Senior Division Animal Sciences

Gracean Hoesli   2-01-001
Tails a Wagging

The purpose of this experiment is to test dogs and find out what temperament by seeing if they are left and right brained. The experiment can help with further adoption with shelters. It can also help dog owners discover the temperament of their dog. The experiment is a harm free way to help dogs and people all around the world. When dogs come into the shelter the people can determine the temperament so they can give a good dog to a good family. Dogs around the world don't get good homes because they are falsely deemed. This experiment can help the dog enjoy the home they get and keep dogs out of the shelters.

Andie Caton   2-01-002
The Effects of Different Strengths of Magnets on Planarian

The purpose of this project is to discover which different strength of magnet will help increase the regeneration process in planarian. The chance of a planarian to regenerate incorrectly is slim. The planarian may grow a tail when they are in need of a head. If this occurs, the planarian may not be able to survive. Throughout this experiment, different strengths of magnets will be surrounding decapitated planarian to see which strength will regenerate more efficiently and with better results. Five planarian were placed in each of the six petri dishes. Groups 1-4 were decapitated and groups 2, 3, 4, and 6 were surrounded by magnets. Overall, group 2 had the best results and a total of zero deaths throughout the two weeks of testing. This is important because it can lead to further regeneration practices on larger organisms.

Kylie Kay Franklin   2-01-003
Walk It Out

Equine massage therapy is a technique used to release tension and promote muscle growth. This process is done by a certified equine massage therapist, thoroughly massaging superficial muscles. Being a certified equine massage therapist, with a future in veterinary medicine, I wanted to find out if this was a real benefit. My main question was, "Does massage therapy work for lengthening a horse' stride?" A horse' stride is the distance from the back hoof to the front hoof at a walk, and can lead towards better athletic ability. I assume that the horses' stride will lengthen by one hoof length after 15 minutes rest, post massage. I began my project by choosing five horses that hadn't been ridden in a month. I haltered a horse, measured height, hoof length, sex, age, breed, and amount of previous massages. After collecting data, I took one full walking stride with the horse and measured the stride. I then measured the length of one lunging stride. Following the initial stride measurements, I massaged the horse. Fifteen minutes post massage I repeated the walk in hand and lunging. After the first massage set; all horses had increased their stride length between 4 -12 cm. All of the horses received their second massage one week later. At the end of the experiment the average stride had increased by 60cm. The goal of future experiments would be to extend research on multiple breeds of different size and muscular structure, to determine how massage lengthens stride.

Olivia Fross 2-01-004
Analysis of Demographic Variation Reflected by Colony Size in Cliff Swallows

A critical question in animal biology is why animals aggregate. Aggregation may for example provide safety from predators and higher foraging efficiency. The cliff swallow is an aggregating animal species and is one of the most intra-social and colonial bird species in North America, making them prime research subjects for aggregation studies. Here I investigated if colony size is a deciding factor for individual birds choosing where to nest. Data from cliff swallow colonies in Boulder, Colorado were compared to the results of a Nebraska study on variation of age composition among colony sizes in cliff swallows. The Nebraska study found that there was a higher distribution of young birds in larger colonies and old birds in smaller colonies. Initial results revealed an age-class proportion to colony size trend similar to that of the parent study. A Hypothesis Test using Python programming language revealed no difference in probability for older birds choosing a colony based on its size. I used the p-value (~0.04) calculated from my data during the Hypothesis Test to determine statistical significance (<0.05) and reject the null hypothesis. This result supports my hypothesis that colony size reflects the aged-based sorting of cliff swallows among colonies in Boulder, Colorado. The analogous conclusions of these two otherwise differing studies speaks to the relationship between the demographic variation and size of cliff swallow colonies.

Devyn Wood 2-01-005
Exploring Nutritional Variance in Rabbit Diets

The domestic rabbit livestock industry has begun to increase in size, and this results in the increase of commercialized pelleted feeds appearing to be the sole food source for rabbits. This results in rabbit health problems, including but not limited to unexplained death, intestinal blockages, and obesity. Despite the numerous implications regarding what is included in marketed pelleted feeds, there is little to no research regarding the appropriate diet for a market/breeding rabbit. In this study, three rabbit diets will be tested in reference to the animal with the greatest overall show performance and meat-producing quality. There will be three test groups, each group consisting of 2 silver fox does and 1 silver fox buck. The first group will be fed an organic, natural diet (leafy greens, herbs, etc.) The second group will be fed 1/2 natural feed and 1/2 pelleted feed. The third group will be fed the pelleted diet. The results of this study revealed the groups with the largest growth rate are the pellet feed group. The highest quality rabbits were produced from the 1/2 natural 1/2 pellet diet. The sample size is small for this study, and the genetics of each rabbit likely had an impact on the results. For more accurate results, this experiment must be done with a larger test pool to eliminate genetic differences as a factor.

Emma Perkins   2-01-006
Identifying Causes of Ectoparasite Presence on the American Pika (Ochotona princeps)

The purpose of this project is to identify probable causes of ectoparasite presence in American pikas (Ochotona princeps) and evaluate their connection to properties of the ecosystem. The working hypothesis is that increased presence of ectoparasites in American pika populations is observed at lower altitudes and may be attributed to increased interspecies contact. Data for flea and ear mite abundance on pikas for years 2008 to 2017 (except 2009) was compiled along with possible contributing factors. Data was then analyzed in both R Studio and Microsoft Excel and explored graphically. Predictor variables were analyzed in three categories: Physiological, environmental, and observational factors. A Poisson regression was used to construct models of environmental and physiological factors, in both cases accounting for effects of the observational factor of handling time. Location relative to treeline and month of year with Poisson regression coefficients of +0.62 and -0.61 respectively were the best environmental predictors of fleas, all other environmental factors had a coefficient of less than ±0.40. Male reproductivity with a coefficient of +0.44 was the best physiological predictor of fleas. Month of year with a coefficient of +0.51 and male reproductivity with a coefficient of -0.90 were the best predictors for ear mites. The coefficient on handling time was never greater than ±0.21. These findings lead me to believe that interspecies contact below treeline may be contributing to flea abundance on pikas, while ear mite presence on male pikas may be reducing their reproductivity.

Alyssa Rawinski   2-01-007
Mealworms . . . A Potential Solution to the Global Plastic Problem

Approximately 267 aquatic species are negatively affected by plastic garbage in the ocean (Barry, 2009). The prevention of this problem starts on land with effective recycling methods. The purpose of this project was to determine if mealworms (Tenebrio molitor) could be an effective method to recycle plastics. My study analyzed polystyrene and two plastics that haven't been tested (polypropylene and low-density polyethylene). I also tested two sizes of polystyrene: 30 milligram (mg) and 100mg pieces; and a ratio mixture of 75% plastic and 25% potato. I had two control groups fed potato in 30mg and 100mg pieces (all referred to as "variable groups"). I took measurements for 29 days on plastic weight, and weight and number of worms. The worms consumed all three kinds of plastic with a preference for polystyrene. Eating plastic did not cause more worms to die, when compared to the controls. However, eating strictly plastic slowed the worms' metamorphic rate. My 75% plastic mixture indicated a normal metamorphic rate, while still eating plastic. Surprisingly, every variable group lost weight. Also, mealworms were excreting more than they were consuming. I measured CO_2 output for the worms and couldn't conclude whether the worms were metabolizing the plastic although, a Stanford study concluded that mealworms can metabolize polystyrene (Yang, 2015). The overall goal of my project was to learn more about the mealworms' ability to help with recycling and according to my research, there is a good possibility that mealworms might be a solution to cleaning up the planet.

Pack on the Protein

Pack on the protein is an experiment that was used to determine if protein content of feed and weather conditions affect the protein content of the body. The hypothesis was the colder the weather conditions and the higher the protein intake will result in a higher protein content of the body. A protein sample of the hepatopancreas gland and tail tissue was taken for data analysis. The hepatopancreas gland served as a short term protein content reading and the tail tissue served as a long termprotein content reading. Protein samples were collected on a regular basis. The cold-water condition in both 21% and 27% had a lower protein content than the baseline in the digestive gland and the tail. The normal-water, 21% and 27% had the tail and digestive gland protein content higher than the baseline. The warm-water also had day five be higher than the baseline in the 21% and 27% along with the digestive gland and the tail protein content.

Will They Survive?

Within the livestock industry, today there is an increase in the use of probiotics, both to treat illness by reestablishing bacterial cultures in the digestive tract, and as a method of maintaining digestive health and boosting the immune system. The concern addressed in this experiment is that the bacteria in the powdered probiotic products are dehydrated and essentially "freeze dried" in a process called lyophilization. The purpose of this experiment is to determine if the bacterial cultures found in powdered livestock probiotic products actually survive to produce live colonies. Lyophilized cultures need to be stored under refrigeration to keep the cultures viable. Considering that most powered livestock probiotics are not refrigerated, the number of cultures that will actually form viable colonies will be substantially lower than that on the label. The data for this experiment was collected by culturing four different probiotic powders to determine the amount of viable bacterial cultures. Using the probiotic labels as the basis for calculations, the amount of each powder that would contain 10 million CFU (Colony Forming Units) was inoculated into growth media, and then serial dilutions done to obtain measureable amounts of cultures. Bacterial growth was measured using OD 600 and plate counts. Two different tests were performed. The Immediate Test measured the bacterial growth resulting from serial dilutions directly after inoculations. The 24 Hr Test incubated the inoculated bacteria for 24 hours before the serial dilutions. The data collected showed that for all four brands tested there was less bacteria in the Immediate test than in the 24 hour tests. Likewise, the 24 hour T/Y test produced more bacteria than the 24 hour N test. The data collected from this experiment only partially supports the hypothesis. The data collection method did not allow for an accurate colony count, but did allow for a comparison between brands of probiotics. All four brands did produce some bacteria, with brand 2 being the best overall performing brand. The data does indicate that there was a significant increase in bacterial growth when the probiotic powders were allowed to hydrate and incubate for 24 hours prior to serial dilution. More testing needs to be completed to get conclusive results.

Matthew Buckman & Dylan Drew   2-01-301
The Effects of Substrate Architecture on L. vannamei

The purpose of this project is to create a substrate that will provide refuge for Litopenaeus Vannamei shrimp, and also remove pollutants from the surrounding water. This is a continuation of a project from last year, which examined the ability of substrates to remove ammonia from water. This year we focused on the how the shrimp interacted with substrates. We hypothesized that the shrimp would be interested in using the substrate. To test our hypothesis we designed 3 separate substrates. The substrates consisted of a 1x1, a 2x2 and a 3x3. These substrates were placed in an observation tank containing 29 shrimp. The shrimp in the tank were all classified by their mass and age. The shrimp were observed 7 times each 5 minutes. A Manly-Chesson selectivity index was used to analyze the data. The alphas taken from the selectivity index showed the shrimp preferred the substrate with 4 compartments each 2.7cm by 2.7cm. The alphas for all sizes is 1.393, for small is 4.079, for medium is 0.714 and the large is 0. This data showed the small shrimp preferred the 2x2. We used this year's and last year's information to develop a new modular prototype. The prototype consists of two hexagons layered over each other. The hexagons are connected by 6 bridges, each with two locking mechanisms. The diameter of the internal hexagon is 3cm. we plan to test this prototype in the future.

Senior Division Behavioral & Social Sciences

Paige Carlson   2-02-001

Does Music Affect the Speed of Tasks

The purpose of my project was to see if participants were able to complete tasks faster and more accurately with music than without music. I did this because people always want a quicker way to get things done and I thought perhaps music would be that way. I hypothesized that music without lyrics would help more than music with lyrics or no music at all. In order to test this I gathered 45 participants and split them into 6 groups. These groups were lyrical music with a puzzle, non-lyrical music with a puzzle, no music with a puzzle, lyrical music with a math test, non-lyrical music with a math test, and no music with a math test. I gave them two minutes to complete the puzzle and one for the math test. Then I analyzed these results and graphed them. I discovered that music did help and the data did support my hypothesis. This can help people have an easier and more fun way to get things accomplished.

Iliana Castillo   2-02-002

Remember Me?

The process of this investigation was to test if people memorize pictures better than words. I hypothesized that if I showed 10 test subjects 12 pictures and 12 words of my choice, then they will memorize the 12 pictures better. This experiment involved creating two tests with 5 questions in each test. I had to test 10 people from ages 14-16. They were told to look at 12 pictures in 3 second and try to memorize each image. They were also told to look at 12 words in 2 seconds and try to memorize as much as words as they could. The data collected did conclusively support the hypothesis. 9 of the tests subjects memorized the pictures better than the words. Only one test subject memorized the words better than the pictures. These findings helped me to conclude that people memorize pictures better than words. More testing is necessary in order to confirm results.

Aylin Kahraman   2-02-003

The Impact of Education on Student Athletes Regarding Concussions

Concussions can result in serious damage to the brain, yet some student athletes do not seek proper treatment for concussions or concussion symptoms. This begs the question: what effect does education have on student athlete's opinions, attitudes, and behaviors regarding concussions? This study of 104 student athletes set out to answer this question through surveying. The students surveyed were a mixture of mixture of boys and girls between or at the ages of 13 to 18. The students were split into two groups. One group (the experimental group) read a short informational passage about concussions before taking the survey, and the other group (the control group) did not read the passage. Both groups took the same 12 question survey asking them to rate, on a scale of 1-5, how strongly they agreed or disagreed with various statements or scenarios regarding concussions. Overall, the averages for both the experimental group and the control group were relatively similar. On average, 58% of the control group chose safer options, 22% of the group chose riskier options, and 20% chose neither safe nor risky options. As for the experimental group, 50% of the group chose safer options, 26% of the group chose riskier options, and 24% of the group chose neither safe nor risky options. Thus, education, in the form of a written, information passage, does not have an impact on student athletes opinions, attitudes, and behaviors regarding concussions.

Andres Villa 2-02-004

Virtual Illness: Can Virtual Reality Cause Motion Sickness?

The purpose of this experiment is to test the relationship between Virtual Reality and Motion Sickness in different groups of people. This experiment is conducted through the use of a roller coaster simulation played by a Virtual Reality Headset worn by the subject over a maximum period of 90 seconds. Subsequent to the 90 seconds the subject will fill out a short survey asking about their experience with the test in regard to possible symptoms of Motion Sickness shown during or after the test itself. The subject will follow the same procedure for the control trails but instead of using the roller coaster simulation they will use a simulation of a meadow, in which the subject does not appear to be moving but can still move their head too look around in the 360-degree simulation. I found that the variables I tested had very scattered data ranges in both the correlation and T-Tests. Out of the thirteen graphs I printed, a few of them did have a statistical significance between the data sets being compared and helped support my hypothesis. However, many of the graphs I made did not have a statistical significance between the data sets being compared. Thus, refuting my hypothesis. I concluded that certain groups, such as age, determined a positive correlation in age and motion sickness average. In which many other tests proved to bear the same results.

Dylan Cantrall 2-02-005

The Role of Economic Variable in Election Outcomes: A Global Analysis

This study examined the role of economic variables in election outcomes. Previous work found that factors including social media, polling data, and party identification influence election results. It was believed that if the condition of a country's economy was in decile, then the party in power would switch. In order to test this, data from the Organization of Economic Co-operation and Development (OECD) on five economic variables: GDP, CPI, Industrial Production, Exchange Rates, and Unemployment from the United States, United Kingdom, Germany, Australia, Mexico, and France were collected. The data was analyzed using a single factor Anova to determine if a significant correlation between economic condition and election results existed. A human survey (N=27) was conducted using Google Forms. The survey found that when exclusively presenting economic variables as determinant factors for political choice, voters had a general understanding of the economic factors. The data analysis found, that in the United Kingdom, between 1968 and 1970 the economy fell 2.99 points on a 4 point scale developed by the researcher. This demonstrated an economic recession in the United Kingdom. In 1970 the party in power switched. The only country to show that economic conditions affect election results was Great Britain, (p=0.04). Future work should attempt to determine the reason for the United Kingdom being the only nation studied to have a significant correlation between party in power switches and the nation's economic condition.

Theo Bayard de Volo & Luke Barnocky 2-02-301

Examining Whether Agency and Anthropomorphism Interact in an environmental Risk Setting

Climate change is a huge problem facing society today and psychology is believed to be able to play a critical role in reducing it. Through the better understanding and use of psychological phenomenons it is possible to curve human behavior and increase climate positive action. Past research has shown that anthropomorphism is one such thing that can be used to these means. In this research we investigate whether anthropomorphism, and more specifically intentionality, has an effect on the effect of agency on climate donations. To do this we used data gathered by Jennifer Catherine Cole from over 400 paid online survey takers. Statistical analysis revealed a statistically significant correlation between intentionality and the effect of agency on climate donations.

Laila Buchler & Rachel Fasbender   2-02-302
Altered Halter

The purpose of our project is to create a more useful, multipurpose, and comfortable dog harness for people with visual impairments. We have done lots of research and have constructed a harness that we believe will be more practical for blind people to use, and will increase their mobility and interaction with their environment. Our project includes many prototypes, such as an accelerometer (measures gravitational force in x, y, and z axis) prototype which is mounted on a harness. This circuit includes a piezo buzzer to warn the visually impaired person when there are steps in front of them. Our other prototypes which include LEDs and a servo motor are to demonstrate how we are using light sensors to turn LEDs on so that in the dark the blind person becomes more visible to cars and other passerbys. The servo motor circuit is a prototype of how we will be using pressure to signal the dog when it needs to turn left or right or when the dog needs to stop or go forward. We built the servo motor prototype to show how the harness which in theory would be able to connect to a smartphone could lead the dog by directing it to a certain desired place of the user. Lastly, we have created a model dog which has been assembled of cardboard to display and present our harness.

Hanna Salman & Sravya Dhanwada   2-02-303
Smelly First Impressions: Analyzing How the Application of a Scent Affects Perceptions of a Subject

The purpose of this study was to identify associations between scent and perceptions concerning personality and success of a subject. It was hypothesized that the scents applied would lead to more positive perceptions. Participants aged 14-17 years old took a questionnaire with questions pertaining to an image of an individual without a scent associated, for the control, or with a scent associated, for the experimental trials. The scents used were peppermint, rosemary, lavender, and citrus. Chi-squared tests were used to analyze results and determine statistical significance. The effects of the association of scent varied according to gender. For the male individual, the association of a scent led to an overall decrease in estimated age by on average, 11.53 years. The $x2$ test determined significance with a value of 13.21>7.81. For the female individual, the association of a scent lead to an overall increase in estimated age by on average, 9.70 years and was determined statistically significant according to the $x2$ test with a value of 17.16>7.81. Intelligence was not determined to be statistically significant by $x2$ test (0.14<7.81) and perceived favorite color varied significantly within the female subject as a result of scent association. This study has expanded our knowledge of how the brain perceives olfactory environmental stimuli and how it affects perceptions of another individual, emphasizing the influence of gender. The conclusions can be applied practically in any environment for more successful interactions.

Riley Douglas & Amelia O'Toole   2-02-304

How Do Various Types of Music Affect Sleeping Patterns in Teenagers?

The purpose of our experiment is to better understand how the music that teenagers listen to affects their sleeping patterns. We can then use this data to help others sleep better and feel more refreshed. The first two steps taken were for the participants to record their normal sleep time without any music before they went to bed. Then on the next two days the test subjects will each listen to four different pop songs before they go to bed they will then record the time they went to bed in an online document provided, they will also be asked to write any difficulties that they had falling asleep or if they woke up during the night and how many times. The next test will be over the next two following days, they will be asked to listen to four rock songs and record their experience again. Finally, the fourth and final test the participants will be asked to listen to four classical music songs before bed and then to record their experience. We had our four participants record there sleeping difficulties. It was then found that rock music made them sleepless, pop music made them more energized, and classical music help them sleep more. This research is important because it spreads awareness about how to maximize their sleep and help others to feel more rested.

Senior Division Chemistry & Biochemistry

Sarah Bian   2-03-001
CO2 Sequestration by Mineral Carbonation in Ambient Air: Wollastonite Ratio

Carbon dioxide in our atmosphere has become an increasingly important issue- as are the methods to reduce the content in the air. Carbon sequestration by mineral carbonation (direct aqueous) utilizes high temperatures, intense pressures, water (H20), and wollastonite (CaSiO3) to stimulate a reaction that produces CaCO3 (calcium carbonate) and SiO2 (sand). A process normally utilized for flue gases, the potential of ambient air sequestration is dependent on how the wollastonite ratio in the water solution. Testing this premise would require an autoclave to produce the heat and pressure with the wollastonite and water mixture inside at different ratios, ex. 1:5 (60 grams of wollastonite per 300 mL of water is the proven ratio for flue gases to react the maximum amount of CO2). I found that that ratio that produced the largest average of CaCO3 and SiO2 was 1:5; but a systematic error of 20.90 grams was found due to the difficulty with separating the water from the products. An evaluation of the process concluded that the difficulty with separating water from byproduct, differentiating reactants and byproducts, and the disposal of the byproduct limited the method's efficiency and rendered it unpragmatic for use. In ambient air, carbon sequestration by mineral carbonation is an innovative but impractical method for near future sequestration of CO2.

Jan Gradon   2-03-002
The *Chemiluminescence of Bleaches Induced by Luminol: A Study of Glows Over Periods of Time*

The aim of this study was to investigate the interaction of the luminol solution with the most commonly used household cleaners - bleaches. I posed a hypothesis that the intensity of the glows depends on the concentration of sodium hypochlorite (NaClO) in a given bleaching agent. I also wanted to know which of these cleaning agents (while catalyzing the oxidation of luminol) give the luminescence answer closest to the reaction occurring between luminol and blood, which (for ethical reasons) was prepared by mixing dried hemoglobin with water. The substances (bleaches and the blood imitation) were tested in a triplicate, where each well contained 125 microliters of a given fluid. To investigate the influence of time on the samples, 95 microliters of luminol was added to the wells containing the fluids after one hour, two days and four days. After getting the results in relative luminescence units, the average for each group was taken. I found that there is not a significant correlation between the concentration of sodium hypochlorite and the intensity of the glow. However, the chemiluminescence changes in time; in the samples, which were measured after two and four days, the glow was very different than in the samples from the first day of the experiment. My research also answered the most significant question in the study - the bleach containing the highest concentration of sodium hypochlorite gave the answer closest to the one given by the reaction of blood with luminol.

Mary Jefferson   2-03-003
Denarturing Proteins

The purpose of this investigation was to see which protein would present the most change when denatured. The researcher hypothesized that ovalbumin would present the most change. The experiment involved three different proteins, (ovalbumin, casein, and keratin) which were placed in a sauce pan with a thermometer to see at what temperature their physical appearance would change. One cup of milk was used (casein), four eggs (ovalbumin), and hair was used (keratin). The egg whites were placed into a sauce pan, and then placed in the oven to be heated until they had a physical change. The change was then recorded onto a data table. The test was done seven times and the results were recorded. The hypothesis that the ovalbumin protein would denature the most out of the three proteins tested was incorrect. The findings showed that the protein, keratin, can endure the highest temperature before a physical change is observed.

Logan Klein   2-03-004
How Magnesium Almost Lost World War Two: Environmental Effects on Magnesium

A magnesium alloy was used in the construction of the Boeing B-29 crankcase during World War Two. The development and subsequent combat deployment of the B-29 showed that the magnesium crankcase was prone to fires. Magnesium has been known to corrode with prolonged exposure to heat, humidity, and saltwater. The environmental conditions in the Northern Mariana Islands included a yearly average temperature of 28.9°C (84°F), and an average humidity of 79%. Due to its oceanic location, exposure to salt from the ocean was also highly likely. The research question investigated was: Could the environmental conditions in the Pacific Theater have led to deterioration of the magnesium crankcase on B-29s in World War Two? It was hypothesized if magnesium strips were exposed to salt humidity, corrosion would be apparent in both direct observations and in a strength test. To test the hypothesis, strips of magnesium ribbon were exposed to salt water humidity in a salt chamber for 24, 48, 72, and 96 hours. After removing the magnesium ribbon from the chamber, the magnesium strips were examined for changes in appearance and were subjected to a strength test. After the research was concluded, it was found that a general decrease in the strength of the magnesium strips occurred with prolonged exposure to the salt water humidity conditions; therefore, leading the researcher to accept the hypothesis. Magnesium strips were also was analyzed by microscope (before and after exposure to the salt chamber); however, there was no conclusive evidence of corrosion from direct observation.

Rollin Leavitt   2-03-005
Investigation of Transcription Factor Preferences of Bacterial Receptors

Interactions between NOD2 and TLR4 bacterial receptors play an important role in the maintenance of intestinal homeostasis. Dysregulation of the NOD2 inhibition of TLR4 has been highly associated with the inflammatory immune disease Crohn's Disease. However, the mechanisms behind this important interaction are currently unclear. Western blot and ELISA analyses were performed to determine if these receptors have differing preferences for NF-kB subunits and if this preference could account for the observed inhibitory interaction between NOD2 and TLR4. It was found that NOD2 stimulation caused less RELA to be translocated into the nuclei of cells than TLR4 stimulation. This data concludes that the RELA subunit is preferentially activated by TLR4. Further research is required to see if the other commonly inflammatory REL subunits show similar behavior, and if the anti-inflammatory subunit p50 is preferred by NOD2 activation.

Katelynn Salmon   2-03-006
Synthesis of Acetylene-Perfluorinatedpyridine Monomer for Click-Mediated Polymerization

Polymerization is the process by which building block molecules (monomers) are joined together to form a large chain or network. The chemical properties of a polymer are determined by the specific properties of the monomers that make it and the type of linking used to attach the monomers. The purpose of my project was to synthesize a monomer with physical strength, chemical and temperature tolerance, ability to interact with its environment, and terminal functionality for ease of polymerization. One-pot coupling reactions followed by liquid-liquid extraction, filtration, and chromatography were employed for synthesis of the molecule. Analytical Sample Analysis Probe with a tandem Mass Spectrometer, Nuclear Magnetic Resonance, and Thin-Layer Chromatography were used to monitor for desired structural changes within the monomer. The yield of each reaction step makes the synthesis process applicable industrially. Copper(I) Catalyzed Azide-Alkyne Cycloaddition "Click Chemistry", a reaction defined by its high efficiency at combining nearly any two molecules containing an azide and alkyne fragments, was tested as a linear polymerization strategy. The polymer has potential for interaction with metals. The lone pair of electrons on the nitrogen centrally located in the monomer will allow the formation of coordinate covalent bonds with metal ions. These types of complexes are known as metal-organic frameworks or porous coordination polymers. Currently, metal-organic frameworks are being used for water and air purification, drug delivery, and as separation membranes. Future direction will include investigation into polymerization strategies for the creation of applicable metal-organic frameworks.

Michael Santo Savala   2-03-007
Ferro-Solution? Can Iron Naoparticles Help with Oil Spill Cleanup? Phase 2

The goal of this project was to find which surfactant was best and more efficient in removing oil. A surfactant is a substance that reduces surface tension of a liquid in which is dissolve. We use surfactants in the things like soap to help with the removal of things like oil and grease. By using a surfactant I was able to combine both iron oxide and oil which I removed with a magnet. My procedures included first filling a beaker with 170.0ml of salt water, then putting 30.0ml of vegetable oil .Next I put 15.0g of a surfactant (citric or lecithin) in the beaker then adding 15.0g of iron oxide in the beaker as well. After letting the mixture stir for 15 minutes I put two magnets in the beaker and remove the mixture for 30 minutes then record my data. My experiment had found that on average the lecithin removed 1.7ml of oil more than the citric. On average the lecithin removed 19.0ml of oil, and on average the citric removed 17.3ml of oil. An issue I did run into was getting the surfactant to stick to the oil, I had this problem with both of the acids but more so with the citric. It took a couple of attempts of putting the magnets in and out of the beaker but over the 30 minute time period the oil did start to come up with the magnet. I believe this experiment needs to be tested over and over to be perfected, and this kind of thing should not be overlooked. If I was only able to take one thing away from this project it would be that this technology has a lot of potential and could help prevent catastrophic events from occurring in the future.

Acidtaste

The purpose of this experiment was to determine which type of metal used in the structure of buildings, utilities, and housing structures have the greatest resistance to acid rain in the events of a flood. The hypothesis stated that the steel test strips would have the most resistance to acid rain due to it being the most commonly used metal in the infrastructure of buildings. It also stated that aluminum would have been most affected by acid rain due to its light and weak structure, and being used mostly in utilities and housing structures. The hypothesis was supported partly in what had been stated. Aluminum had been most affected by the acid rain but stainless steel had lost the least amount of mass out of the three metals. The approach to this experiment was to find a solution that could be used in real life situations. Many science fair experiments have very interesting experiments dealing with space, time, and structures of an atom, but knowing what metal would be best suitable for housing infrastructure is a very knowledgeable thing to know. Many people like to do projects around the house on their own because they either like doing it by themselves or they don't have the money to hire someone to do it. Knowing the outcome of this experiment may save people hundreds of dollars in repairs and structural damage, because they didn't know what metal was best suitable for what they needed.

UV-Vis Analysis of Silver Nanoparticles Released from Odor Control Clothing, Part II

In last year's research, I tested and confirmed the hypothesis that odor control clothing (socks) can kill aquatic life, in particular, water boatmen (Corixidae). From my research, I found the anti-microbial agent in the clothing was likely silver nanoparticles but had no way to prove it. This year, I synthesized my own silver nanopartcles to test their toxicity on water boatmen. I then compared the synthesized particles to the particles released from odor control socks using a UV-vis spectrometer. The synthesized nanoparticles made an absorbance peak at 390 nm on the UV-vis spectrometer and the nanoparticles from the odor control clothing made an absorbance peak at 360 nm. The peak at 360 nm is likely due to a commercial coating, which makes the peak shift farther left (5). The silver nanoparticle solution was then used in an experiment on the water boatmen where it was found that higher concentrations of silver killed the insects faster. Using the data from the UV-vis, it was possible to find the concentration of silver nanoparticles (0.0003488 ppb) needed to kill pollutant tolerant insects such as the water boatmen within a day in 100 mL of water. The EPA limit for concentration is 3.4 ppb (2). My research shows that even small concentrations of silver nanoparticles are harmful to life and that the safety limits are too high. Therefore, the widespread use of odor control clothing is an important issue that needs further study to protect the health of society and the environment.

Developing a Novel Inhibitor for Cdc14 in the Fungus Aspergillus niger

Fungal pathogens are a major cause of crop damage. In these fungi, Cdc14 could be a critical phosphatase for regulating cell division by ending the mitotic process, as demonstrated by studies in Saccharomyces cerevisiae. Due to Cdc14's absence in higher plants and noncritical role in animals, an inhibitor which can reduce its activity could function as a potential fungicide. In this project, I developed an inhibitor for Cdc14 in the fungal pathogen Aspergillus niger (AnCdc14), a pathogen that causes black mold on crops. After characterizing the catalytic specificity of AnCdc14, I designed multiple inhibitors that modeled the specificity. A combination of bioinformatic and biochemical approaches was used to determine the most effective inhibitor: one that contained four benzene rings and functioned through irreversible inhibition. Through computer modeling, I optimized this inhibitor to improve its affinity for AnCdc14. This modified inhibitor can be tested in vitro and in vivo for its efficiency in preventing A. niger growth and eliminating its pathogenicity. Due to high conservation of Cdc14 among fungi species, the inhibitor I created could be tested in multiple fungi, such as F. graminearum. Eventually, these results could be developed into a new antifungal compound that broadly prevents plant fungal infections.

Senior Division Earth & Space Sciences

Antonio Arant   2-04-001
Parallax Part III: A Study on the Effect of Time Duration on a Stellar Parallax's Accuracy

For three years I have sought out a stellar parallax. This year I wanted to successfully measure a stars parallax and see if a stellar parallax is linear; meaning if I measure a stellar parallax in proportionately less time, the parallax angle that is measured will be less accurate based on that proportion. I tried three ways to measure a stars' parallax. The first was taking six consecutive month pictures and comparing the pictures with plastic overlays marking with colored markers, and then measuring the stars with a caliper. The second method I used was the use of azimuth to plug into the angular diameter formula. Thirdly manipulating distance value in the angular diameter formula. The first method of experimentation gave off wild results. The inconsistencies were caused by insecurely anchoring the picture on the sleeve and the hand measurements were not precise. The second method didn't work because I couldn't get an accurate enough azimuth readings from the website, Sky View Café. The results of the final approach both proved my hypothesis right and wrong. Parallax is not linear but, there is a correlation. The percent accuracies of the time taken to measure a parallax are: 5 months 95%, 4 months 85%, 3 months 70%, 2 months 50%, and in 1 month 25%. This means that a parallax will be 70% of the normal parallax if measured in half the time. These results show that mathematically, you can get preliminary results when measuring a star's parallax.

Raja Braford-Lefebvre   2-04-002
Is It Hot in Here?

The purpose of this project was to compare and contrast annual high temperatures and annual low temperatures from 1905-2017 (the independent variable is the year and the dependent variable is the Temperature), photos of Lake Emma in 1905 and one in 2017, and photos of Kendall Mountain in 1905 and 2017. The hypothesis was: the earth is gradually heating up, but the change is not noticed over short amounts of time; when looked at over longer amounts of time, the temperature is noticeably warmer. If the earth is heating up the tree line is probably changing as well. The same with the water level. Weather data was collected from Silverton school science teacher Kevin DeKay and was put into scatter plots, then photos of Lake Emma and Kendall Mountain were compared and analyzed. The scatter plot on the left represents the annual high temperatures from the years 1905-2017. The highest temperature was 97 degrees Fahrenheit in 1929 and the lowest was -38 degrees Fahrenheit in 1984. There was a huge spike in the data with 97 degrees being the outlier. Overall you can see that the temperature is gradually getting warmer proving this part of the hypothesis correct. There are two photos of Kendall Mountain. The photos do not show much change but this could be because of where the photos were taken. This proved part of my hypothesis wrong. There are also two photos of Lake Emma. In these two photos the water level has definitely changed but this could be because of the draining of the lake, droughts, or lack of snowfall. In conclusion I learned that the data does support a warming trend but the photos do not provide concrete evidence of climate change. If the photos had been higher quality the data could have been more accurate and detailed.

Adrienne Jones 2-04-003
Varies Crystals Responding to Environmental Audio Variables

The purpose of the experiment is to determine if the input of environmental audio/frequency selections played to various crystals will remain constant in growth during various hours of timed periods. This information is based off my last experiment so determine if my findings hold up with different situations. Pipe cleaners hold the various crystals while they develop in a supersaturated. They are under a variety of harmonics, musical structures or Hertz tones. Music and various tones affect the crystals in negative and positive growth directions. Test playing Hertz scales in the audible range are also tested to tell if these variables in increase waves per second are to also to be a key in the increase crystal growth. With my results I conclude that sounds and the manner they are played have affected the crystals. Further testing to see how sounds affect protein crystals will be explored.

Matyson Jones 2-04-004
Global Storming: Is Climate Change Intensifying the Number and Duration of Tropical Storms and Hurricanes?

This year my project is on hurricanes and global warming. What I was looking to see is if Global Warming causes an increase in the duration and intensity of the storms and causes them to be higher category storms. I started out by researching data on hurricanes and their classification. The time line I used ranged from 1940-2017. From there I went into Tropical storms. Then I looked at the categories of the storm and looked to see how many there were for each category. I went in and compared wind speed to Lowest MB pressure. I compared Hurricanes and Tropical Storms to CO_2 Levels and Change in Ocean Temperature and did data analysis and then made scatter plots. My data showed that there were correlations between temperature and the duration of storms as well as CO_2 levels and duration.

Rain Orsi 2-04-005
Shaken: A Statistical Analysis on Induced Seismicity

For my project, I attempted to build a model that would predict the cause of induced seismicity by looking at different measures of an earthquake. To do this, I collected data on ninety earthquakes, split into three groups of thirty by cause. One cause I looked at was geothermal drilling, another was wastewater injection, and the third was conventional oil and gas drilling. I collected data on depth, magnitude, and tectonic setting. My data mostly came from the Human-Induced Earthquake Database, and what I couldn't find there, I looked for on various other earthquake databases. I then put the data into a spreadsheet and ran it through a tree model I built in R, a statistical modeling program. I came to a few different conclusions. The biggest one was that it is possible to determine the cause of an earthquake using statistics, to a certain extent. However, not all of the models I ran were as accurate as I had hoped. This means one of two things: either the cause of induced seismicity cannot be accurately predicted by a statistical method, or I chose poor measurements to predict with. Since I did have some success with certain models I ran, I think that the latter is more likely. My overall conclusion is this: I was able to build a model that has the potential to predict the cause of induced seismicity, but it needs refining before it can be a consistent and accurate predictor.

Casey Shaw   2-04-006

An Analysis of Compositional Characteristics of Two Distinct Fossil Butte Member Localities

The Green River Formation is one of the world's most productive fossil sites, with its Fossil Butte Member (FBM) preserving millions of individual freshwater fish from the Eocene epoch with immaculate quality. Two localities in particular, the 18-inch layer and the split-fish layer, contribute most of the formation's specimens; the latter represents near-shore deposits, while the former preserves strata from the center of the lake. Materials from the two localities can be distinguished by color, texture, and matrix composition; this experiment sought to observe the exact compositional differences responsible for the two groups' dissimilarities. 18-inch layer fossil material was hypothesized to contain elevated levels of organic and calcareous compounds, while split-fish layer strata was hypothesized to display higher concentrations of silicates and other non-calcareous inorganics. Experimental groups representing 18-inch layer (18L) and split-fish layer (SFL) materials were further divided into sub-groups of fossil (F) and matrix (M) material. Material was gathered from three samples from each locality, totaling twelve samples overall. Samples were tested by way of x-ray diffractometry (XRD), infrared spectroscopy (IR), and energy-dispersive x-ray spectroscopy (EDS) to determine crystalline content profile, organic molecule profile in fossil materials, and elemental proportion and distribution, respectively. Qualitative analysis of data yielded the following observations: 1. XRD patterns showed no discernible differences in trends between 18L and SFL-group materials, though showed low homogeneity within group 18L-F. 2. EDS indicated no distinct differences in elemental distribution or concentration. 3. IR spectroscopy indicated elevated presence of saturated hydrocarbons in 18L-F materials.

Sarah Tang   2-04-007

Measuring exoplanetary Radii Using Transit Photometry

The goal of this study was to measure the radii and constrain the orbital periods of three Hot Jupiter exoplanets, HAT-P-25b, HAT-P-9b, and HAT-P-30b. Through remote observing, raw images of the host stars were acquired using the ARCSAT telescope and FlareCam Imaging Instrument in Sunspot, New Mexico. A data processing pipeline utilizing the Python programming language was used to convert the raw data images into calibrated pixels and transit light curve graphs. The normalized transit graphs of HAT-P-25b and HAT-P-30b were fitted with multiple light curve models, which varied based on a given range of radius and time of mid-transit parameters within the Python code. The data associated with HAT-P-9b were not fitted with light curve models due to a non-detection in the data. Chi-square tests were performed on all the light curve models to isolate the chi-square value closest to 1.0, which would signify a strong data to model fitting. Chi-square maps were used to estimate the 1σ error bars (68% Confidence Intervals) for all light curve calculations. A shift in mid-transit time (-0.41 ± 0.31 hours from expected value) was detected for HAT-P-25b. This will help scientists more accurately predict the transit times for this planet. The normalized radius ($R_p/R\star$) calculated for HAT-P-30b differed significantly from the literature value by 0.04 ± 0.0020. This discovery can be used to more accurately constrain the radius of this planet. These findings will help scientists obtain more accurate knowledge about these exoplanets and their characteristics.

Natalie Keller & Melanie Gong

The Reduction of Perchlorate in Mars Regolith Using Hydrogen Gas to Produce Chloride and Water

If humans successfully travel to Mars, it would be necessary for them to grow consumable plants in Mars regolith as a source of nutrients. Mars regolith contains perchlorate, a toxin that has detrimental effects to human health, at hazardous concentrations of 0.5% - 1.0%. The goal of this experiment is to reduce perchlorate in Mars regolith using hydrogen gas so that plants grown in regolith would be consumable. Mars regolith simulant with 1%, 0.7%, and 0.5% concentrations of perchlorate was placed in Erlenmeyer flasks whose atmospheres were replaced with hydrogen gas. The flasks were allowed to sit for 72 hours for the reaction between hydrogen gas and perchlorate to occur. The reaction was not successful because perchlorate is stable and will not release its oxygen unless a catalyst is present to help stabilize the oxygen once it is released. In order to allow the reaction to occur, solid titanium dioxide, a catalyst, was mixed into three samples of regolith with 1% concentrations of perchlorate, and the mixtures were put into Erlenmeyer flasks. A wire was placed across the surface of the regolith with 10V of electricity passing through it, and the atmosphere was replaced with hydrogen gas at 1.5 atm of pressure. The flasks sat for 72 hours so that the reaction could fully occur. This study was successful in decreasing the concentration of perchlorate in Mars regolith so that future astronauts could grow consumable plants without toxic perchlorate on Mars utilizing Mars regolith as soil.

Kathryn Kummel & Michelle Kummel

Using 3D Drone-based Digital Models To Investigate the Fluvial Geomorphology of an Eroding Arroyo

In the arid West, conversion of intermittent streams to arroyos makes the already limited water even less available to the ecosystem. This study used two drones (one we designed and built in 2016, and a DJI Phantom we piloted in 2018) to study a rapidly down-cutting stream--the average movement of the major nickpoint from 1999-2017 was 5.6m/year (Google Earth data). The stream had three active nickpoints and was divided into 4 sections: Surface Stream, Incised Section (downstream of the first nickpoint), Active Section (defined based on movement seen in Google Earth), and Arroyo. Two hypotheses were tested: (1) Basic hydrologic characteristics of the stream should differ between the sections and reflect the increasingly incised stream. (2) The sections should differ in erosion and deposition rate. Statistical analyses of two digital surface models from 2017 and 2018 and the multispectral orthomosaic from 2017 showed that the intermittent stream transitioned from an upstream section with deep pools and shallow, grassy riffles to a deeply incised state (low entrenchment ratio) with no or few shallow pools to hold water. As the stream transitioned, it became disconnected from its floodplain until the floodplain re-formed in the Arroyo. The Active section had the steepest slope and the highest erosion and deposition rates. However, the presence of multiple sharp "nickpoints" and bank collapses suggested that erosion was generally occurring "catastrophically" (i.e., quickly, in large quantities) in a few places rather than gradual erosion in all areas.

Senior Division Energy

Kevin Yang   2-05-001
Design of a Novel Energy-Saving Radiative Cooling Bilayer Paint for Space Cooling

Space cooling is a significant global end-use of energy and a major driver of peak electricity demand. The accumulation of heat from the sun during daytime increases the indoor temperature of buildings, which necessitates air conditioning. In order to reduce cooling demand, solar reflective white paints have been used to reduce solar heating. However, current reflective paints have intrinsically high near-infrared absorption, contributing to its heat gain. In this project I create and demonstrate the properties of a novel bilayer paint with a metal reflective layer underneath a high IR-emissivity white paint. Taking advantage of (1) radiative cooling by maximizing emissivity in the mid-infrared and (2) reflective cooling by maximizing solar reflectance, the bilayer paint serves to reduce solar heating while maximizing radiative cooling power. A temperature measurement of the bilayer paint after direct sun exposure revealed a consistent ~0.5°C decrease in surface temperature of the bilayer paint as compared to a commercial solar reflective white paint. Spectroscopic characterization of the bilayer paint showed much improved near-infrared reflectance as well as retention of high emissivity in the mid-infrared. Calculated from the spectroscopic characterization, the bilayer paint displayed significant ~7 W/m^2 more cooling power than the commercial paint (t = 4.06, α = 0.01, t_crit = 3.14). This study proved the effectiveness of a novel bilayer paint for building energy savings. Previously unexplored in literature, the bilayer paint provides a novel cooling roof technology which can serve to reduce cooling energy demand during the summer time.

Mark Bloomfield   2-05-002
Heating Up: Using Phase Materials as a Thermal Battery

Phase change materials are a proposed large scale storage method for solar energy; mirrors melt a material - often salt - storing solar generated energy. As the sun sets, the salt resolidifies, releasing energy during peak usage times. This investigation examined whether materials which go through a phase change perform better in a small scale thermal battery than liquids. It was hypothesized paraffin wax would store more energy because it goes through a phase change and has a high specific heat. The experimental setup used peltier coolers to test four different readily available materials: paraffin wax, canola oil, Crisco, and water. The materials were heated for a set amount of time and energy recovered was measured. The average energy recovery over 29 minutes was 1.58 watts from paraffin wax, 1.32 watts from water, 1.26 watts from canola oil, and 1.06 watts from Crisco. The P value from one-way ANOVA test showed results to be significant with a P value of 0.0009. The Tukey HSD post-hoc test showed paraffin wax vs. canola oil and paraffin wax vs Crisco to be significant. Paraffin wax vs. water, canola oil vs. Crisco, canola oil vs. water, and Crisco vs. water did not show significance (P < 0.05). As hypothesized, wax recovered the most energy. Areas for further research include testing additional materials and finding a more efficient method for reclaiming energy. A viable small scale thermal battery has potential to be a cheaper and environmentally conscious alternative to lithium ion batteries.

Jason Foutz

Efficiency of a Hydrogen/Oxygen Gas Generator

HHO gas generators have been around for a long time, however, few people know of them. With the world running on fossil fuels, we need to find more efficient ways to use them or to develop renewable fuels. One of the ways to use fossil fuels more efficiently is to use HHO generators in conjunction with regular combustion engines. It is more efficient because it completely burns the gas, most engines will leave soot that builds up with unburned gas. These generators take water through a cell and decompose it into its elements. I will test the performance differences by operating this generator at different amperage inputs. HHO generators allow you to increase your gas mileage and lower your emissions. This is less expensive, and causes less wear and tear on a vehicle by burning the soot off of your pistons and cylinders. When I started this project I did not realize how much information is out there. That pushes me to understand more and show the world that this is a viable alternate to use with today's combustion engines. When I continue this project I will try to prove that this piece of technology will give off lower emissions, create more efficient fuel economy and is better for your vehicle.

Max Markuson DiPrince

Windmill Efficiency Part 3: Testing the Magnetic Flux of Magnetostrictive Solenoids to Optimize Oscillatory Energy Production

Windmill efficiency: How can we harvest wind energy from more natural movement of oscillation instead of spinning turbines? How can we optimize energy production in an oscillatory generator? Applying different levels of magnetic flux on a copper solenoid surrounding magnetostrictive materials, it is possible to harvest energy by absorbing oscillatory movement. If the magnetic flux density is increased in an oscillatory magnetostrictive generator, then the more AC-current will be generated because more magnetomotive force is applied onto the solenoid and magnetostrictive conductor. The experiment involved measuring the current and voltage peak values when increasing magnetic flux -- by adding neo-dysprosium magnets -- to the solenoid. Peak performance increased when increasing magnetic flux, but only when adding two to four magnets. At four magnets, the galfenol and terfenol-d peak values spiked dramatically, producing energy almost three times more than level two. Steel, at this point, produced less than the magnetostrictive materials. Magnetic-saturation occurred with four magnets on the solenoid. After adding more than four magnets, the peak values continued decreasing dramatically. The magnetostrictive material electron mobility is extremely flexible, so when it came into contact with certain level of magnetic flux, the magnetic field resistances were able to efficiently bend the electron motions and vice versa. Magnet levels greater than four produced magnetic saturation because magnetic flux resisted with too much strength, forcing the electrons to float. The solution for this project would be to maximize magnetic flux on the solenoid surrounding the magnetostrictive material before reaching saturation for most efficient energy generation.

Sophia Markuson DiPrince   2-05-005
Anaerobic Digestion of Food Waste Part 3: Comparing Different Conductors in the Production
of Food Waste Generated Electricity

This experiment is comparing conductors (carbon, copper, and aluminum) to determine which is the best at conducting the electricity produced by the anaerobic digestion of used coffee grounds. To perform this experiment, I made several fuel cell systems in which the electricity would be produced and held similar to a battery. Each fuel cell had the same amounts of coffee grounds, yeast, and water and each cell had either a copper sheet, aluminum foil, or carbon paper acting as a conductor. The object of this experiment was to see which fuel cell displayed the most voltage because of how well the conductor in each cell worked. My hypothesis stated that the copper sheet would be the best at conducting the electricity, was not supported by the data. In fact, both the copper and aluminum killed off the bacteria in the fuel cells and no electricity was produced. The fuel cell with the carbon paper was the only fuel cell that produced any electricity at all.

Zeb Shields   2-05-006
Photos of Synthetic Photosynthesis

The need for a clean, carbon-reducing system that produces a burnable fuel has been known for a long time. Plants and certain photosynthetic bacteria have been doing this since the beginning, and recently humans have begun to discover processes that mimic this behavior. This project is to design a system that, like plants, can take only two abundant ingredients, being H_2O and CO_2, and combine them over a catalyst to create a burnable fuel, CH_4, and O_2. This system makes use of three reactions: Water Photolysis (H_2O + energy = H_2 + O_2 [over a Pt or Co catalyst]); the Sabatier Reaction (CO_2 + H_2 + energy = CH_4 + O_2 + energy [over a Ni-based or Fe Porphyrin catalyst]); and the Combustion of Methane (CH_4 + O_2 = CO_2 + H_2O + energy [no catalyst required]). Each of these steps, given the right catalyst, can been driven by sunlight. The first step has an energy requirement of 1.23 to 3.4 electron volts, with a quantum yield of nearly 5%. The second step is endothermic, with an activation energy requirement of 46 kJ/mole and a yield of 123 kJ/mole and a quantum yield of 1%, which should go up soon as the catalysts improve. The third step, the combustion of methane, yields some 50.1 kJ/g. This system does not produce more energy than it requires, as stated by the second law of thermodynamics; it is simply a means of storing sunlight as a liquid fuel. The system can either be rigged as a perfectly closed system with no carbon emission by piping the exhaust directly back into the reaction chamber, or it can be used to fix carbon permanently into shale or graphite via the Bosch reaction.

Leveraging Satellite Imagery to Map Road Surface Conditions

Classifying road conditions is a time taking and expensive task as the two current methods of road classification require driving on each road to classify their condition. However, a possible solution is to use satellite imagery to classify road conditions. The objective of this project was to develop a method in which satellite imagery could be used to accurately map road conditions. This was done by using a geographic information system and collecting the statistics of the blue spectral band in the satellite imagery to correlate certain statistical values with good, fair, and poor road conditions. After collecting, analyzing, and implementing the blue spectral band statistics, a map was created classifying road conditions as one of three conditions: good, fair, or poor. By visiting some sample sites it was determined that the map was in fact accurate and specific. This project has many implications especially with the Department of Transportation. The process used in this project to create the map of road conditions can be scaled to be used for images of roads all over the nation and world and later given to the Department of Transportation to then deploy their resources to repair the roads classified as poor. This can save millions of dollars in the United States alone. The future of the project is also bright as machine learning and artificial intelligence can be used to optimize and speed up the process to completely revolutionize the mapping of road conditions.

Healing Air Pollution with Hydrogen

The purpose of this experiment was to discover if introducing hydrogen and oxygen into the intake of a small engine would reduce gasoline consumption and pollutants such as carbon dioxide (CO_2), volatile organic compounds (VOCs), and ozone. It was hypothesized that CO_2, VOCs, and amount of gasoline consumed will decrease because hydrogen will burn and supplement some fuel that regularly would not ignite. Ozone was hypothesized to increase due to high combustion temperatures. The emissions of an unmodified small engine was measured with an air quality monitoring instrument. In the experimental trials, the engine was modified to run on supplemental hydrogen and oxygen, produced through a homemade electrolysis apparatus. Throughout the experiment, the carburetor was adjusted in order to keep revolutions per minute (rpm) constant. Multiple trials were performed to increase data accuracy and reduce error. The data supported some of the hypothesis. CO_2 decreased by 13.855%. Light VOCs decreased by 8.086%. However, heavy VOCs increased by 5.122% and gasoline consumption increased by 5.783%. Ozone experienced no change. These findings suggest that engines modified to run on hydrogen-hybrid fuels have the potential to reduce CO_2 and light VOC emissions. However, the same could not be confirmed about the gas consumption and heavy VOCs. This experiment provides data to support the claim that homemade hydrogen-hybrid technology can be a cheap, readily available, renewable resource to help reduce a small portion of vehicle emissions globally.

Adam Vasquez   2-05-009
Dye Sensitized Solar Cell

This study was to allow the observance of the solar energy in order to comprehend the Dye Sensitized Solar Cell. It was hypothesized that a decrease in resistance in semiconductors and a change in surface area will result in an increase in electrical flow. In the first two trials of the cell two variables were changed, the coating of the glass and the surface area. The study was kept constant of which the electrode, counter electrode, and electrolyte solution were made from. The difference in surface area was 625mm^2 and a difference of 80 ohms per 25mm^2. Each cell was measured at the same time of day within 5 minutes of the cell before. The increase in voltage varied from test to test, however it averaged to a difference of approximately .3 volts from the first cell made to the second cell. The surface area to me was a factor in why more electricity was produced, the resistance was a factor in the ability to transfer the energy to a usable form. The implications of changing type of glass and a bigger surface area would increase the amount of electrical flow, however not every variable will result in such action. From the data collected manipulating other variables such as a different electrode or counter electrode and a different electrolyte solution, or possibly a different dye is in the best of interests.

Scott Clousing & Daniel Orbidan   2-05-301
Use of Monte Carlo Methods to Evaluate the Viability of Hydroelectric Dams

Hydroelectric dams are a proven energy alternative to fossil fuels, yet their long-term viability is a subject of concern. This research utilized energy data to monetize energy production and saved carbon emissions, and salmon return data to monetize the loss of salmon. Using Monte Carlo methods to overcome variability, these monetized factors were inserted into a model which calculated the adjusted profitability of the dam. To simulate future streamflow conditions, energy generation and saved carbon emissions, which both vary directly based on streamflow, were reduced by 10% and 25%. The simulations were repeated for these adjusted values. For current streamflow conditions, every dam was found to be profitable. For a 10% reduction in streamflow, every dam remained profitable and few had a notable decrease in profitability. For a 25% reduction, many dams had a significant decrease in profitability, and Ice Harbor Dam was no longer reliably profitable. Dams with a larger current profitability saw small change as streamflow declined 25%, often remaining profitable over 99% of the time. Larger dams on the Columbia River are an extremely viable source of alternative energy and will remain that way far into the future.

Senior Division Engineering

Austin Blomstrom   2-06-001
The Reliability of Model Rocket Simulation Software

Model rocketry is a hobby for people of all ages and skill levels. Rockets are comprised of many different components and are constructed from many materials including: cardboard, plastic, balsa wood, and fiberglass. One of the most challenging parts of rocket design is finding the right size engine. This is where Computer Aided Drafting (CAD) software can be of assistance, as it allows one to design and test different styles of rockets and determine which style has the best flight performance. The researcher wanted to determine if model rocket CAD programs would produce accurate projections of model rocket performance. It was hypothesized, if the difference in flight performance between the CAD program and direct observation had a less than 25% error, then it is accurate enough for hobby use. To test this, three rockets were designed using the computer program SpaceCAD 5. From these designs, rockets were built, launched, and data was collected. Outside weather conditions were also recorded. Once the rockets were launched, environmental conditions were put back into the SpaceCAD 5 software and simulations were run for each rocket. Direct observations were then compared to the simulation. The four parameters that were analyzed were height, velocity, acceleration, and thrust. For two of the rockets, the percent error for velocity, acceleration, and thrust were under 25%. For the third rocket, only the velocity and thrust were under 25%. The original hypothesis was accepted for the parameters of velocity and thrust for all three rockets.

Will Brown   2-06-002
Supporting the Future: design and Creation of an Air-Evacuated Maglev Tunnel

In a study done in 2008 in China, run by Dr. Deng Zigang, it was predicted that a maglev train running inside of an air-evacuated tunnel has the potential to reach speeds of up to 1800 mph. By reducing the air pressure inside the tunnel to near 0.0 pa it is possible to reduce the total drag on the train by 80% - 90%. The goal of this project was to create a support for the tunnel that ensures the tunnel will not collapse as the air is pumped out. The design was based on the classic building strut support but was modified to act as a circular support. A small-scale model of the support was constructed using 1/16 and 1/32 inch thick stainless steel wire. The first method of testing the designed support, the vacuum test, was successful. The small-scale support was able to withstand one atmosphere of pressure with very little deformation. The second method of testing, the band test, was flawed so no accurate data on the support was attained. The support is able to withstand full atmospheric pressure, however, the full capabilities of the model are unknown due to the flawed test method labeled the band test. The intended application for this design was to create a way to support a large scale air-evacuated tunnel to prevent collapse due to outside air pressure.

Jakob Buller   2-06-003
Home Aquaponics

My project was an aquaponics system. My goal for this project was to create a low cost, space efficient, home aquaponics system. The purpose of this project was to design a way to grow your own produce for a cheaper cost. The experiment involved growing deer tongue lettuce in the aquaponics system I made. My procedure involved putting together PVC pipe by water sealing them with silicon. I also drilled holes for plants and hoses to be inserted in. The data collected supported my goal, to successfully design a cheap home aquaponics system. The results of this project were successful in completing my goal. The project was successful. These findings lead me to believe that there is a cheaper, more efficient way of farming.

Stampede Arm II

Can 3D Printing be used to manufacture a myoelectric prosthetic arm for under $350? The design criteria for this version were: 6-7 piece hand, no drilling for assembly, 35+ lbs knuckle strength, 5 hour battery life, arm weighs 5.7% or less of patient weight, and the arm meets all 14 points of evaluated range of motion. The design was updated to extend the range of motion and correct previous errors. The prosthetic was then re-printed and assembled, meeting part count and drilling requirements. Final testing measured and compared the prosthetic with the model arm along with battery runs. Results show that the prosthetic performs under simulated load for 15.5 hours on average before loss of power. The knuckle strength averages at 95lbs before breaking. Comparative tests for weight and size requirements show the prosthetic matches the model arm. Range of motion evaluation showed all functionality is normal except for the wrist's radial and ulnar movement because the arm has no mechanism for that movement. Additionally, the elbow flexion motion was 23° short of the 150° requirement. This version and its properties successfully meet 11 of 12 cumulative design requirements. Future additions could be to allow the arm to receive and interpret data from a brain-based headset or to create a second arm and explore dual mobility processes such as driving or typing. Extended knuckle testing with more trials and varied hinge designs/diameters could provide even more conclusive and informative data on an optimally strong knuckle.

Parallel Plate Capacitor from the Ground Up

The purpose of the project was to build a capacitor and prove the laws governing it. The capacitor was created by taking two conductive plates and putting a non-conducting material in between them. The capacitance was later measured by using a theoretical value given from the math and an actual value given from a multi-meter. Different capacitors were used for different tests. The 10 by 10 cm ones tested how capacitance was affected when in series vs. parallel; the biggest capacitor was used to prove that as surface area increases and distance decreases, then capacitance increases. There were many complications when testing the capacitors. The biggest obstacle was a lack of an adequate multi-meter, without one there was no way of telling if the capacitors worked. The next problem was that, most of the capacitors built had such little capacitance that they couldn't hold a sustainable charge. These problems were resolved by acquiring a working multi-meter and the construction of a large capacitor. The data collected from the project did confirm the laws that they set out to do, with the most notable being the jump from the nano-scale to the micro scale when increasing surface area. In conclusion, the project was a success; a working capacitor was created that proved the laws of capacitance while being simple to explain to lay public.

Aaliyah Garcia   2-06-006
Wildland Firefighter Defense System: Phase III

Since I was a little girl, I have always looked up to firefighters being that my father has been a volunteer firefighter in my home town for nearly twenty years. After years of being scared for my father's life and after learning about the 2013 Yarnell Hill Fire, I knew a change had to be made in the safety equipment we service to the men and women who protect our communities. This year my hypothesis was "If I combine Temptrol, Pyrogel XT-E, and a carbon fiber hybrid mesh together, then there will be a low chance of overwhelming heat to transfer through to the person the shelter is protecting as well as provide a structure light enough with the materials woven over to allow easy carry and deployment for wildland firefighters to carry through tough terrains". The steps I took to prove my hypothesis was to cut a one 6x6 inch square of each fabric, carbon fiber hybrid, Pyrogel XT-E, and Temptrol, to find the final materials I plan on working with. Along with materials testing, I conducted research to start the structural process of the updated fire shelter. I concluded that by rearranging the Temptrol and carbon fiber hybrid material, less heat was able to transfer to the bottom surface under high temperatures for five minutes.

Ashley Gilmore   2-06-007
Exploring the Troposphere

The data that weather balloons give us about the conditions of the upper atmosphere is critical in making accurate weather predictions. This project is about sending weather balloons into the atmosphere to help local weather stations get more accurate weather predictions. I know radiosondes have a low return rate of about 20%. How can you get any data with a low return rate? Also how will you get temperature and humidity readings if it's in a radiosonde? The radiosonde will have a GPS in it. I also had to build a board that would have a temperature, humidity sensor, and a storage card. Since the project doesn't have funds like a professional weather station does, I had to make it work on a budget. To make sure the board was working I did pretest on the 18, 19, and 20th of January. To conducted it I set up the board and took temperature and humidity readings manually. The board only worked successfully 2 out of 3 nights. The average difference of the temperature sensor and the thermometer was 2.4 degrees Celsius. The average difference of the humidity sensor and the wet/dry bulb was 18.9%. Down in Southeast Colorado there is terrible cell service, so the balloon can't be tracked. Collecting data from the board was successful, but launching and tracking it wasn't. This project is definitely something that needs to be developed further in the future.

Isaac Jordan   2-06-008
A Novel Approach for Sensing Seismic Events: Applications of Graphene Nano Flake Powder Composites

The goal of this project was to refine and create sensors that are more sensitive and more repeatable than the year before. This was done by combining graphene Nanoflake powder and silicon. By changing the known variables such as the thickness of the sensor and varying the duration and voltage applied to the sensors while curing the sensors were made more sensitive. A mold was designed, 3D printed and used to enable uniformly formed batches of sensors and to accurately control the thickness. This made the sensors more repeatable and allowed to have more control over the variable. The new sensors now have a smaller footprint which allows for the sensor to be used in a wider variety of fields. By making the new sensors about 50% the mass of the original sensors means the cost of production is less than the previous sensors. The new sensors also have sheets of aluminum foil on both sides of the sensor with copper tape attached to the aluminum. This allows for the sensor to be used in more fields because the testing or operating system doesn't have to be conductive because that is now built into the sensor.

Marissa Jordan
A Helping Hand: A Softer Side of Robots, Part II

An estimated 6.8 million people in the United States alone suffer from hand mobility issues, whether it is from a degenerative condition, a stroke, or old age. The project goal is to design a glove that will aid those with limited use of their hands and help them to restore independence by giving them the ability to grasp with their hands again. The use of soft robotics will allow more flexibility and be easier on a person's joints and skin than a hard-robotic hand. This project used 3D printed molds, silicone rubber, and a couple types of gloves to try to develop a hand that would be easily pulled on, easy to operate being powered by air pressure, and made inexpensively. The molds for the fingers were designed in Autodesk Inventor, and fabricated using a Robo3D printer. Several versions of the fingers were designed, printed, silicone rubber cast, cured, and tested with air pressure. It has been challenging to find a design that has the range of motion and power needed to effectively bend the fingers of the glove. Some of the tests tried were different shaped molds, using thread reinforcement, elastic backed fingers, fabric backed fingers, fabric sleeves, and sleeves that used fabric and elastic. The project will take a bit more adjusting to finalize the project. To date, only limited success has been achieved due to the challenges of incorporating the soft gripper with a human hand shape. More design and testing will be done until one works!

Alyssa Keirn
Solar Powered Decontaminator Design and Testing

One in ten people in the world fall ill from foodborne pathogens each year. Of these, an estimated 420,000 die. Non-typhoidal salmonella is one of the most common types of bacteria responsible for foodborne illnesses ("World Health" 2015). In this project, a solar powered device was designed, built, and tested to decontaminate eggs, fruits, and vegetables of bacterial pathogens in locations where access to electricity and medicine are limited. It was hypothesized that the device would reduce the amount of salmonella on treated foods. The device generates ozone gas in a sealed chamber to oxidize and kill pathogens. The ozone is generated using a household air purifier, powered by rechargeable batteries. These batteries power the entire device, and are charged by a dual-axis, sun-tracking solar panel. The device is controlled by an inexpensive single board computer (Raspberry Pi 3). The optimal time interval for decontamination is calculated based on the humidity and temperature measured in the sealed chamber. A motorized roller can be utilized to rotate food to prevent any airtight seals being formed between the food and the tray. The device was tested at Colorado State University's BSL-2 laboratory on food items treated with Salmonella enterica serovar Enteritidis. Following exposure to ozone for 15 minutes, the average percentage of the S. enteritidis decreased by 93%, 59%, and 86% on the surface of kale, potatoes, and eggs, respectively. It was concluded that the device would be a worthwhile resource in off the grid locations to reduce bacterial foodborne illnesses.

John Quinn   2-06-011
Restoration of Manipulated Serial Numbers Using Electron Backscatter Diffraction

Serial numbers can be manipulated by criminals to try and make them unidentifiable (scraped off). The goal of this study is to re-identify these manipulated serial numbers more effectively than they are being re-identified today. The method of re-identifying that is used today is chemical etching where a prescribed etchant is used to reveal deformation in the grain structure of the material caused by the stamp of the serial number (60 % effective). A new way to re-identify serial numbers is using Electron Backscatter Diffraction (EBSD). EBSD re-identifies the serial number by using the backscattered electrons interference pattern. EBSD finds grain structure at higher magnification than optical techniques used in etching and also can be used to measure crystal damage through a quality index. In this project EBSD is compared to etching. Samples of 17-4 stainless steel were stamped with an "s" using a hydraulic test machine under displacement control to create a series of uniform samples. The "s" in the samples was polished off so it could not be seen and then etched with Fry's Reagent. The samples were then polished to multiple depths, etched and imaged with EBSD. Electron Backscatter Diffraction was able to identify the "s" at greater depths (up to 90 μm) than the etching method. The wet etching process takes considerable skill and experience of a trained metallurgist with specific knowledge of the alloy and etchant, whereas the EBSD method can use the same standard procedure for most alloys.

Krithik Ramesh   2-06-012
Suppression of Aeroelastic Instabilities in HR Wing Structures using Principal Component Analysis

The aeronautical industry struggles to find a balance between making aircraft efficient and durable simultaneously, high-ratio wings are able to provide efficiency at the loss of structural integrity. Aircraft wings are vulnerable to fatigue at high speeds and turbulent conditions, these conditions lead to limit cycle oscillations and wing flutter putting stress on the structure of wing and decreasing aircraft efficiency. I designed a wing structure in conjunction with a machine learning algorithm that is optimized to predict turbulent conditions based off weather radar data from the cockpit and modify surface controls on the aircraft to proactively handle unfavorable regions of air. I simulated each wing in real-world scenarios and collected data on: dynamic pressure, turbulence intensity and length, sheer stress, and velocity for all three axes. By preventing aircraft from entering limit cycle oscillations or conditions where the wing starts to flex, it protects the structural integrity of the wing and improves aircraft performance. To simulate all flow tests, I used SolidWorks and SolidWorks Flow Simulation 2016. I 3D-Printed a wing, and created a functioning wing using a series of servo motors, altimeter/ barometric/temperature sensor, and 9-axis gyroscope/magnetosphere/accelerometer sensor, and an Arduino board. The results showed that the time taken to overcome a limit cycle oscillation in the control group wing was 539 iterations compared to 166 iterations for the experimental machine learning wing. The data suggests the experimental wing and machine learning algorithm would prove effective in reducing the stress on wing structures and increase aircraft performance and efficiency.

Josie Riseling   2-06-013
Hit Me with Your Best Shot, Part 2

There are 4 rules of gun safety. If everyone follows these rules, the rate of injuries caused by carelessness with guns will decrease. The first step in selecting the appropriate protection level of body armor is to establish the level of protection that users need based on the realistic weapon threat they face. The appropriate body armor would be the level of body armor that won't be pierced by any bullets. The best is Level IV but it is used in the military, so Level III is what most police use. The Hypothesis for this project was if fire blankets and a Level III body armor plate can stop a 9MM pistol, SKS rifle, and a Ruger 10-22 bullet. The hypothesis was correct and incorrect. The reason the hypothesis was incorrect was because the SKS rifle did not penetrate the plates at all. The fire blanket on the SKS plate had to be clipped on several times because of the power of the SKS. This means that the plates held up when being shot at. This project will be continued for two more years and will help schools in the future.

Jenna Salvat   2-06-014
Synthesis and Characterization of a NiO-ZnO Semiconductor Junction for an Electromechanical Effect

ZnO, a semiconductor metal oxide, exhibits a property known as piezoelectricity, which is a product of its crystalline lattice anisotropy and tetrahedral molecular unit cell. In this research, ZnO was produced using a sol-gel synthesis route utilizing ethanol as a solvent and zinc acetate as a precursor reactant. A complexing agent, such as triethanolamine or ethylene glycol, was combined with the solutions after the zinc acetate dihydrate partially dissolved into the solvent. Upon dissolution of the precursor and the formation of colloidal nanoparticles, the solutions were deposited via spin coating onto nickel substrates with an oxidized nickel upper surface in order to establish a NiO-ZnO P-N type junction responsible for an increased electromechanical effect. Characterization of this material was conducted using X-Ray diffraction and scanning electron microscopy. An upper gold electrode that was sputtered using a Denton Vacuum sputtering machine with a gold target coated a portion of the film surface in order to provide an upper conductive contact for wire attachment; the nickel substrate functioned as the second electrode contact. The electromechanical effect was analyzed by deforming the ZnO-NiO films on the substrate by using a programmable linear actuator and an oscilloscope that was attached to the conductive electrodes of the thin film apparatus. A piezoelectric signal was generated from a sample that was produced via the sol-gel spin coating method with a reinforcing layer of a piezoelectric polymer, polyvinylidene fluoride.

Maximilian Shen   2-06-015
Harvesting Water from Air with Solar Power for Underdeveloped Areas

The global human population is currently seven billion and is expected to grow to eleven billion by 2050. This makes problems such as water scarcity challenging as five hundred million people live under water scarcity twelve months a year. The goal of my project is to create a cost effective water harvester that is fully solar powered and capable of pulling water out of the air without having to rely on expensive infrastructure to power my device and without the need to access water sources such as rivers and lakes. My design is based on a design done by Kim et al. 2017 that utilized metal organic frameworks (MOF) to absorb moisture from their device. The moisture was then turned into water condensate by cooling. I replaced the expensive MOFs with cheap silica gel and made my device fully solar powered. My harvester consists of silica gel which absorbs water moisture during the night and a solar absorber which is black sheet metal capable of absorbing sunlight and desorbing the moisture out of the silica gel. The desorbed moisture is cooled by a solar powered thermoelectric cooler, generating water condensate. I tested each component individually with the silica gel being able to absorb ~40% of its mass in 85% humidity and the solar panels were able to generate 12.24 V of electricity to power a 12 V thermoelectric cooler and fan to generate water from the device. The final device was capable of generating water fulfilling proof of concept.

Jayden Edson, Jonathan Belcher & James Rindt   2-06-301
Underwater Invaders

The purpose of the project was to design an underwater robot that is capable of early detection of zebra mussels. Zebra mussels are an invasive species that pose as a threat to many water sources around the US. This robot must be able to take samples off of surfaces and bring them back to the surface for further examination under a microscope. The procedure consisted of placing the robot in a body of water, using the thrusters to move the robot to a solid surface, then use the scraper to collect samples off of the surface. The robot was placed and tested in a real river at Blue Valley Ranch. The robot was able to efficiently collect samples off of rocks in the river. It would be logical to conclude that the robot is able to successfully take samples of potential zebra mussel larvae in a real life environment.

Nizhoni Valdez & Trinity Lynch   2-06-302
Pioneering Mars' Agriculture

Conceptually, once humans have started pioneering Mars, our vex robot will be key to agriculture success. Currently, Mars has all the macro and micronutrients needed to produce plant life with terrestrial soil similar to Earth's. In theory, once an atmospheric dome is constructed, agriculture on the red planet is ready to begin. Engineering is complex and inspired from real ideas-- bouncing from one creator's ideas to another's. Our robot design is a product of the ice auger. Similar to an ice auger, our vex machine will break and pull up soil for planting seeds. In addition, space and proximity awareness is included on the robot. Our design also consists of a seed dispenser, a soil recovering device, and a solar panel. Our robot is ideal for pursuing foreign agriculture. My partner and I decided that if we design a vex robot capable of pioneering agriculture on Mars then, ideally, our robot will be able to use augers to drill effectively enough to plant seeds and begin to cultivate agriculture.

Senior Division Environmental Sciences

Keaton Fischer   2-07-001
Understanding the Rio Grande Cutthroat Trout Resiliency in the Trinchera and Ute Creek Watersheds

My project seeks to understand the availability of habit in the central Sangre de Cristo (SDC) mountains outside of Fort Garland, Colorado on the Trinchera Ranch. I am doing a comparative study of like elevation tributary stream reaches to develop a picture of macroinvertebrate availability, pH, Temperature, Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and conductivity. This information will help me understand the habitat availability for Rio Grande Cutthroat Trout populations. I will also be incorporating the Signal 2 Scoring method to better understand the food availability in the SDC Watershed streams. Originally developed in Australia in 1993 for use in the Hawkesbury–Nepean River system near Sydney, it was used for assessing macro invertebrate stream health. (Chesman 1994). "SIGNAL stands for 'Stream Invertebrate Grade Number – Average Level.' It is a simple scoring system for macro-invertebrate ('water bug') samples from Australian rivers. The SIGNAL score gives an indication of water quality in the river from which the sample was collected. Rivers with high SIGNAL scores are likely to have low levels of salinity, turbidity and nutrients such as nitrogen and phosphorus. They are also likely to be high in dissolved oxygen. When considered together with macro-invertebrate richness (the number of types of macro-invertebrates), SIGNAL can provide indications of the types of pollution and other physical and chemical factors that are affecting the macro-invertebrate community." For the purpose of this project my goal was to see if the SIGNAL 2 Scoring method would be valid in Colorado mountain streams.

Angel Castillo   2-07-002
Coloring with Crops

In my project, I used natural materials to make eco-friendly water color paint. My goal is to find which crop makes the best blue, red and yellow using the following criteria. Is it water activated? Does it dry out (to reuse)? Is it the right shade? Does it dry right? Does it mix well with other colors? I first, got all my materials ready. I cut up all the fruits and vegetables (to make later steps easier).I put half a cup of water into a pot. I then put one cup of the fruit or vegetable into the same pot as the water. I put the pot with the ingredients on the stove, over medium high flame. I repeated steps two through five for all the fruits and vegetables. I then put all my steamed fruits and vegetables into a blender. After I had all my blended fruits and vegetables I sifted them through a sift. This gave me my final food die for the paints, except for the cabbage and radicchio. Since they are not many natural blue food we needed to add one teaspoon of baking soda to the cabbage and radicchio solution to make it blue. The reason it turns blue is because, cabbage and radicchio are naturally neutral. Baking soda is a base so, when it is mixed together the solution has a chemical reaction and the color changes. After this I mixed four tablespoons of baking soda, 2 tablespoon of white vinegar, ½ teaspoon of light corn syrup, and 2 tablespoons of cornstarch, all together. I added this mixture to the cupcake pan. I then added the color mixture to the paint solution and mixed. I repeated steps 11 through 13 for all the crops. I waited nine hours for the paint to dry. I then tested the paint using the criteria. I analyzed the results and drew my conclusion. My results said that red cabbage was the best for the blue, hibiscus was the best for the red, and jackfruit was the best for yellow.

The Evaluation of the Resuspension of Cyanobacterial Toxins into the Water Column in Eight Lakes

This study was focused on the potential of resuspension of sediments to introduce cyanobacterial toxins into the water during the winter. Climate warming may result in an increase of Cyanobacteria as they do well in warm climates and therefore challenge water quality. The issue is that some Cyanobacteria release Cyanotoxins that can be harmful to human health and aquatic ecosystems. Cyanotoxins accumulated in the sediment can be recycled into the water through resuspension events. By resuspending lake sediments in water and analyzing the water samples for toxin concentrations, the sediment is used to test for the potential of sediment resuspension to cause problems related to cyanobacterial toxins during the winter. I collected water and sediment samples from 8 different Lakes. The first test I performed was a Chlorophyll-a test that provided an estimate of algal biomass. I also tested for Microcystins and Anatoxin-a concentrations with Test Strips. More data was collected through World Lake Database for maximum depth and chlorophyll concentrations. Also, the EPA for Microcystins concentration and lake depth. In my overall findings, I concluded that the amounts of Microcystins and Anatoxin-a found in the Eight Colorado Lakes, including samples of water and sediments, were not concerning for the safety of the public if the toxins were re-suspended during the winter into the water. These results suggest that there would be no health risks associated. I was also able to conclude there was a positive correlation between an increasing amount of chlorophyll and Microcystin concentration in shallow lakes.

EcoGuardians

The purpose of this project was to determine the effects of soil runoff on various species of macroinvertebrates. I hypothesized that if the concentration of heavy metals increases then the number of macroinvertebrates will decrease because the metals will collect in the insect's tissue and guts. The experiment involved collecting macroinvertebrates from different areas of the Colorado River, putting them in buckets in a fridge to live, and add soil to two of the buckets to observe the effects. The data collected did support my original hypothesis. There was, on average, a significant decrease in macroinvertebrates in the two buckets I added soil to. There was a medium amount of magnesium and 100 ppm chloride, which could be one of the reasons they died off. These finding lead me to believe that soil runoff negatively impacts macroinvertebrates in rivers and streams. More testing is required to provide more accurate data.

*To Add or Not to Add: Possible Relations Between Nitrogen Fixing Bacteria and Nitrogen
Fertilizers*

The purpose of this experiment was to determine how nitrogen fertilizers affect the efficiency of nitrogen fixing bacteria which in turn will determine usable nitrogen in the soil. Based on research by Dr. Rick Haney that determined the nitrogen fixing bacteria aids in the production of corn. Therefore, if nitrogen fixing bacteria have nitrogen added to the soil they will be more efficient. The process of determining how nitrogen affects bacteria was simple. Four tubs were filled with soil, to be treated with either nitrogen fertilizer or bacteria. Initial soil samples were pulled and then corn was planted. After a three week growth period soil samples were pulled again. Plant growth was monitored throughout the growing period to determine if more nitrogen helped the plants grow more. Bacteria were also incubated for 24 hours to determine how the big of a role the nitrogen played in the growth of the bacteria. After the data was analyzed it was determine that when nitrogen and nitrogen fixing bacteria meet a greater increase in overall nitrogen will be seen than without adding the nitrogen to the soil. After the incubation test it was seen that nitrogen had helped the bacteria colonies to reproduce faster. Due to problems at the beginning of the testing periods plant growth was hard to use. The data suggests that there is a correlation in the efficiency of nitrogen fixing bacteria and adding nitrogen to the soil.

The Alamosa River Watershed: A Proving Ground for Natural Selection

The goal of this project is to describe the differences in macroinvertebrate species quantities, biomass, water quality, and dorsal brightness of plecoptera on several locations in the Alamosa Watershed. Examination of dissolved metals, nutrients, and pH/alkalinity/hardness/dissolved oxygen at the control site yielded the best water quality values. Water quality was poorest downstream of creeks that drain geologically altered sediments, and distance from these areas showed an improvement in water quality in the Alamosa River. Water quality at the mouth of Wightmen Fork (the creek draining the Summitville Superfund mining site) indicated the drainage is recovering from the leach pad/retention pond leaks in the late 1980's, but is still experiencing high levels of copper and zinc, placing stress on the aquatic fauna. Macroinvertebrates showed the greatest diversity at the control site, and several family groups were absent below the geologically altered creeks. Dorsal brightness (paleness) of several species of plecoptera seemed to correspond with substrate color, suggesting that these insects are responding to natural selection. This is significant because fish are either intermittent or completely absent from a large stretch of the middle mainstem of the Alamosa River, and this observed dorsal color pattern in stoneflies may indicate that fish may be migrating upstream from Terrace Reservoir, placing selective pressure on the stoneflies.

Tyler Nelson

The Temperature effect on a Physarum polycephalum's Diet

The purpose of this study is to see if the temperature of an environment changes how a Physarum polycephalum would go to food. Five compartments with three chambers were made to help control the temperature. A heat pad went in one chamber, ice in one, and nothing in the last one. Non-nutrient 2% agar formula was placed to cover the Acrylic sheet on top of the five compartments. Throughout the trials, an oat flake, rice flake, and oat and rice flake food sources were placed at the top of the compartments. Then five water droplets were placed on the foam sheet while a Physarum polycephalum sample was placed at the beginning. One drop of water was placed on the Physarum polycephalum. A clear plate was put on top to maintain moisture. The experiment ran for 12 hours over the course of a 3-day period. The control was then tested by only changing the compartments to make it room temperature. The more preferred food source the Physarum polycephalum liked best was also tested. The only thing changed was also the chambers to all room temperature. Over the 12-hour period, the Physarum polycephalum not only just stayed on the agar, but also went backwards. However, the control went to a food source every single time. The food the Physarum polycephalum liked best was the rice flake and the oat and rice flake. The data suggests that the chemotaxis or the plasmodium liquid of the Physarum polycephalum was affected by the temperature changes.

Isabella Rusk & Emika Brown

Distinguishing Microbial Communities in Low Elevation Ponderosa Pine Forests After Prescribed and Natural Burns

The resiliency of a forest ecosystem to fires depends on the microbial communities, and soil nutrients present in those environments. Fire is essential for the health of ponderosa (Pinus ponderosa) forests, like those found in many western regions, and have helped to shape ecological processes in these ecosystems. Soil microbial communities and soil conditions are important parts of forest ecosystems and can be impacted by the changes to the soil surface fires can generate. Here we investigate the relationship between soil microbial communities, soil nutrients, and forest resiliency in low elevation ponderosa forests in Boulder County, Colorado. Samples were taken from five different treatment sites that included two prescribed burns, one wildfire, and two controls. This study is the first in Boulder County to look at the impacts of fire on soil microbial communities and soil conditions in Ponderosa ecosystems. Water content and water capacity were analyzed and DNA electrophoresis was used to analyze the samples. DNA electrophoresis band comparisons revealed distinct differences among the treatments implying differences in microbial community fingerprints. Water holding capacity, a key indicator of soil nutrient availability, was found to have no statistical differences between treatments. This study suggests more research to be done to identify specific microbial species present in each treatment and further analysis of soil nutrients.

Emma Stone & Reiley Leake   2-07-302
Roots for the Road

Our project tested the theory that cattail roots could produce a sufficient amount of ethanol to be considered a viable supplement in the production of ethanol used as a clean burning fuel additive. We decided to compare the ethanol production of cattail roots to corn, the most commonly used product for ethanol production, and sugar beets, a product that has been considered as a supplement to corn. We tested our theory by using the same procedure to make ethanol from cattail roots, sugar beets and corn. For the first test we filled a container with 125 mg of distilled water. Then we added 1 gram of yeast. Next, we added 1 gram of dried and ground cattail roots to the mixture. Three probes measuring C02, temperature, and ethanol were attached through the top of a sealed container. A lab quest device took measurements through the probes every ten minutes for twenty four hours. This same procedure was repeated with ground and dried sugar beets and field corn. We analyzed the data and found that our hypothesis was incorrect. Cattail roots and sugar beets both produced a significantly greater amount of ethanol than corn. We feel that cattails should be considered for use to produce clean burning ethanol. This would allow more corn, the material currently in use to produce ethanol, to be used for food and for production of many other essential products in our economy including medicines, plastics and textiles.

Robert Vanderschaaff & Brei-Lynne Nelson   2-07-303
The Effects of ice Melts on Water pH

The intention of this research is to determine whether or not ice melts, specifically: calcium chloride, potassium chloride, magnesium chloride, and sodium chloride, affect the pH of water systems. The results that we are looking for are going to be strong enough that they could support a new regulation, restriction, or law that limits the amount of ice melts used or create a procedure that regiments how the ice melts can be laid on the ground. To discern these results we used the following procedure: 1) added 200 mL of water to four beakers, 2) used a probe to identify what the pH of the water is, 3) then we added a specific amount of each of ice melt to a corresponding beaker, 4) then tested the water to determine what the pH was after the ice melt was added, 5) we determined what the change in pH was. Our results found that there was a minor amount of change in the pH of the water, and not nearly enough alteration to support new regulations or legislation. This led us to the conclusion that even though the ice melts change the pH of the water, there is not enough change to warrant concern. However, this does not mean that the ice melts are not a negative influence on the environment, we are only stating that the pH is changed enough, but there is a need to further investigate how the ice melts change other abiotic factors.

Delaney Yehle, Dana Coe & Loren Rylander   2-07-304

Assessing Goat Browsing as a Form of Wildfire Mitigation and Its Environmental Impacts

The purpose of our investigation was to assess the efficacy of goat browsing as a wildfire mitigation tool and its environmental effects. We hypothesized that goat browsing would be an effective wildfire mitigation tool while increasing soil health and plant biodiversity. The experiment was conducted in Castle Pines, Colorado. Measurements were collected both pre and post goat treatment over six months. A total of 300 goats browsed the two experimental transects, while the control transect received no goat treatment. We measured soil health, biodiversity, and goat browsing efficacy. The data collected partially supports our hypothesis. To assess soil health, we measured nitrogen, phosphorus, potassium, pH, and organic matter. Nitrogen and soil organic matter both increased with treatment an average of 70 lb A/6 and 0.31% SOM respectively as compared to the control, while phosphorus, potassium, and pH, stayed consistent throughout all three transects. To assess biodiversity levels, we measured the number of plant and insect species, and the dominant species percentage along the transects and saw a decrease within the treatments and control. To assess wildfire mitigation efficacy, plant height to browsing was measured and showed a decrease an average of 14.8 m with goat browsing. These findings support goat browsing as a potential effective and environmentally friendly tool for wildfire mitigation and a promising start to a longitudinal study.

Senior Division Math & Computer Sciences

Elia Gorokhovsky   2-08-001
Assimilating Time-Uncertain Measurements in ensemble Kalman Filtering

The purpose of this study was to propose an inferential method for determining the extent of error in reported observation times. Analysis in a previous year's study uncovered a largely significant effect of time error on overall error when assimilating in a turbulent system. The method proposed to deal with this error succeeded in decreasing overall error, but required prior knowledge of time error. Because time error is generally not known in advance, it was necessary to determine time error during assimilation. Furthermore, because the previous solution required modifications to the system model, it was advantageous to create a more elegant solution to the problem that could be easily slotted into existing assimilation schemes. The method proposed herein involves finding the time that minimizes error in space at each assimilation step, then factoring it in to a discretely defined time likelihood. This likelihood could be directly included in the state variable likelihood in order to produce similar decreases in overall error to those seen in the previous year. The inferential method functioned exceptionally well when used with Gaussian random variables for time offset, with the inferred time likelihood matching the true distribution almost exactly. Goodness-of-fit tests returned p-values upwards of 0.999 for all tests - if the assumption that the probability distribution function for time offsets was zero-valued outside of an interval was eliminated, the p-values dropped slightly. The alternative likelihood method was not significantly different in result to the previous year's method or inflation. Further improvements are in progress.

Siddarth Ijju   2-08-002
Autonomous Anomaly Detection and Classification Using Neural Networks

Search and Rescue (SAR) teams are constantly facing problems such as a lack of volunteers, hard to navigate areas, and lack of connectivity. My project aims to address these issues by implementing a novel method that combines anomaly detection and object classification to quickly identify and classify anomalies in the field of vision on an autonomous low powered device such as a drone. The anomaly detection part of the project implemented a 3-layer neural network (auto-encoder). The auto-encoder was tested initially on a dataset of about 200 grayscale images with a Binary Cross-Entropy loss function, resulting in an accuracy of 23%. Subsequent trials increased the size and quality of the training data set and changed the loss function to a Mean-Squared-Error, resulting in an accuracy increase to 72%. Final trials involved changing the images to include color and gathering more data, achieving a final accuracy of 87.5%. For the subsequent Object Classification stage, a convolutional neural network called MobileNet was retrained to classify objects into categories of interest (backpacks, boots, hats, and water-bottles). The final classification accuracy achieved on the training set was 93%, after a previous trial accuracy of 53%. The two models were then compiled into a super model and deployed on an autonomous intelligent device with an AI-capable chip. The contributions of this project include performing real time object classification and anomaly detection that does not require Wi-Fi or cellular service, and can be extended to help SAR teams respond to floods, avalanches and other natural disasters.

Austen Mazenko   2-08-003
Characterization of Certain Non-Homogeneous Meta-Fibonacci Sequences

The Fibonacci recursion is one of the most beautiful recursive sequences in mathematics, possessing countless patterns and applications, but related meta-Fibonacci sequences are known for their chaotic behaviors and sensitivity to initial conditions. In this research, we considered the effects on the structure and order of meta-Fibonacci sequences which had non-homogeneous terms in their definitions. Java 7 was utilized to generate sequences with given recursions, which were then analyzed for patterns both graphically and through other methods such as finding successive differences of terms as well as asymptotics. General trends observed in such sequences, such as the eventual periodic nature exhibited by those with particular non-homogeneous terms, were noted and subsequently proven through mathematical methods. Additionally, drawing off of the observation that a majority of meta-Fibonacci sequences which have been thoroughly studied and found to exhibit sorts of patterns are slow, which is to say each term is either 0 or 1 greater than the previous term, we described an infinite family of slow meta-Fibonacci sequences with slow non-homogeneous terms. Using mathematical induction, the infinite family was proven to be, in fact, infinite, and patterns of its structure were described. This work opens up a new type of meta-Fibonacci sequence in non-homogeneous ones with not necessarily constant terms, and has possible applications both in chaos theory, when treated as discrete dynamical systems, and communications theory with regards to canceling out noise.

Stephen McDonald   2-08-004
Does Sample Size Affect Studies Done on Populations with Various Communities of Different Sizes?

I chose to study the effects of sample size on the outcome of a study because of the numerous ways populations are used to determine the path of companies, research, and even communities. Samples of a population, often referred to as "focus groups" are used to represent a population. They are used because of financial benefits but is it really worth the circumspect spending to not receive correct data after the study? This project weighs the pros and cons of different sample sizes and proffers the answer to this question. I used various colors of beans to represent a majority, a minority, and a neutral community in the population. I chose a small, medium, and a large sample size from the population and determined which size best represented the majority, minority, and neutral population.

Sara Nehring   2-08-005
Small World Networks: I Know Someone You Know, But You Don't Know It and Neither Do I

This year my project is based on the six degrees of separation which is the idea that everybody in the world is connected to each other through six people. I wrote a computer program that uses Dijkstra's Algorithm which is an algorithm that finds the shortest path between one node and all other nodes. I used the program that I wrote for Dijkstra's algorithm to create different types of networks and find the degrees of separation. I wrote three programs that created a random network, a clustered network, and a cluster in cluster network. With this project I learned how to us MATLAB computer language as well as learned a lot about networks in general. I also learned that it is incredibly difficult to correctly model a human world or network where people are separated by six degrees because there are so many factors and variables that I can change that will drastically change the outcome. In the real world the degrees of separation is used in social media and how people have recommended to follow or be friends with.

Learning to Player Hammurabi

Two types of machine learning algorithms, along with one heuristic-based approach were used to play the game, Hammurabi. Two reinforcement learning-based algorithms and two genetic algorithms attempted to play Hammurabi. The reinforcement learning algorithms used were Q-Learning and Policy Gradients. The genetic algorithms used were Neuroevolution of augmenting topologies (NEAT) and Bill Ray's Artificially Intelligent Networks (BRAIN). Hammurabi's large state and actions spaces presented a challenge for the reinforcement learning algorithms and it would have been interesting if the reinforcement learning solutions could have been modified to overcome this challenge and perform well. The three different types of algorithms were compared, and the genetic algorithms outperformed the reinforcement learning algorithms and the heuristic-based approach.

Senior Division Medicine & Health

Natali Shaw   2-09-001

Color War

Does color really affect how you feel? What can I do to better or enhance the mood I'm in? Well to figure this out I performed multiple tests to prove that colors do in fact change a person's heart rate. My test consisted of sitting in a dark room with colored lights for 30 minutes, checking my heart rate every five minutes. From this data I concluded that color does in fact change a person's mood. Red for example is a very "energizing" color. With an average heart rate of 76.28 beats per minute, this color increased my heart rate the most. Following the color red is the color pink with 70.71 bpm. Next come yellow (70.42) and orange (70.14) bmp. From my tests I have concluded that colors such as red and pink made me feel anxious. I think this might be because of how these colors increased my heart rate. The color green however surprised me. With an average of 69.85 bpm I found that green is the most "normal" color, meaning that this color barely affected my heart rate at all. Purple and blue I found are "calming" colors. With an average of 65.14 bpm, purple reduced my heart rate a noticeable large amount. However, the color blue, with an average heart rate of 63.28 bpm is a significant drop, showing that blue is the most calming color. After my research, my data strongly supported my hypothesis. I hope that in the future this will help others prepare for their day. Whether it is an important meeting, a game, or a nice relaxing day by yourself, colors truly do make an impact!

Daniela Acosta   2-09-002

What Are your Pulse and Oxygen Levels?

The purpose of this experiment was to determine the resting and exercised pulse and oxygen levels of people that are conditioned to exercise versus people that aren't conditioned to exercise. I hypothesized that the group conditioned to exercise will have a lower pulse and oxygen levels. To test my hypothesis I gathered my subjects after school in the gym for two days a week for two weeks. I took their resting pulse and oxygen levels and recorded them. The data table included subjects age and conditioned and unconditioned. Subjects used the elliptical for three minutes at their full capacity. Pulse and oxygen levels were then measured. My hypothesis was proven partially correct. I found that the subjects that do exercise do have a lower pulse, but the oxygen levels were about the same for both conditioned to exercise and unconditioned to exercise subjects. This information is significant because the heart circulates oxygen and nutrient-rich blood throughout the body. When it's not working properly, just about everything is affected. A really slow heart rate (depending on your age) can indicate good things it can also indicate bad things like heart disease. A fast heart rate might also indicate that you have some sort of infection. Knowing your normal oxygen and heart rate can help people better understand their health and that is an important step to healthier people and healthier communities and we all benefit from healthier communities. Being healthy can lead to being more happy.

Edwin Bodoni

Bruxism: A Novel Diagnostic Approach

Bruxism is the involuntary grinding and/or clenching of teeth, which is characterized by contractions of the jaw muscles and development of forces high enough to excessively burden the masticatory system. Since bruxers are usually unaware that they grind their teeth, this condition often goes undiagnosed until irreversible damage occurs. Although extensive research has been conducted on this topic, there is currently no objective and cost-effective clinical diagnostic method for assessing bruxism. Most of the time, bruxism is still only diagnosed based on clinical examination and patient history. With the aid of an original device (a novel bite force recorder), this study explored the existence of a correlation between individuals' maximum bite force (MBF) values and bruxism. The results of this study showed that MBF values recorded for bruxers (967N for males and 740N for females) were dramatically higher than those for non-bruxers (611N for males and 459N for females). Since occlusal guards help masticatory muscles relax and lose their hyperactive status, splint therapy is the standard procedure for treating bruxism. The present study demonstrated that MBF values recorded for bruxers after four weeks of splint therapy decreased by 27% for females and 23% for males. These results support the hypothesis that measuring the MBF could provide useful data for the evaluation of jaw muscle function and activity, and MBF values could be instrumental in diagnosing bruxism. With bruxism being on the rise, further research is required to develop easier and more effective methods to diagnose this condition.

Mindi Carr

Knee Tension

The effects of knee angles on a hyperextended knee joint strain. The purpose of this investigation is to determine if more acute knee angles injure and strain the quadriceps tendon more than obtuse angles. This is important to others because people have knee problems and/or experience knee pain during activities and discovering the knee angle that puts the most discomfort or strain on the knee will help others in activities. If the angle of the hyperextended knee becomes more acute then the quadriceps tendon will be intensely stretched greater than at a more obtuse angle which shows that as the angle becomes more acute there will be more strain and discomfort on the knee. A mechanical hyperextended knee model was built. To measure the strain put on the quadriceps tendon Hooke's Law was used ($F = -kx$). Measure the length of the spring at rest. Measure the stretched length of the spring needed to hold the knee joint in place at a series of different angles then subtract the original length of the spring. Add weight and repeat again. The data showed that as the hyperextended knee joint angle became more acute the strain and stretch on the quadriceps increased. When weight was added the model could not hold the dumbell because it was not distributed across the whole body and/or model correctly.

Flu Vaccine's Accuracy

The purpose of this study is to find out how accurate and effective the influenza virus vaccines are for the 2016 and 2017 influenza season. Each year, an average of 140,000 to 710,000 Americans are hospitalized due to flu symptoms. It is estimated that each year deaths from flu viruses range from about 12,000 to 56,000 and the flu causes 9.2 to 60.8 million illnesses. Despite 157 to 168 million doses of injectable influenza vaccine for the U.S. market, the number of deaths is notably higher, indicating the ineffectiveness of the vaccines. This experiment will include using the NCBI's BLAST program, to compare influenza strains subtyped to strains used in the season's vaccine. For each influenza strain, hemagglutinin and neuraminidase sequence was compared with vaccine's sequence. After each comparison, identity number (percent of accuracy) was found under the alignments section. The 2016-2017 vaccine was only 41.25% effective in protecting the patients against certain diseases. Less than half of the patients were protected which indicates that vaccine itself alone is not the best protection. Redesigning the Switzerland and Phuket vaccine increased the effectiveness from 41 percent to 95 percent. Even though, vaccines never have a 100 percent accuracy rate, it is still important to get flu shots every season, as the vaccine may provide some protection to the virus, even reduce the severe symptoms, and also help protect not only the vaccinated person, but also others around them.

Spoorthy Reddy   2-09-006

Determining the Role of Ferroptosis in Parthenolide and Its Analog Mediated Cell death in AML

Parthenolide (PTL) is a drug that is shown to selectively target cancer stem cells, unlike most current cancer treatment options. PTL's intermediate, MMB, is miscible in water, unlike PTL, and produces highly selectively cytotoxic dimers (JVM), which may be useful to study. The goal of my research is to determine whether PTL and its analogs use ferroptosis as a mechanism of cell death, which may explain why these drugs can selectively target cancer stem cells. Current literature indicates that PTL uses apoptosis as its mechanism of cell death. However, the pathways targeted in experiments conducted to determine whether PTL uses apoptosis are also affected in ferroptosis, another mechanism of cell death. To determine whether these drugs use ferroptosis, I investigated cytotoxicity with ferroptosis inducers and inhibitors, protein levels, and glutathione levels. I found that PTL uses ferroptosis but MMB does not use ferroptosis, which was unexpected, considering that it is PTL with the addition of a hydroxyl group. I discovered that PTL's dimers, JVM, partially use ferroptosis and partially use another mechanism of cell death to selectively induce cancer cell death. This study offers new insight into the mechanisms of PTL and its analogs in selectively inducing cancer cell death and may enable the discovery of a novel mechanism of cell death that is used by JVM in addition to ferroptosis. These findings may also lead to the determination of the specific pathway used by ferroptosis to selectively target cancer cells, which can be further targeted to create a new drug.

The Effect of Ketoacidosis on the Breath: A Cost-Efficient Way to Monitor Ketones

Insulin levels in diabetics are monitored by checking blood glucose levels. When there is not enough insulin in the body, hyperglycemia occurs. In extreme cases, diabetic ketoacidosis (DKA), may occur resulting in the production of acetone, a ketone, and the by-product isopropanol, an alcohol. Both acetone and isopropanol are exhaled through the breath. When using a breathalyzer with a semiconductor oxide-based sensor, there is the possibility of detecting isopropanol, because the sensor is not specific to different kinds of alcohol. The purpose of this research was to determine if correlations could be made among blood alcohol levels (BAC) reported by a breathalyzer test and/or a ketone or blood glucose test. The alternative hypothesis states if there is a case of DKA, then correlations can be made between the blood alcohol levels reported by a breathalyzer test and the blood glucose/ketone test. If the hypothesis is maintained, the breathalyzer should register a reading above 0.00 when the blood glucose levels are found to be greater than 250 mg/dl. Five, juvenile, Type-1 diabetic test subjects were asked to do a minimum of three breathalyzer tests per day in conjunction with normal blood glucose testing for a thirty-day period. A ketone test was conducted if blood glucose was below 250 mg/dl, but blood alcohol content was above zero on the breathalyzer; or if blood glucose was above 250 mg/dl. Statistical analysis was conducted using a correlation test, t-test, and p-values (α=.05). No correlations were found with BAC because of inconclusive results.

Investigating the Development Requirements of Sex Chromosome Genes Affected in Turner Syndrome

Turner Syndrome (TS) is the set of phenotypes associated with the 45, X karyotype, which is the result of a missing second sex chromosome in women. We hypothesized that a precise expression of candidate TS genes located on the sex chromosomes is required for viable human development, implying all living TS patients are mosaic and only some of their cells are missing the second sex chromosome. First, we set out to optimize DNA probes that could specifically bind to the X and Y chromosomes for fluorescent in situ hybridization (FISH). We used a Y chromosome probe in mouse tissue to test the FISH protocol on formalin fixed paraffin embedded tissue sections. We optimized the human X chromosome probe on human embryos to detect mosaicism. Additionally, we analyzed RNA sequencing data on developing embryos for expression of TS candidate genes. The following genes were highly expressed in 46,XX and 46,XY samples and may therefore be haploinsufficient in TS: RPS4X, TMSB4X, DDX3X, EIF1AX, RPS4Y1, DDX3Y, EIF1AY, SLC25A6, and CD99. Through quantitative polymerase chain reaction analysis of samples from lymphoblastoid cells, TS samples (45,X) were found to have lower expression of these genes when compared to controls. The results in this study support the hypothesis that changes in expression level of TS genes are responsible for the TS phenotype. Our analysis of TS candidate gene expression can lead to targets for gene therapy or exogenous replacement of proteins coded for by these genes, resulting in better health care for TS patients.

Kaitlynn Alcorn & Shalynn Hoffman   2-09-301
The Effects of Caffeine on Daphnia and H. Dujardini

Different types of 1,3,7 trimethylxanthine (caffeine) seems to affect the heart rates and bodily functions of H. Dujardini, and Daphnia. The original thought was that the amounts of caffeine would negatively affect the overall condition of the little creatures. The chance of these creatures surviving were highly unlikely, while some did die during the research process most lived. When using the microscope to observe the H. Dujardini and Daphnia there were attempts to take pictures of the microscopic water animals. Due to the fact that they were microscopic it was difficult to take the pictures. In the end of the experiment when observed it was noticed that caffeine does affect these two small animals.

Hailey Chapman & Valerie Warkins   2-09-302
Lactates Effects on Mitochondrial Phospholipids and Function

Levels of blood lactate increase in several different types of diseases involving mitochondrial dysfunction including heart failure. Previously, lactate was believed to be a side effect of mitochondrial dysfunction but recently some have started to think it might be a signaling molecule affecting the mitochondria. We set out to determine the effect of lactate on heart cell mitochondria. We focused on cardiolipin, a mitochondrial lipid, which is an integral part of the electron transport system. When a heart cardiolipin contains linoleic acid it is in its most functional form and electrons can flow through the membrane efficiently. For our project we added lactate to neonatal rat cardiomyocytes (which were harvested by a member of the lab at CU Anschutz medical center) and investigated cardiolipin composition with mass spectrometry, mitochondrial function and reactive oxygen species with high-resolution respirometry, and gene products of the cardiolipin synthesis and remodeling enzymes with PCR. We found that lactate causes a switch away from the most functional form of cardiolipin to a less efficient form with oleic acid. We also found that the mitochondrial function decreased when treated with lactate and reactive oxygen species increased. Lactate also causes an increase in the synthesis gene in cardiolipin and decreases in two remodeling genes which put the linoleic acid on cardiolipin. In conclusion, lactate in heart cells affects the mitochondria through decreasing the functional form of cardiolipin leading to a decrease in the efficiency of the mitochondria and an increase in the production of reactive oxygen species.

Characterization and In Vitro Differentiation of Myeloid Derived Suppressor Cells

Myeloid-derived suppressor cells (MDSC) are a population of heterogeneous cells whose further characterization could lead to the development of an antitumor drug due to the heavy role of MDSC in cancer cell growth and metastasis. Research into MDSC is limited due to their severe heterogeneity and inability to be produced in large quantities in vivo. The purpose of this experiment was to develop an efficient method of in vitro differentiation and to further characterize MDSC. In order to study these enigmatic cells, MDSC were differentiated in vitro using bone marrow derived from the C57BL-6 (black-6) laboratory mouse strain and conditioned medium required for differentiation from BALB/c 4T1, murine mammary carcinoma cells. The amount of G-MDSC and M-MDSC, the two recognized populations of MDSC, present was measured with flow cytometry utilizing the fluorescently tagged CD11b, Ly6C, and Ly6G antibodies. Additionally, an evaluation of the effects of interleukin-6 (IL-6) on MDSC differentiation was performed. The presence of this cytokine was determined through an ELISA, and the overall effects of IL-6 on MDSC differentiation was quantitatively measured through IL-6 depletion and addition assays. This study suggests that MDSC can be differentiated in vitro, producing significant amounts of M-MDSC and G-MDSC that are physiologically and morphologically similar to those differentiated in vivo. In addition, IL-6 was determined to be crucial to MDSC differentiation. The experimentation yielded MDSC with a Ly6C+Ly6G+ phenotype, which has not yet been recorded, potentially indicating discovery of a new cell type, or high plasticity of MDSC.

Senior Division Microbiology & Molecular Biology

Isla Anderson   2-10-001

Anthropogenic Induction of Antibiotic Resistance by Sulfamethoxaozle

Antibiotics are not fully processed by the body, remaining active when excreted. Municipal water and wastewater treatment plants do not have the technology to filter antibiotics from fluids that make their way to waterways and ultimately become drinking water. In these waterways, bacteria have contact with antibiotics that either kill the microorganism, or force bacteria to develop resistance in order to survive. The objective of this study was to examine if non-resistant Escherichia coli could be forced to develop resistance when subjected to elevated concentrations of sulfamethoxazole. Concentrations were chosen to simulate those found along the Platte River to show how current environmentally relevant concentrations found in local waterways have the ability to cause non-resistant bacteria to develop resistance. To simulate sulfamethoxazole levels found in the Platte River, a 12"x 20" 'mega' plate was constructed containing five sections with varying amounts of Sulfamethoxazole—0mg/L, 162.5mg/L, and 325mg/L. Non-resistant E.coli was inoculated across the concentrations and assessed for growth for five days. From growth that occurred across the plate, 20 samples were chosen for analysis to confirm the growth was due the initial E.coli. A two-pronged approach, utilizing biochemical and molecular analysis was employed to verify that the bacterial growth on the plate was the same as the starting strain of E. coli. Results showed nearly all collected samples were the same as the initial E.coli strain, demonstrating an induction of antibiotic resistance in a previously non-resistant strain.

Owen Beute   2-10-002

Coliform Bacteria in Front Range Water

The purpose of the experiment was to find out which major city in the Front Range had more coliform and water-based bacteria in its public water supply: Colorado Springs or Denver. To test the experiment, samples were taken in plastic sample bottles and filtered twice to reduce sediment and floc inside the sample. 5 mL of the water was evaporated in 100 mL glass beakers in order to let bacteria settle at the bottom that could be swabbed directly onto the Petri dishes. Each of the ten samples was swabbed onto Petri dishes for replication and was grown in an incubator at 32º Celsius for 48 hours in order to give the bacteria enough time to form visible colonies. Using a graph paper method, the average number of colony-forming units for each Petri dish was able to be counted, so that the average for both cities could be taken to test the hypothesis. After the colonies were counted and averaged, the sites of water in Denver had drastically more colonies on average than those of Colorado Springs, and the range of colonies per source ranged from the upper three thousands to the lowest count of three. The experiment concluded that Colorado Springs had cleaner public water than that of Denver, which may have been caused by the snow that had recently fallen when samples were being taken. The number of average bacterial colonies in Denver in all samples averaged higher than samples located in Colorado Springs.

Anand Chundi   2-10-003
   Identifying Downstream Targets of HCFC1: A Gene Linked to Severe Neurological Disease

Derivatives of cobalamin (Vitamin B-12) are important to the function of enzymes required for metabolism. Failure to convert cobalamin into its derivative forms leads to build up of methylmalonic acid and/or homocysteine in blood and urine. One of the genes responsible for the metabolism of cobalamin is MMACHC. Combined methylmalonic acidemia and hyperhomocysteinemia type cblX is characterized by missense mutations in HCFC1, a global transcriptional regulator that is associated with severe neurological disease. Individuals affected by cblX have craniofacial symptoms that are more severe than other cobalamin disorders, most likely caused by the dysregulation of other downstream genes of HCFC1. Analyzing RNA sequencing data from a cblX-affected-individual, 4 candidate genes were identified and their expression was tested in various zebrafish knockouts of hcfc1a, a zebrafish paralog of the human gene HCFC1, with qPCR (quantitative Polymerase Chain Reaction). Preliminary experimental results show that hcfc1a regulates the gene grin2aa, which is a neurotransmitter shown to be associated with epilepsy, autism, and intellectual impairment.

Brecken Dobbs   2-10-004
   Investigating Capsicum frutescens as a Means of Treating Common Bacteria in Sinusitis

Chronic sinusitis is an inflammation of the tissue lining the sinuses which can become blocked and filled with fluid causing infection. It is often treated with OTC drugs that are not always effective. I ran across an article about Capsicum frutescens (cayenne pepper) and its natural uses and it sparked my interest. The goal of this study is to determine the ability of capsicum to fight off streptococcus bacteria and staphylococcus bacteria which are often the cause of chronic sinusitis. The Kirby Bauer method was used for initial testing. A sterile disc was soaked with capsicum and placed in the middle of each half of the petri dishes which were streaked with Streptococcus and Staphylococcus. Dishes were incubated for 48 hrs at 35° C. In a second test the capsicum solution was placed in the bacteria stock cultures. Each bacteria/capsicum was streaked onto the appropriate petri dishes. Dishes were incubated for 48 hrs at 35° C. Quality control samples were used in both tests. Initial test results were as followed: 0 growth inhibition with test 1-4 Streptococcus and Staphylococcus. Both QC showed 0 growth inhibition. Second test results were as followed: total growth inhibition with test 1-4 Streptococcus pneumoniae and 0 growth inhibition with test 1-4 Staphylococcus aureus. The results of this study indicate that when the bacteria and the capsicum treatment interact together it is effective in inhibiting the growth of Streptococcus pneumoniae. Applications of these findings indicate that capsicum could be used to suppress chronic sinusitis.

Peyton Leyendecker   2-10-005
   Optimizing the Ratios of Manuka Honey t Adhesive in an Antibacterial Surgical Adhesive

The purpose of this science project was to optimize the ratios of Manuka honey solution to adhesive in an antibacterial surgical adhesive. Specifically, the different ratios were investigated to determine how they affected the strength of the adhesive and the bacterial growth on stimulated wounds sealed with the adhesive. To determine how the differing ratios affected the amount of bacteria on the simulated wound, slits were cut in pieces of meat on which the different formulations of the adhesives were applied, and swabs were taken a day after the adhesive was applied. There was a linear decline of bacteria on the wound as the Manuka honey solution in the ratio increased, while the adhesive strength differed depending on the percentage of honey solution added.

Calcite Production in Cyanobacteria

In order to manufacture concrete, limestone, along with other ground materials, must be heated at very high temperatures in kilns that are mainly fueled by coal. During the heating, the ground limestone is heated nearly to its fusion temperature, driving off carbon dioxide from the calcite, and only calcium oxide remains, which is later used in actually making the cement. However, the emissions from fossil fuel combustion and production of cement contributed to 3.4% of global carbon dioxide emission in 2000, and the number has only increased since then. Cyanobacteria are photosynthetic organisms can survive in a wide variety of environments and need very few resources to thrive and make calcite, an ingredient necessary in cement production. Cyanobacteria have the ability to concentrate carbon dioxide in proteinaceous compartments called carboxysomes. Carboxysomes are located inside cells and work to concentrate the CO_2 and "fix" it to make sugars to use for cell survival. For this study, Synechococcus 7002 was the strain of bacteria that was used, including a mutant strain labeled ΔCCM. Through experimentation, a physiological condition was designed where the Synechococcus 7002 bacteria were able to produce calcites. Additionally, different carbonate precipitates were identified (vaterites and aragonites). It was determined that the CCM mutant could not grow in air because their carboxysome structures are unable to function, leading to cell death. CCM mutants grow astonishingly well in CO_2 because the cells are equipped to survive in the presence of CO_2 even without carboxysomes.

The Effect of Caffeine vs. Energy Drinks on the Heart Rates of Daphnia

The purpose of this study is to gather more information on whether it is the caffeine contained in energy drinks or the entire concoction of caffeine, sugars and chemicals that result in the numerous cases of hospitalization and deaths from their consumption. Two main portions of this experiment are conducted. In the first 6.8%, 10.2%, 13.6% and 17% solutions are created using water and either Monster Energy Drink or caffeine. The daphnia are exposed to the solution for 1 minute before being assessed under a microscope. The second portion of the experiment is an acclimation study in which daphnia are exposed to the 10.2% solution of either caffeine or Monster (5 trials each) for 30 minutes, and reassessed every 5 minutes. In the first portion of the experiment, daphnia exposed to caffeine demonstrated a higher average heart rate that those in Monster, separately factoring in the daphnia that died and not. During the acclimation portion daphnia exposed to caffeine showed a higher heart rate than those in Monster; however neither caffeine nor Monster showed a downward trend. in the observation tables, however, several patterns emerged including the numerous deaths of daphnia in Monster compared to the very low death rate in caffeine as well as their physical reactions, including death. The data suggests that caffeine does speed up the heart rates of organisms, more than energy drinks, but the number of deaths indicates how dangerous Monster is for one's overall health.

Milk vs. Aerobic Bacteria

Milk is a substance that is consumed to help get daily nutrients of calcium and protein. According to the USDA in 2012, the per capita consumption was 90.2 kilograms (198.8 pounds). A downside to milk is, it spoils. When milk spoils, it separates into citric acid and fat. Milk spoils because the aerobic bacteria gets into the protein coat of the milk cells. The researcher wanted to know if antibiotics can prevent spoilage when milk is exposed to an increased temperature. It was hypothesized if milk samples were exposed to an increased ambient temperature, then the rate of bacteria growth will decrease when exposed to antibiotics. To test the hypothesis, the researcher purchased samples of pasteurized organic, non-organic, and camel milk. Samples of each milk type were plated using nutrient agar plates. Antibiotic discs, including chloramphenicol, kanamycin, streptomycin, and penicillin were used to test antibiotic resistance. A control disk was also used. Plated milk samples were exposed to the heat for five days, at temperatures of 25℃ 30℃ and 45℃. After five days, the plates were evaluated and data was recorded. After data was collected, the hypothesis was concluded to be null. It was concluded that bacteria would not grow on the petri-dishes with temperatures above 35℃. There was also no evident zone of inhibition on organic or non-organic milk like the researcher hypothesized.

The Best Way to Disinfect Kitchen Sponges

The purpose of this experiment is to let people know the safest way to disinfect their kitchen sponges in an easy way by commonly used house appliances without having to get new, clean ones every two weeks. The experiment was designed by testing 16 sponges in total, 4 in each group. While one group is a control variable- where the sponges are not disinfected, the rest of the 3 groups is each put into a dishwasher, washing machine, or a microwave. Before "disinfecting" the sponges, all 16 sponges are infected by wiping down 2 even sprays of fruit punch on a clear table for 6 days, also being left dry. On the 6th day, the 1st group is left in the dishwasher at full normal cycle, 2nd group is being cleaned in a washing machine at full normal cycle, and the 3rd group is left in the microwave at full power, 2 mins. All kitchen sponges are spread evenly onto nutrient agar plates and left in the incubator for 48 hours at 32 ℃. Bacterial Colonies are then counted to determine how dirty the sponges are. As shown in the graph, sponges disinfected by the microwave had the least number of bacterial colonies while the washing machine had the most counts of bacterial colonies. Inferences such as the kitchen sponges may get more infected by absorbing the filthy water when getting "cleaned" in the dishwasher and the washing machine. Also could make an inference that heat is the key when killing bacteria.

Evelyn Bodoni & Nicole Hankovsky   2-10-301

Novel Strategies for Detecting and Treating Podocyte Injury in Diabetic Nephropathy

Diabetes is a multifactorial disorder, characterized by chronic elevation of glucose in the blood. Chronic exposure to high glucose (HG) is a leading cause of cell damage, which is responsible for diabetes' numerous complications. Since diabetes is an energy metabolism dysfunction disease and mitochondria are the cells' power generators, it is believed that these organelles play a central role in the pathogenesis of diabetic complications. Consequently, finding new therapies to restore mitochondrial function is essential. Our study investigated if supplementation with beta nicotine amide mononucleotide (NMN) or with a combination of NMN and cyclodextrin (MBCD) is effective in reducing podocyte injury in diabetic nephropathy. By utilizing advanced microscopy methods, this study indicated that human podocytes which have been exposed to HG conditions and were treated with these pharmacological agents displayed improved mitochondrial function in vitro. Treatment with NMN alone or with the combination of NMN and MBCD reduced co-localization with lipid droplets, partially restored mitochondrial volume (via confocal microscopy), improved altered mitochondrial shapes (via STED), reversed glycolysis and restored oxidative phosphorylation (via FLIM). The present study provides experimental evidence that NMN alone or in combination with MBCD attenuate mitochondrial changes and metabolic reprogramming in podocytes, which could be a potential therapeutic strategy for treating diabetic nephropathy.

Senior Division Physics

Eric Bauman   2-11-001

In the Absence of Air Revisited

The purpose of this project was to test if the environment (air, vacuum) would affect the charge depletion time, power output, and temperature of a lithium-ion battery. I hypothesized that in a vacuum, the charge depletion time and temperature would increase, and the power output would stay constant. This experiment involved placing lithium-ion batteries in a circuit in a small vacuum chamber attached to a multimeter and a thermometer and letting the circuit drain the batteries. A video camera recorded the time and the readings from the multimeter and thermometer. The data collected partially supported the original hypotheses. These findings lead to the conclusion that the environment (air, vacuum) did not affect the charge depletion time, power output, and temperature of a lithium-ion battery. The data ranges for air and vacuum respectively were 0.9 and 0.92 hours for charge depletion time, 2.56 and 2.53 volts for power output, and 4 and 0 degrees Celsius for temperature, all covering about the same range of data. Therefore, it is reasonable to conclude that whether lithium-ion batteries are in air or a vacuum has no effect on charge depletion time, power output, and temperature.

Jasmine DeMeyer   2-11-002

Totally Tubular: Calculating the End Correction to Find the Wavelength of a Wave in an Open Tube

My experiment is based around a lab done where you calculate the sound of speed in an air column. My goal was to find out what the end correction need to be in order to find the anti-node that occurs just outside the tube. I did some research and found two commonly used end corrections, one being 1.6 and the other being 1.2. For my experiment, I created five expandable tubes with different diameters. I then put the tubes through a box and played a frequency through one end of the tube. I found the length of tube that produced the loudest sound and kept the tube at that length. I then played frequencies of 200Hz, 400Hz, 600Hz, 800Hz, and 1000Hz each five times through the tube. I used the sound level meter to see when the level of sound stopped going down and began to increase again, which is where the anti-node occurred. After averaging out all of my results, I took my average distance for each diameter and divided it by the diameter with which it correlated. Once I averaged all of those out, I came up with a final end correction of 1.27. This experiment allowed me to take an interesting turn on a common experiment. If I were to continue with it, I would want to test more extreme diameters and less common frequencies just to see how the results differed.

Fionna Kopp
Voltage-Potential Profiles of Glow Discharges Using an Emissive Probe

Voltage-potential profiles through glow discharge regions produced in a glass vacuum tube ~1 m long with a cathode and anode 46 cm apart under various pressures—12, 36.5, and 113 mTorr—are characterized by an emissive probe to better understand electron and ion kinetics of each region. Currently, there is a lack of published measurements beyond illustrations. A voltage of -800 V was applied to the cathode through a resistor of 12 kOhm. A large potential drop occurs in the cathode dark space due to the formation of a cathode sheath which causes electrons to be shielded from the cathode surface while ions strike the cathode with high energies causing secondary electrons to be emitted. These secondary electrons cause ionization forming the negative glow and are then reaccelerated by a weak electric field in the Faraday dark space. Through the negative glow and Faraday dark space, the potential reaches a plateau. In the positive column, stair-step like multiple double layers correlated with the light/dark striations. Electrons lose almost all of their energy due to ionization and are reaccelerated to ionization energy between striations by these double layers. The potential step in each dark band is approximately 13 eV—the ionization energy for N2 and O2. As the neutral pressure increases, the electron-neutral mean free path decreases resulting in thinner striations and double layers. At high enough pressure, the striations of the positive column merge toward fully illuminating the entire positive column corresponding to a linearly increasing potential ramp toward the anode.

Molly Nehring
Far Out! Analyzing NASA's Kepler Space Telescope Data Using the Transit-Timing Variation Method to Discover Additional Exoplanets in Planetary Systems

The goal of this project is to utilize the public database of NASA's Kepler Space Telescope and analyze the data of single-star-single-planet systems to potentially discover additional exoplanets. Kepler discovers planets using the transit method, where the light of a star is observed continually. If a planet is orbiting the star, it periodically crosses in front of it, creating a small decrease in its host star's light. The transit-timing variation method is a well understood but technically challenging way to discover additional exoplanets in these systems. Using a pre-confirmed planet's light curve file, one can calculate and investigate differences in the discovered planet's orbital period, indicating that the gravitational force of an additional object in the system is having an effect on the confirmed planet's orbit. I developed a computer program that could model a one-star-one-planet system with a second planet in order to observe to what extent an additional object's gravitational effect would affect a "discovered" object's orbit. I then developed a computer program to find the exact start and end of planetary transits and used that information to calculate the orbital period of each planet I was investigating. In the end, after sorting through and analyzing the data of about 300 Kepler objects, I discovered three potential planetary candidates. Their orbital periods varied consistently and by a large margin over time, indicating the presence of an additional object in the system.

Emma Schmit   2-11-005
The Effects of Magnetism and Algae on Voltage on Tin Oxide Plates

Globally 1.2 million people go without electricity and "ninety-five percent of these people are either in sub-Saharan Africa or developing Asia, (International Energy Agency). The primary energy sources around the world (oil, fossil fuels, etc.) have created a dramatic change in the Earth's climate and have negatively impacted the world's wildlife and ecosystems. This experiment used natural algae growth found in water and magnets as a way to create a renewable and environmentally friendly energy source; the increase of electrons that both the algae and magnets create will help generate a more powerful energy source. Tin oxide plates, which produce no voltage, are placed in water that contains algae, collected from fish tanks full of nutrients and natural growth, while magnets are placed in varying positions to test and observe either an increase or decrease of voltage.

Kyra Slovacek   2-11-006
Diurnal Variation and Duration of Meteors Usable for Radio Communications

This project set about to build a radio astronomy station capable of receiving radio signals reflected from ionized meteor trails to measure two important characteristics affecting their use in one type of radio communications system. The parameters of interest are: diurnal variation of the rate of meteor occurrence and the distribution of meteors of different durations within a population. In order to measure this, a pair of systems was developed and data ultimately combined to arrive at a prediction which could be shared with users of this medium to optimize their communications based on these parameters. To measure diurnal variation, an antenna, receiver, and signal processing were employed to count occurrences per hour. The collected dataset was averaged across days, by hour, to generate an "average day" which followed the expected sinusoidal pattern showing a maximum at ~04:00 and a minimum at ~16:00 local time. To measure duration, the previous system was extended with an additional filter and detection algorithm which measured the time during which each meteor reflected the signal. Detections were then grouped based on duration with each group's proportional size following the expected decaying exponential trend. Analysis of the data from both systems allowed for combining to produce a product distribution. As this accounts for both diurnal variation, using the sinusoidal pattern, and duration, using a distribution generated based on the decaying exponential, the resulting graph is a useful reference for those users of this means of communications.

Finn Bridgham & Mason James   2-11-301
On the Comparison of Drone Propellers

Drone racing is a new and exponentially growing sport. Because of the nature of new sports, there is much room for modification and innovation, so in this experiment we are testing the max thrust for each type of propeller. There are many kinds of drones and modifications of them that could have been tested, so for the sake of simplicity, this study will use a modified Blade Inductrix quadcopter, colloquially termed a Tiny Whoop. Put standard four bladed propellers on the quadcopter; Attach the micro quadcopter to the scale; Zero the scale with Micro quadcopter on it; Boot up Micro quadcopter with fully charged Battery; Fly Full throttle upward with Micro quadcopter; Record data for each second for 3 seconds (3 data points); Repeat B through G with three bladed propellers; Repeat with the two bladed propellers. Results for Thrust (Newtons): Four Bladed: avg. 0.193 N; Three Bladed: avg. 0.231; Two Bladed: avg. 0.228 N. This test did not support our hypothesis as the data was inconclusive. Moving on we will test this to have less of a margin of error with the scale. In our most recent experiment we noticed that the four bladed propellers had a lower average thrust, which might be caused by the fact that it had more mass to spin up.

Cameron Eldridge, Patrick James & Tyler Woodbrey 2-11-302
Inductive Power Transfer

The rapid growth of technology is a defining characteristic of human history. Our ability as humans to consistently improve upon technique, models, and ideas is the key to our years of success. In the past years, we have witnessed many technological advancements in the field of power transfer methods. From solar panels to dams, ideas have been rethought over the past decade. A particularly noticeable trend is the increasing absence of wired, which used to be considered detrimental to the transfer of electricity or information. Our phones connect to the internet through Wi-Fi: a completely wireless connection to a router which in turn connects a device to the internet. Wireless Keyboard, mice, and eve speakers have been trickling in throughout the past decade. Recently, wireless charging for phoned has increased in popularity. But how "high-tech" is this? For our project, we wanted to explore the ins and outs of wireless power transfer. Our experiments led us to believe that is was in fact possible to power a single Light Emitting Diode (LED) by using alternating currents produced by induction coils. Though this may seem like and easy task, transferring power through the air will be difficult goal to obtain. Operating at a high enough efficiency to create light is a truly daunting task. Through this project, we hope to understand how inductive power transfer and electromagnetism at a level of mastery as well as be able to teach others who observe us what this new, cutting edge technology has to offer. In addition to introducing the benefits of this form of power transfer, we will discuss the drawbacks of this technology, namely: inefficiency and underdevelopment of the new technology.

Hauk Hubbard & Braden Sandersfeld 2-11-303
How Helicopter's Wing Speeds Are Affected By Weight Offsets

This project was chosen because to observe how much an offset wing would affect a helicopters flight. To measure the wing speed, a laser tachometer was used. When tape was added to a single wing (offsetting the weight balance) the helicopter slowed down. The helicopter became less aerodynamic and less capable of flying. The results show that even some of the smallest weights threw the speed off by hundreds of RPMs. Adding only one piece of tape decreased the average RPMs from above 4400 to almost 4000, whereas adding two pieces of tape decreased the average RPMs to below 3800. With the data collected, ratios and weights to real life helicopters can be applied and determine how much a damaged wing would affect the helicopter's wing rotation.

Drake Ludgate & Nathaniel Miner   2-11-304
Analysis of Various Wing Structures for Hovering Capacity

The purpose of this research is to test various researcher-designed two/three dimensional wing models with varying surface areas using an oscillating air column apparatus for determination of hovering capacity between five and fifty Hertz. A vertical oscillating wind tunnel was designed and built. Ten two dimensional (flat) and twenty-two three dimensional (pyramidal) shaped objects were designed and constructed out of Japanese tissue. All shapes were tested at frequencies between 5 and 50 Hertz and various amplitudes. Some of the pyramidal shaped objects included flaps for testing. Flapped and non-flapped three-sided pyramids were tested of various surface area and constant mass. Results indicated that it takes a greater amplitude to induce hovering at lower frequency for any designed pyramid, whether they have flaps or not. The research presented in this paper indicates that there exists an inverse relationship between surface area and air speed necessary to induce hovering. The largest pyramids (flapped and non-flapped) showed the smallest range of air speeds and frequency required to induce hovering. A three-sided pyramid-shaped object is capable to hover freely in an oscillating background airflow with zero mean component, provided the amplitude of the oscillation is sufficiently large. The required amplitude to induce hovering at a given frequency is dependent upon the body size (surface area) and geometry (flapped vs. non-flapped) when mass is held constant.

Steven McConnell, Jayden Markland & Zabstian Medina   2-11-305
Orientation of Jumping Masses

The purpose of this experiment is to find what orientation of unequal masses will cause the Springbok machine to be launched the highest in the air through controlled experimentation. Acquire the required materials and set up the lab. Run three trials for each orientation of masses. Calculate average height and use that to make graphs for data analysis. Through experimentation the researchers have discovered that the best orientation of masses is when a significantly heavier mass is on top. The only major design difficulty was the threads on the first bolt we used. Through experimentation the researchers found that the best orientation of unequal masses is having a heavier mass on top. The researcher's process was successful in completing the purpose.

Olivia Odle & Brady Sanchez   2-11-306
CAN You Handle This?

The purpose of this project was to see how a can filled with different masses of plastic BBs behaves when rolling down an incline at various angles. The researchers predicted that the heavier massed cans filled with BBs will roll much faster than the lighter massed cans filled with BBs. In this research, the researchers used six millimeter diameter plastic BBs of three different masses. A ten centimeter (OD) coffee can was filled with each type of plastic BB. Total mass was determined for each type of BB. The can was then filled with ¼ total mass, ½ total mass, ¾ total mass, and full mass of each type of BBs. The can was sealed and rolled down an incline at 8, 12, and 18 degrees. Time and velocity was calculated over a one meter speed trap. After completing all trials, the researchers found that on some heights the ¼ and ½ filled cans would only skid and rarely roll. The researchers predicted that the ¼ and ½ full cans didn't roll at some inclines because they didn't have enough BBs or mass to avalanche down the table. The ¾ and full filled cans rolled at all inclines because they had more than enough BBs and mass to avalanche and roll at constant speeds down the table. In the end, the heavier the massed BBs the faster the filled coffee proceeded down the ramp.

The Study of an Obstructed Aperture

Our project is a study of finding the best rate of flow of spherical granular material around an obstruction through an orifice. The purpose is to determine the best flow of objects through an opening at the bottom of an object. We hypothesize that the flow of material through an apparatus would be increased using an obstruction. We believe that bridging will occur if the obstruction is lowered too close or too far from the bottom opening. First, we built our apparatus and made the right adjustments for the type of materials used. The materials used included eight different obstructions, 336 pellets, and a stopwatch. The apparatus had an opening at the bottom that was four times the diameter of a pellet. The obstructions were centered and adjusted to the appropriate height before each trial. Next, we placed a piece of wood under the opening to keep the pellets from falling through as we poured them into the apparatus, making sure to evenly distribute the pellets into one of the two joint openings at the top. We place a bowl under the apparatus, then removed the stopper, and recorded the amount of time from the first pellet dropping until the last pellet stopped moving. Then we repeated these steps 10 times for each of the four heights for each of the eight different obstructions. In conclusion, we found our hypotheses to be correct, and the rate of flow for the pellets varied depending on the obstruction used.

Senior Division Plant Sciences

Paige Beedy   2-12-001
Fungicidal and Nutrient Application Impact on Wheat Germination

This project was completed to help farmers with the application of fungicide and zinc nutrient on wheat seeds. The problem being assessed with completing this project was to see if fungicide treatments actually do delay the germination of wheat seeds and if the zinc nutrient application helped cancel out the delay. For this project the seeds were treated then germinated for 5 days in the dark. After they germinated, the petri dishes were placed in the freezer so the seeds would stop growing, and root and shoot growth was then measured. Once the seeds were measured, the results were determined. The results showed that the fungicide did delay the germination of the wheat, but the fungicide plus the zinc germinated faster because the zinc counteracted the fungicide delay. In the long run these results will help farmers get their wheat to sprout up out of the ground faster than they have before.

Kit Bellefeuille   2-12-002
Effectiveness of Cereal Rye as a Cover Crop on Alfalfa

In this experiment, the problem addressed was if rye was a useful cover crop for alfalfa. To test this rye was planted in flats and then killed with the herbicide glyphosate. Alfalfa seeds were then planted in the killed rye, and after growth the alfalfa was harvested and the biomass was measured. It was discovered that the alfalfa planted in the flats without rye as a cover crop produced more biomass. The biomass after desiccation was more than 10g higher for the alfalfa planted without the rye cover crop. This indicates that planting rye as a cover crop for alfalfa may not be beneficial for alfalfa crop production. This research and additional allelopathy research on rye will assist farmers in determining whether or not to use rye as a cover crop for alfalfa and other crop species.

Emmalie Byrne   2-12-003
Dirty Water . . . Dirty Food: The Effect of Environmental Pollutants on the Life of Garden Plants

The purpose of this experiment was to discover the effect of common environmental pollutants on garden plants. I tested three different water pollutants: engine oil, salt, and chlorine bleach. I hypothesized that the bleach would have the biggest impact on the garden plants that I was testing. I believed that the plants would not react well to the extra chlorine. My experiment involved introducing three different water pollutants and watering two different plants with each of them. In four cups, I planted three mint clippings each, which ensured three trials within each cup. In four more cups, I placed one green onion plant, with three stems on each, which also allowed three trials within each cup. The three water pollutants that I tested were; engine oil/water mixture, salt/water mixture, and a bleach/water mixture. My control was water only. My collected data did not support my hypothesis. The mint - salt/water cup started showing signs of death on day two. Two of the trials in that cup were hanging down, and unable to stand up straight. The bleach cup had two trials that showed a small loss of color on day two as well, but nothing as extraordinary as the salt/water cup. These findings lead me to believe that salt is not compatible with garden plants. They also lead me to believe that too much bleach can harm plants, but not as quickly as salt can.

Vanessa Haggens 2-12-004
The Effect of Nutrient Availability on Plant Communities in the Alpine Tundra

Terrestrial ecosystems are frequently limited by one or more nutrients. Most nutrient limitation studies have been conducted in grasslands, with few studies looking at the effects of nutrients in tundra ecosystems. Understanding how nutrient limitation affects the alpine tundra is critical because increases of anthropogenic nitrogen (N) alter nutrient ratios, which may adversely affect species dependent on other nutrients. This study investigated the effects of N, Phosphorus (P) and Potassium-based micronutrients (K) on species composition and diversity in alpine plant communities in Niwot Ridge, Colorado (elevation 3259 meters). Since 2008, 40 plots have been treated with combinations of these nutrients biennially. The point intercept method was used to determine species composition in 2013 and 2017 and data were analyzed using R. Micronutrients showed no significant treatment effect on diversity in 2013 ($t(10) = 1.498$, $p = 0.165$) and in 2017 ($t(10) = 0.779$, $p = 0.454$). In 2017, there was a significant treatment effect on diversity between N+P+K and N (p,adj= 0.00556). Forbs demonstrated a preference for certain nutrients ($F4,23 = 2.976$, $p = 0.0407$), with the percent of forbs increasing between N and N+P+K (p,adj= 0.0497) but not between N and N+P (p,adj= 0.263). The results of this study indicate that micronutrients alone are not limiting nutrients in this community. However, the response of forbs to N+P+K but not N+P warrants further research to understand how micronutrients affect communities in tandem with N and P.

Fairs Jones 2-12-006
GMOs and Onions: a Molecular Controversy

The purpose of this project was to test and visualize the difference between organic and genetically modified onions. I hypothesized that the onions would ultimately be the same, meaning the labelling would be false. The experiment involved me breaking onions down and adding them to a solution that allowed the onion to pass through a coffee filter. Once through a filter, I added alcohol to the liquid to let DNA precipitate with a snot-like consistency. Once in a test tube, I let the DNA run in the centrifuge once, then once again with ethanol added. The DNA was then left to sit in water, then dyed blue and placed in the electrophoresis chamber. Magnetic charges pulled the DNA through gel, able to be seen clearly over the viewing light. The data collected did not support the original hypothesis. These finding led me to believe that the DNA of organic and GMO onions are incompatible.

Jaret Lichty 2-12-007
Leaching of Nitrates in Different Soils

The purpose of this experiment was to determine which soils best kept nitrogen from leaching, and whether corn plants affect how much leaches out. Eight soil columns of sandy soil and eight columns of clay soil were constructed. Each soil column was saturated with water and then 1 Liter of water was poured on top of the soils. Samples of this run-off water were collected for a base line test. Nitrogen fertilizer in the amounts of 60, 100, and 200 pounds per acre were applied to the appropriate columns and corn planted. Two days after planting, a second water sample was collected and tested for nitrogen. The nitrogen levels were determined by using the Hach Nitrate test. The data collected did not support up the hypothesis, that there would be less nitrogen leaching from the clay soil. The sand soil had lower amounts of nitrates in the waste water, and held water a longer than the clay soil. The clay soils did hold nitrogen, there was a greater amount found to be leached out into the run-off water. Continued data collection is needed to further investigate nitrogen leaching.

SALTY

This project all started with a lesson in science class about what a plants needs to live. The lesson consisted of plant macros NPK (nitrogen, phosphorus, potassium) and some micros like magnesium, calcium, and the most interesting one was sodium. The soil used in this project was found from four different places. The control was just regular potting soil from our school green house, slow salinity came from my house, and not anywhere in particular from my house. The highest sodium concentration in soil came from an irrigated corn field. It's believed to be the highest because irrigation brings water and with water comes small amounts of sodium that are just left in the soil if it isn't used by the plants, which if that's accurate, there will be a very high content of sodium in the soil. The average soil came from a field next to our house that houses cows. The steps for conducting this experiment where quite simple. First you need to collect your soils and find out with ones have the highest sodium concentrate in them. Plant the seeds accordingly in their pots then water them for the next 4 weeks. The soil that produced the most fully grown plants was the soil with low salinity. The beans grew the best in that soil because beans have a very low salt tolerance and that's why they didn't even grow in the soil with the highest sodium content.

Covering the Cover Crop

In this project I wanted to find a better way to aerate and help your soil samples in a more natural better way. At first I wanted to look at chemicals but instead of chemicals I looked at different types of plants. I ended up using a couple plants that are mainly known as fibrous tap root, the have a very complex root base and I planted these and saw what they did to the soil and measured the root length the longest was almost 52 inches. They turned out to work great and are the new face of agriculture in my eyes.

The Effects of Electricity on Bean Seed Imbibition

The purpose of the experiment is to determine is electricity affects the rates at which pinto beans imbibe water. I hypothesize that beans placed within an ionic solution with an electrical charge will have a higher rate of imbibition than seeds in deionized water without an electrical charge. Four different solutions will be prepared twice, with one set of each solution having electrical currents from a copper wire and a nine volt battery. Beans will have their dry mass recorded before being placed within the solutions. Data will be collected by measuring the mass of the beans on an electrical balance. Analyzation of the results occurred by averaging the masses of the beans from the beginning of the experiments until the end in order to find out which group had the largest difference in mass and the fastest imbibition rate. The cup with the largest difference in mass and the fastest imbibition rate was the cup with no salt and an electrical charge and the cup with the smallest difference and the slowest rate was the cup with 518.39 milligrams of salt and an electrical charge.

Emily Soder & Swami Velamala   2-12-301
Plant-Powered Homeostatic Habitat

This project researched how sustainable energy can be created using plants without harming them, as well as ways to regulate the internal environment of a greenhouse so that plants can be grown efficiently. We created a greenhouse and used Arduino sensors to create a cause/effect system that recorded soil moisture, temperature, and light values, then counteracted it with a water pump and fan if the values were too low. It was shown that it decreased the need for human interaction significantly. We researched how energy can be generated from plants, and found that when plants break down the glucose created in photosynthesis for cellular respiration, excess electrons are released into the soil. By putting electrodes on either side of the plant, a current is able to pass through and collect these electrons. We experimented with different plants and electrodes to find the most efficient way to generate energy. We found that this system with the two main elements put together could generate enough energy to power the 5V system, with a surplus of energy that could be used for other needs the customer might need.

Andrew Tokar & Maya Hegde   2-12-302
Assessing the Viability of Household Food Scraps as an Alternative to Traditional Fertilizer

Synthetic fertilizers wreak havoc on the environments around them and often produce less healthy food than their natural counterparts. If they could be replaced with cheaper, but still effective, natural fertilizers, everyone would benefit. The essential function of fertilizer is to provide nutrients for plants. Thus, the question being investigated is: Can natural substances, like those that could be found in household waste, be turned into effective replacements for synthetic forms of fertilizer? To answer this question, four groups of plants were planted in equal conditions, but with different fertilizers. The different groups were synthetic fertilizer only, mixture of natural fertilizer and synthetic fertilizer, natural fertilizer only, and no fertilizer. The natural fertilizer was a ground mixture of several substances determined to be rich in Nitrogen, Phosphorus, and Potassium: the three essential nutrients for plants. Growth in each test group was measured and compared weekly until the plant life cycle ended. It was found that plants containing amounts of natural fertilizer grew less than those with only synthetic fertilizer, but those with a mixture of both fertilizers were comparable to only synthetic. The conclusion that can be drawn from this is that perhaps the viable goal is not to replace synthetic fertilizer, but to reduce its usage by replacing some of it with a natural version. The lackluster growth of only natural fertilizer plants suggests that there are issues with at least the mixture used and perhaps others that prevent total nourishment from natural sources.