of the US' honeybee population died during the winter of 2018, making it the highest winter loss in thirteen years. Honeybees pollinate $\frac{1}{3}$ of all flowering plants, which equates to 15 billion dollars in US food crops. As honeybee populations decline, our food sources and economy go with them. Global atmospheric Co₂ levels have increased by 409.3 ppm since the 1960s (Lindsey). Along with another multitude of climate crisis, increased Co₂ levels from global warming have been shown to decrease the protein content in pollen (Ziska LH et al). Bee's main source of protein is pollen, and protein is vital within a hive. The nine essential amino acids which heterotrophs must get from autotrophs are phenylalanine, valine, tryptophan, threonine, isoleucine, methionine, histidine, leucine, and lysine. Through the use of the CRISPR cas-9 editing system I will genetically edit the lysine pathways of yeast to produce increased lysine, an essential amino acid.

Chloe Hinds

SR-MMB-004

Reduce, Reuse, Digest? Optimizing pETase function within k-12 E-coli

One of the biggest problems of modern society is the over pollution of single-use plastics. Thus, the goal of this project is to chemically break down polyethylene terephthalate (PET) plastic using the enzyme pETase. This study will describe the function of pETase in k-12 E-coli relative to the amount of available nutrients outside of PET plastic. AddGene.org isolated the RNA sequence for pETase and inserted it into k-12 E-coli via. a plasmid vector. The culture stab containing the modified k-12 E-coli, provided by AddGene, was inoculated onto ten standard culture plates and incubated for 48 hours. Single colonies were extracted and inoculated into culture tubes containing different nutrient concentrations and PET plastic. The plastic was filtered from k-12 E-coli and any media to measure weight loss. Through microscopic images, pETase function was shown by pitting on the PET plastic and k-12 E-coli cell residue. However, the plastic weight loss was too small to be considered significant. The results of this study can be used to help further understand pETase function in an effort to commercialize "plastic-eating bacteria."

Senior Division Microbiology & Molecular Biology

Armaan Gill

SR-MMB-005

Using the Plasmid pACYC184 to Make a Novel Fluorescent Tracking System

This year my project was about transforming *Staphylococcus epidermidis* with the plasmid pGLO. Its purpose was to see if a novel fluorescent tracking system for *S. epidermidis* could be developed using the pGLO plasmid along with the pACYC184 plasmid. All transformations were conducted on Brain Heart Infusion agar petri dishes containing 10 mcg/ml of Chloramphenicol and 100 mcg/ml of Ampicillin. In this experiment I decided to test what amount of pGLO plasmid would deliver the highest amount of successful fluorescent transformations. I believed that 0.25 micrograms of plasmid would produce the highest amount of successful transformations. Cells of *S. epidermidis* were first diluted to a proper optical density after being incubated overnight in Tryptic Soy Agar broth. The cells were then placed on ice and centrifuged for 10 minutes at 4,000 x g. The cells then sit at room temperature for five minutes until centrifuged again at 5,000 x g for a minute and then resuspended in 50 microliters of 10 percent glycerol solution. Then the solution is supplemented with 500 mM of Sucrose and then 0.3 mL of pGLO plasmid is added. The cells are then pulsed at 2.1 volts in a one mm cuvette and then immediately resuspended in one mL of Tryptic Soy Agar Broth and 500 mM Sucrose. The tubes are then poured into petri dishes and incubated. Several experimental trials have been conducted, but conclusive results have not yet been identified, further research is needed.

Colleen Farrell & Blake Barron

SR-MMB-006T

The Effects of the Estradiol Hormone on Osteoblast Activity

Beta-estradiol is a form of estrogen hormone. Postmenopausal women who lack estrogen are at higher risk of osteoporosis, where bones weaken, become brittle and are susceptible to fractures. The FDA recommends using estrogen in as low a dose as possible as a treatment for osteoporosis. Osteoblasts are the cells responsible for forming new bone. The goal of this study is to evaluate the effects of estradiol on the gene expression and phenotype of osteoblast cells, and to determine how the different levels of estradiol affect osteoblasts. We will be treating cells with a 1nM, 10nM, and a 0nM control concentration of estradiol to determine how the concentration of estradiol affects the activity of the ALP enzyme and formation of calcium deposits. ALP is an enzyme used in bone formation so tracking it can help us determine when cells begin to signal for the formation of bone. By staining calcium deposits, we can determine where and in what quantity products of bone mineralization are being formed. When treating patients with postmenopausal osteoporosis it's important to know exactly how these hormones will affect their osteoblasts. Understanding the way our bodies signal for the creation of more or less new bone is important to understanding osteoporosis and bone health as a whole.

Senior Division Microbiology & Molecular Biology

Carolyn Jewett & Alicia Chapman

SR-MMB-007T

Exosomes as a Signal Amplification Mechanism for Energy Production in the Heart

Exosomes are lipid vesicles 50-150nm in diameter containing proteins, lipids and RNA. Some exosomes act on the cell that generates them (Autocrine); others affect neighboring cells (Paracrine). Exosomes have mitochondrial DNA and RNA, so could influence mitochondrial energy production although this has never been shown in heart. For our project, we characterized exosomes from Nonfailing (n=4) or Failing (n=3) human hearts from the outside (Paracrine) or inside (Autocrine) of a cardiomyocyte. We first used Nanosight technology to verify that we had exosomes and found that they were the correct size. We then used proteomics and phospholipid mass spectrometry to determine if they contained mitochondrial proteins and phospholipids. We found exosomes contain proteins from all five complexes of the electron transport chain plus vital mitochondrial proteins and that exosomes have cardiolipin, a mitochondrial phospholipid. Next we analyzed data generated from a Seahorse analyzer measuring mitochondrial function from neonatal rat cardiomyocytes to which these exosomes had been added. We found that Paracrine exosomes caused a significant increase in ATP production and maximal mitochondrial respiration when added to these rat cells for 48h. In conclusion: (1) Exosomes were successfully isolated from human heart cells; (2) Exosomes contain mitochondrial proteins and phospholipids; (3) Paracrine exosomes from Failing hearts increased maximal mitochondrial respiration in treated cardiomyocytes, and Paracrine exosomes from both Nonfailing and Failing hearts increased ATP production. We therefore disprove our null hypothesis to conclude cardiac exosomes are a potential mechanism for increasing mitochondrial respiration in neighboring cells, especially in Failing hearts.

Senior Division Physics

Bailey Link & Giulia Roccasalva

SR-PH-001T

Comparing the Leidenfrost Effect on Distilled Water and Ethanol

The Leidenfrost phenomenon is the term given to the phenomena observed when small quantities of a liquid are placed on an extremely hot surface. The purpose of this project is to investigate the Leidenfrost effect between ethanol and water at the same time; the Leidenfrost effect on different ratios of water and ethanol; the temperature and the amount of time the water and ethanol droplets take to combine. Droplets of water and ethanol were pipetted onto a hot plate. Multiple trials were completed, a different ratio with each one. Each different set of droplets was tested with different temperatures. Data was obtained and graphed from each trial. Data collected from this research indicates that water and ethanol under the Leidenfrost effect take the longest to combine when the ratio of water is greater than ethanol. Temperatures ranging from 330°C - 350°C, resulted in the longest amount of time that the droplets took to combine. The Leidenfrost effect is most successful on distilled water and ethanol when the ratio of water is greater than ethanol due to ethanol's lack of strong hydrogen-bonding.

Evan Roberts & Bridger Lynch

SR-PH-002T

The Affect of Dimple Pattern on a Golf Ball's Distance

When a golf ball is flying through the air, small indented circles called dimples help assist the golf ball travel in distance and height by gripping the surrounding air and carrying the air under the ball creating backspin. This backspin allows the golf ball to climb in height which also allows the ball to go a greater distance away from the initial launch point. Using a pressurized air cannon the experimenters are able to simulate how a golf ball would travel without human error. The experimenters think that the #1 golf ball dimple pattern will produce a trajectory that will fly 10% further than competing golf balls. The air cannon is propped up atop an air compressor which is about 45 degrees. Once propped the cannon will have a rag tucked towards the back to allow for the golf ball to travel maximum distance. Once the ball and rag is loaded the cannon will be pressurized to 80 psi. Golf ball number one (which is the most popular) launched 616 feet. The second ball which is rated 2nd launched 482 feet and 8 inches. The 3rd ranked golf ball launched 553 feet and 6 inches. The last golf ball was 3-D printed with equal sized dimple patterns with the dimples equally spaced throughout the golf ball, this ball launched 446 feet exactly. Our hypothesis was not correct because the number one ranked ball did fly the furthest but did not fly 10% further than the competing golf balls.

Senior Division Physics

Skylar Abernathey & Bernard Coleman & Noah Rand

SR-PH-003T

Electromagnetically Driven Surgical Catheters and the Physics That Guides Them

Many heart surgeries are performed by injecting a catheter into the bloodstream and then maneuvering the catheter via a control operated by a human. Autonomously controlled catheters have already been studied, though not tested in actual practice. These electromagnetic catheters could significantly improve efficiency and consistency in the medical world, but they are not yet consistent enough to be put into practice. To understand how these catheters work, and how to improve their effectiveness, we have been studying the complex physics and mathematics that would help guide these catheters through the body. We have also created a simplified model to help show the application of these mathematics and physics in a real-world setting. Given pretenses of constants within the specific electromagnetic solenoid we use, we can find approximate current outputs of the magnetic moment. This allows us to then use calculus and linear algebra to position the catheter. In the testing phase, we discovered that while our mathematical calculations were correct, the electromagnetic equilibrium between the seed and electromagnet is dynamic. Meaning that we need to know the exact position and movement of the seed magnet to adjust the solenoid's output in real time. These results display evidence of a deep understanding and success of the pre-discussed mathematics. We were successfully able to show that the calculus and linear algebra we described in theory are applicable to larger scale projects. This can be applied to future projects in the larger medical field.

Kenedi Brunner

SR-PH-004

Air vs. Earth

Breakage of beachwood wooden dowels, and graphite pencil lead, results in a force in newtons at which the model experienced breakage. The purpose of this research is to determine the relationship between the force needed to cause breakage in trees, and the diameter of the model trees. The force determined will be converted to wind speed to compare the experimental value to the theoretical value, and the characteristics will be analyzed. Wooden dowels and pencil lead of various sizes were broken using a force sensor and LabQuest, to determine the force at the breaking point. The data was obtained and graphed. A line of best fit was graphed, providing an equation to the relationship between force and diameter. Data collected from this graph indicated an increasing force on a curve as the diameter increased. The equation of this line of best fit using power was produced, allowing for varying diameters to be used to determine necessary force for breakage. This given equation will result in nearly 42 meters per second, or 90 miles per hour, even when given unique diameters. This equation references surface area, force, and air mass to determine wind speed.

Senior Division Physics

Nallely Saucedo

SR-PH-005

Blasting Through Gelatin

Light travels and is refracted through different mediums on a day to day basis. The accurate measurement of speed of light is of great importance in understanding various concepts in Physics in particular and science in general. The purpose of this research is to observe the relationship between the index of refraction and the speed of light, using Snell's Law as well as discover how differences in a medium will affect the speed of light. Squared gelatin samples were created with different amounts of sugar in each sample. The resulting batches of gelatin were then cut into small squares and placed on a protractor. Measurements of length, width, incidence angles, and refraction angles were determined. Data was obtained and graphed. Data collected from this research indicates that the more sugar within the gelatin sample, the smaller the refraction angle will result. Increasing the sugar content in the gelatin will result in a larger index of refraction and a slower speed of light. The results show that to slow down the speed of light, the angle of refraction must be made smaller. Hence, the index of refraction must be made larger. The same is true for vice versa.

Valerie Woller

SR-PH-006

How Much Radiation?

The researcher had an RF meter (by ERICKHILL) being held over a cell phone, while the researcher typed and sent a short text message consisting of four words to a willing participant. The researcher then measured the amount of radiation that has emerged from the cell phone. Then the researcher typed and sent a medium length text message consisting of six words to the same participant, and the researcher measured how much radiation had emerged. Finally, the researcher sent a long text message consisting of 14 words again to the same participant. Then logged that data into their book. The researcher then had a short phone call consisting of three minutes. Then the researcher measured how much radiation emerged from the cell phone. Next the researcher had a medium length phone call consisting of seven minutes, then the researcher logged that data in a lab book. The researcher then had a long phone call consisting of 12 minutes. Again, logging the data in a lab book. The researcher repeated all of these steps three times for accuracy.

Senior Division Physics

Mark Reamon

SR-PH-007

Investigating the Electro-Optic Properties of Monolayer Graphene

Graphene is a fullerene that presents many opportunities to investigate 2-dimensional electron systems. Due to its high charge carrier mobility, for investigation of systems involving Quantum Electrodynamics, which describes quantum mechanical electron interactions when traveling at relativistic speeds. As such, testing electrical properties of graphene provides a means to test the predictions of the foremost theory in unifying Quantum Mechanics and special relativity. This study sought to investigate field effect modulation of Fermi Energies in monolayer graphene films, using the material's unique electro-optic properties to model the band structure of the graphene from optical measurement. Using a field effect modulator, a laser beam with a defined photon energy was focused on a sample of graphene, and the intensity of the reflected beam was measured by a photodiode. Absorption was determined using a percentage of incident light reflected to the photodiode. Data were taken at variable gate voltages corresponding to respective Fermi Energies, and absorption data were taken across the surface of a graphene film. These absorption data were then compared to absorption expected at respective gate voltages to estimate the Fermi Energy modulation in the graphene. This Fermi Energy modulation compared to gate voltage was then also compared to existing models using Chi Square analysis to test the underlying theory as a model for real graphene modulators. Results from this investigation produce evidence to examine the effects of QED and Condensed Matter Theory in graphene which has larger applications with regards to graphene's use in electronics and other applications.

Senior Division Plant Sciences

Brooklynn Henschel

SR-PS-001

Here We Grow!

The purpose of this experiment was to test if sugar water, salt water, or regular well water is best for plants. I hypothesized that since plants make sugar to grow, then the sugar added into the water would produce the best growth in comparison to the other two water samples. The experiment involved three Wandering Jew plants, three Coffee plants and three Ivy plants. One of each plant was labeled #1, which was watered with sugar water, followed by #2, watered with control/well water, and finally #3, watered with salt water. The plants were watered for four consecutive weeks. A syringe was used to give the plants water starting with one teaspoon once a day in the first week, then one teaspoon twice a day from then on. The plants were measured every week based on the number of leaves and stem length. The data collected from this test show that, on average, regular well water, or the control plant, grew the best for two of the three plants tested: Wandering Jew and Ivy. The Coffee plant supports my hypothesis by favoring sugar water. This experiment led to the conclusion that the best way for plants to grow is through nature. Plain well water is best. Additives do not necessarily help plants grow in the ways people would think. In the end, nature must run its course.

Carlos Ochoa-Marquez

SR-PS-002

Mycro Madness: A Study of the Effect Mycorrhiza has on Solanum tuberosum, Cucurbita pepo, and Medicago sativa When Exposed to Different Environmental Factors

In 1885 a scientist named Albert Bernhard Frank discovered a fungus that would enhance plants and the amount of offspring they would produce, he coined this fungus mycorrhizae. In this experiment, I grew three different types of plants, russet potatoes, zucchini, and alfalfa, and exposed them to different amounts of mycorrhizae through their growth cycle. I then exposed the plants to different environmental factors that have been occurring more recently due to climate change, these factors being drought, overwater, and cold. After analyzing my plant height data, I found that mycorrhizae had the most positive effect on the alfalfa plants and the most negative effect on the potato plants. There were significant differences between the control alfalfa plants and the alfalfa treated with double the amount of mycorrhizae in the first two weeks of growth, but after the seventh week, there was no significant difference. There were also significant differences in my drought treatments, both in my alfalfa and squash plants. After analyzing my plant biomass data I found that mycorrhizae had a significant effect on the amount of plant material of alfalfa plants, increasing as the amount of mycorrhizae increased. After analyzing my chloroplast counts I found the mycorrhizae affect almost all plants to a significant level before and after treatment. In conclusion, mycorrhizae has an overall positive effect on plants when looking for a better plant yield, but causes less plant growth and plant material.

Senior Division Plant Sciences

Denton Peil

SR-PS-003

Mycorrhizal Fungi (Rhizophagus intraradices) and Its Effect on the Height and Biomass of Marigolds (Tagetes erecta)

Mycorrhiza is a symbiotic relationship between a plant and a fungus. Fungi that exhibit a mycorrhizal relationship can benefit the plant with increased growth, drought resistance, and nutrient uptake. It was hypothesized that plants inoculated with mycorrhizae would exhibit a 50% increase in plant height and in both vegetative and root biomass as compared to the control group. To test the effect of *Rhizophagus intraradices*, a mycorrhizal fungi, on the plant *Tagetes erecta*, (Crackerjack Marigold), three grams of *R. intraradices* were introduced to the roots of twenty plants after an initial growth period of three weeks. Twenty additional plants remained uninoculated and served as the control group. The experimental and control groups were separated to avoid fungi spread and each group was grown under a grow lamp. Plant height was measured weekly. After 91 days of growth, the average height of the control group was 4.9 centimeters and the group with mycorrhizae had an average height of 7.4 centimeters, resulting in an increase of 51.02%. The average vegetative and root biomass of the control group were both 0.02 grams resulting in a combined biomass of 0.04 grams, while the group with mycorrhizae had an average of 0.04 grams for both the vegetative and root biomass with leaving a combined biomass of 0.08 grams, resulting in a 100% increase in biomass with mycorrhizae. With this data, the hypothesis that there would be a 50% increase in height and biomass can be accepted.