CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Cecilia P. Bacich

Project Number
J0801

Project Title
Man vs. Nature

Abstract

Objectives/Goals
My project tested whether a sea wall (made of plywood), or a mangrove forest (composed of olive branches) would serve as a better tsunami barrier.

Methods/Materials
A tsunami simulator was constructed using a water tank with dimensions of 112 cm x 49.5 cm x 42 cm. A piece of plywood (46 cm x 21.5 cm) was placed at a 300 angle and secured to one end of the tank. This represents the beach slope. Then a flat piece of plywood (47 cm x 47 cm) was connected to the top of the beach slope to represent the inland beach and water front land. The sea wall was depicted by a block of wood (53 cm x 6.35 x 3.8 cm) and the forest was represented by olive branches. The newly created tsunami simulator was filled with water and the testing began. A piece of plywood was pushed through the water at a constant rate to create the incoming tsunami waves.

Results
After 30 trials, the average distance the water traveled past the wall barrier, which represented the sea wall, was 18.5 cm. Then I removed the piece of plywood and replaced it with the olive branches. After 30 trials, the average distance the water traveled past the olive branches, which represented the mangrove forest, was 9.7 cm.

Conclusions/Discussion
After 30 trials, the average distance the water traveled past the wall barrier, which represented the sea wall, was 18.5 cm. Then I removed the piece of plywood and replaced it with the olive branches. After 30 trials, the average distance the water traveled past the olive branches, which represented the mangrove forest, was 9.7 cm. the data supported my hypothesis, which stated the mangrove forest would serve as a better barrier than a sea wall.

Summary Statement
My project studied the effects of tsunami's waves on man-made concrete barriers versus mangrove forests

Help Received
None

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Matthew J. Baumann

Project Number
J0802

Project Title
Just Say NO to Erosion!

Abstract

Objectives/Goals
The purpose of the project was to find out which erosion control method works best at preventing hillside erosion caused by rainfall.

Methods/Materials
Four soil-filled Styrofoam bins. One as a control, one using Geo Fabric, one with a mix of wild grasses (Blue Lupine, California Brome annual, California Brome perennial, Blue Wild Rye, California Poppy), and one planted with ground cover plants (French Thyme and Creeping Speedwell). Plants were grown for a 30 day period in order for roots to establish. Three trials were performed. The boxes were set at 45 degree angles to simulate hillsides. Equal amounts of water were used to mimic rainfall. Runoff water and eroded soil were measured.

Results
When the Geo Fabric, French Thyme, Creeping Speedwell, and mixed grasses were applied to each box filled with soil, the French Thyme and Creeping Speedwell boxes proved to be the best soil erosion preventers, and had the least amount of runoff water. In all three trials, the results were consistent.

Conclusions/Discussion
My results were different than my expectations. I thought that the box with Geo Fabric would#ve shown the least amount of erosion, but it was the box planted with Creeping Speedwell and French Thyme that showed the least amount of erosion and runoff water. I believe these plants were successful due to their strong and intricate root systems and low-lying, densely compacted foliage.

Summary Statement
This project proved that Creeping Speedwell and French Thyme are effective in the control of erosion caused by rainfall.

Help Received
The trials and materials were set up by me. My mother helped with purchasing supplies and conducting trials.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Hudson J. Billock

Project Number
J0803

Project Title
Ultraviolet Light Levels in the Upper Atmosphere

Abstract

Objectives/Goals
The objective of the study was to see how UV levels changed as altitude increased.

Methods/Materials
A weather balloon is a large balloon that can go into the upper atmosphere. I had a space balloon carrying the following: a payload with cameras, a raspberry pi, which is a small computer, that had a UV light sensor on it, and a Spot GPS so we could find the balloon when it came down. We bought the UV sensor from ADAfruit, part number GUVA-S12SD.

Results
The UV levels increased slightly as the altitude increased. My hypothesis was that the UV levels would go up as altitude increased, which was correct.

Conclusions/Discussion
In my research, I found that the atmosphere filtered the UV light, so the UV levels should go up, since there is less atmosphere to filter it. This did happen, but The UV levels did not go up as much as I thought they would. My data did show that UV levels increased at higher altitudes, but there was a lot of spread in my data. One reason that there was a wide spread in the data was that I had so many data points.
One way this project was imperfect was the swing of the payload when I was measuring the data. The motion could throw the data off because one measurement could be facing away from the sun, making the UV measurement less than it really was, while another could be facing towards the sun, making the measurement higher than it really was.
I was fascinated by the pictures the camera took on the balloon. It was really cool to be able to see the curvature of the earth. Another project idea is that I could measure UV light in daily activities such as taking a walk at different times of the day like morning, noon, and night. This would be important to know because UV light can be harmful, so it would be good to know when to protect yourself. My hypothesis would be that activities closer to noon would have higher UV light levels than ones farther away from noon.

Summary Statement
I launched a weather balloon with an Ultraviolet light sensor on it to read UV levels in the upper atmosphere.

Help Received
My dad helped me to launch the balloon and program the UV sensor.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Olivia R. Bobrownicki

Project Number

J0804

Project Title

Fighting Fertilizers

Abstract

Objectives/Goals

The objective of this study is to test the impact of fertilizer on soil and fresh water in terms of water retention, run off, and acidification.

Methods/Materials

Three types of organic fertilizer, six types of chemical fertilizer (including three commercial variations), ninety six plastic containers, one hundred API pH test strips, top soil, fresh lake water, scale, fescue sod. Planted sod in uniform draining containers, in triplicate, for each kind of fertilizer and a control, collected and emptied the runoff and water for two weeks, tested the pH of and measured the runoff on the final day before adding it to lake water, and retesting the pH.

Results

Fertilizers designed for home use (both chemical and organic) did not significantly decrease the water's pH, and had the similar quantities of runoff despite their composition. Commercial fertilizers, which were all chemical fertilizers, decreased the pH of runoff from their dish by as much as two points on a nine point scale. The greatest quantity of run off produced by home use fertilizers was 165 ml, while commercial fertilizers had a high run off of 210 ml. The control, which did not contain fertilizers, had a constant pH of 9 through each trial.

Conclusions/Discussion

Commercial fertilizers decreased water retention in soil and increased the acidity of the soil's run off, in turn acidifying lake water. Organic and home-use chemical fertilizers did not significantly affect the soil's run off or other qualities. This means that these kinds of fertilizer are best for the environment due to their lesser impact.

Summary Statement

I demonstrated that high-nitrogen chemical fertilizers increase run off and acidify lake water.

Help Received

None. I designed, built, and preformed my experiment independantly.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Nicole Fassett; Lauren Kim

Project Number

J0805

Project Title

Save Our Beaches: Man-Made vs. Natural Erosion Prevention Solutions

Abstract

Objectives/Goals

The objective of this study is to determine whether man-made or natural structures are more effective at preventing beach erosion.

Methods/Materials

3 plastic bins, beach sand, small rocks, Ceanothus plant, water, and scale. Erosion was simulated for 3 conditions: small rocks with sand, Ceanothus plant with sand, and sand only. The degree of erosion was then assessed by measuring the weight of sand "eroded" in each of the 3 conditions.

Results

The man-made rock seawall's ability to reduce erosion was tested against the native Ceanothus' plants ability to reduce erosion. After three trials, it was determined that the rock seawall reduced erosion by seven fold while the Ceanothus plant reduced erosion by four fold.

Conclusions/Discussion

It was concluded that both the seawall and the native plant had a positive impact in preventing erosion. However, the man-made rock seawall was determined to be more effective than the natural Ceanothus plant in preventing beach erosion.

Summary Statement

We determined that the man-made rock seawall was more effective than the natural Ceanothus plant in preventing beach erosion.

Help Received

My partner and I designed our experiment with the help of Barkev Meserlian, an engineer from the Irvine Ranch Water District. Anthony Malek, a Horticulturist from Roger's Garden, helped us select an appropriate native beach plant.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Kylynn M. Leffingwell

Project Number
J0806

Project Title
The Effectiveness of Various Organic Additives Promoting Water Retention in Extremely Dry Soil

Abstract

Objectives/Goals
The purpose of my project was to determine if various organic additives effect water retention in extremely dry soil.

Methods/Materials
Walnut shells, pistachio shells, almond shells, organic brown rice, dry soil, aluminum tins, plastic bags, hammer, water, and a scale that measures in grams as well as ounces. Measured weight in grams and ounces for the mixed dry soil and additives with water for ten days, then recorded results.

Results
The additives were vertually non-effective, with the exception of the walnut shell, which had the largest evaporation rate.

Conclusions/Discussion
With the conclusive results that the walnut shell removes liquids from soil at an exceptional rate, this can be used to remove liquids from moist soil. This information can be used to provide as an alternative to remove liquid from moist soil in catastrophies such as mudslides, and highly polluted areas, such as the central valley, where percipitation is cotaminated, therefor it is possible it may need to be removed from the soil.

Summary Statement
I measured the evaporation rate of various organic additives, and found that the walnut shell is the only additive with conclusive results.

Help Received
None, I designed and projected the project by myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Max J. Loewen

Project Number
J0807

Project Title
Amendment of Playing Field Soil to Improve Soil Stability

Abstract

Objectives/Goals
My project was to determine if clay amendment can stabilize the soil and decrease soil displacement in front of a base when a player slides into it.

Methods/Materials
A soil collection frame was constructed and soil samples were collected for initial testing. The base path (area just in front of the base in line with the runner's path) was prepared using standard field technique: 1 liter of water from a pump sprayer to coat the top soil and smoothed with two passes of a field drag (or drag mat). The player completed 5 trials of a 40 foot running start and slide into the base. Soil displacement was collected after each trial using a flat head shovel and weighed. Soil was then returned to the base path. Two different amounts of clay kitty litter amendment were added to the top 3 inches of soil using a rake and foot tamp. With each change in amendment, soil samples were collected, the base path prepared using the water and drag method, and player sliding trials completed.

Results
The final sandy clay loam soil texture of 50% sand, 16.7-17.9% silt, and 32.1-33.3% clay had the lowest soil displacement and greatest stability. The initial sandy loam soil did not have enough clay to hold together when impacted by a baseball player's sliding friction.

Conclusions/Discussion
It is important to keep soil in place on a baseball field. Using cheap, natural clay kitty litter to stabilize the soil is a solution for schools that cannot afford name-brand, expensive baseball additives or specially formulated field soil.

Summary Statement
I found a cheap, natural, and effective way to improve soil stability on a baseball field, and keep the soil where the players need it.

Help Received
I designed the project and built the frame with assistance from my parents. I researched soil field amendments online and at a local soil retailer, and received field preparation technique from a former baseball coach.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Ellery McQuilkin

Project Number

J0808

Project Title

Supercool Streams: Flowing with Frazil

Abstract

Objectives/Goals

I wanted to find out if a mountain stream would stay liquid at temperatures that freeze an alpine lake. My hypothesis was that moving water would be able to stay liquid at temperatures that freeze still water.

Methods/Materials

I chose three different sites at 7000 feet in elevation in Mono County, California near Mono Lake: Lundy Lake, Mill Creek, and Wilson ditch. At each site I took air, still water, and turbulent water temperatures. At my Mill Creek site I took observations and I placed a time lapse camera to record whether ice formed. To take the temperatures I waterproofed small thermometers called iButtons and recorded about a month of a winter data. I added additional thermometers to investigate the formation of spray ice. Then I retrieved and downloaded them so I could develop an analysis of my data.

Results

From my data I found that moving turbulent water stayed liquid when still water froze, proving my hypothesis correct. Air temperatures at Mill Creek were almost always below freezing, but they did not freeze the moving water, even when the air was as cold as -15 degrees C. The water was usually below 3 degrees, but even when the water supercooled to -0.5 degrees C my data and camera pictures showed that the creek was always flowing. Still water at Wilson ditch and Lundy Lake froze solid at these same low temperatures. A type of ice I call spray ice formed on the edges of the creek and on my equipment. My data show that spray ice forms when cold water sprays out of the creek and lands on something that is below 0 degrees C. Another type of ice called frazil formed in supercooled turbulent water. I observed three episodes of frazil ice formation, at air temperatures below -10 degrees C.

Conclusions/Discussion

I learned that although a creek might be flowing in the winter, it's not the same as a creek that you might swim in during the summer, because there is a lot ice in and around the creek. The ice in the creek, frazil ice, is very powerful. It helps create a healthy creek by shaping the stream channel, but it can also destroy measuring flumes and take down bridges. Understanding creek dynamics in the winter is important because bridges and other structures need to be built strongly enough to withstand the force of frazil ice.

Summary Statement

I found that turbulent flowing water stayed liquid at air temperatures that froze still water, but unusual types of stream ice formed.

Help Received

Dr. Connie Millar was my science adviser and let me borrow iButtons. Yosemite Geologist Greg Stock discussed turbulent water and supercooling with me. My dad helped me safely conduct my experiment in the field. My mom helped me with design and proofreading.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Luke R. Merickel

Project Number

J0809

Project Title

What's Shaking? The Truth about Liquefaction

Abstract

Objectives/Goals

The object of my project is to determine whether a vertical or a horizontal direction of energy (simulating an earthquake) will cause more liquefaction to occur in saturated sandy soil? It is my hypothesis that horizontal energy will cause greater liquefaction to happen.

Methods/Materials

I placed a brick that represents an apartment building on top of a saturated sand filled container (eleven liters of sand, four liters of water, fourteen liter plastic container). I dropped a 6.8 kilometer dumbbell ten times from a height of 100 centimeters onto a wood pallet. These ten drops equaled one trial. I then recorded the measurement of liquefaction that occurred. I repeated this step for a total of ten times with the vertical drop. I did the same for the horizontal drop. I controlled the height of both drops by hanging a tennis ball 100 centimeters from the wood pallet. I constructed a device that would keep the brick from falling over by designing a metal screen to hold the brick upright. Both directional forces were powerful enough to create the phenomenon of liquefaction.

Results

My hypothesis was incorrect. This experiment revealed that the vertical energy caused more liquefaction to occur. The horizontal energy force caused an average of 1.92 centimeters of sinking. The vertical energy force caused an average of 3.33 centimeters of sinking. I was please that the variance was minimal: 0.5 centimeters for the horizontal drop and 0.7 centimeters for the vertical drop. This shows validity and reliability in the design of my experiment.

Conclusions/Discussion

Understanding liquefaction is important because many buildings in densely populated cities are built on sand that can liquefy. Better understanding of how to prevent liquefaction may lead to prevention solutions while saving lives and resources. Though surface waves (horizontal energy force) from earthquakes cause more structural damage my experiment shows that P waves (vertical energy force) cause more liquefaction to occur. When building structures in areas vulnerable to earthquakes and liquefaction it is important to consider ground and soil treatment as well as building structure design.

Summary Statement

My project explores whether vertical or horizontal energy will have a greater affect on liquefaction in saturated sandy soil.

Help Received

I designed and carried out this project by myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Pascale C. Montgomery

Project Number

J0810

Project Title

Message in a Bottle: Predicting Sea Level Rise from Thermal Expansion

Abstract

Objectives/Goals

The objective of my study is to examine the thermal expansion of seawater and how it could impact sea level rise on a global scale.

Methods/Materials

Plastic water bottle, hard plastic straw, silicone sealant, sea salt, water, digital thermometer, stopwatch, 100 watt light bulb and reflective casing, metric ruler. Changes in water level with increasing temperatures were measured with a clear plastic straw and digital thermometer and recorded every fifteen minutes for a total of 120 minutes.

Results

From the collected data, thermal expansion coefficients were calculated and averaged. The average coefficient was then applied to the ocean on a global scale, and an estimate of sea level rise was calculated. I found that if the upper one kilometer of the ocean were warmed by one degree Celsius, the sea level would rise 20 cm. These results support my original hypothesis that seawater does expand when warmed and that it is possible to create an estimated climate change model of sea level rise from thermal expansion.

Conclusions/Discussion

In short, my experiment offers a simple way to demonstrate one aspect of global sea level rise, and it might be used to further assess current predictions. My predictions, however, are from thermal expansion alone, not accounting for melting land ice and are therefore only one part of a climate change model.

Summary Statement

This study examines the thermal expansion of seawater and how such expansion impacts sea level rise, assuming a projected increase in globally averaged surface temperatures.

Help Received

I built the bottle apparatus and ran the trials, and my father helped me understand the thermal expansion equation.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Antonia B. Perez

Project Number

J0811

Project Title

Analyzing the Effects of Temperature and Soil Type in Absorption and Capillarity of Soils

Abstract

Objectives/Goals

The purpose of my project was to determine if different soils had different absorption and capillarity rates and if environment temperature affects those rates.

Methods/Materials

samples of loam, sandy, and potting soil, beakers, test tubes, water, incubator, refrigerator, and room temperature environment

Take one glass tube and fill it with 20 grams for either sand, and loam, or 5 grams for potting soil. Repeat this for each soil, for each temperature setting, for at least 10 trials. Cut each cotton ball in half and plug the half into the top of the glass tubes. Make sure that, when turned upside down, the cotton ball will stop any of the soil from falling out. Take all the glass tubes in one soil set and tie them together firmly with a rubber band. Make sure all the soil sets are tied together and no tubes are loose. Take a soil set and turn it upside down so the opening of the tube, which is stopped with a cotton ball, is facing down.

Fill a glass beaker with 300 ml of water and pour food coloring into the water based on the temperature of the environment the glass tubes and beaker are going to be in. Upside down, vertically immerse the glass tubes into the glass beaker with colored water. Put the glass beaker filled with the tubes into either a room temperature environment, a refrigerator, or an incubator (each soil will be in all the environments for testing). Allow the soil to sit in its environment and absorb the water for (5) five days to a week.

Record the height the water traveled in the tube, and record how much mass the water added to the total mass of the tube with soil.

Results

Overall, loam soil has the highest capillarity (103%) and absorption rates (22.6 mL of water) . Potting soil had the lowest capillarity (25.6%) and absorption rates (5.2 mL of water). Temperature was an inconsistent factor.

Conclusions/Discussion

In conclusion, from this project, I learned that loam soil has the best capillarity and absorption factors. The potting soil had the worst capillarity and absorption, while the sand soil was in between. These soils are found all around the world and are used regularly. If soils are chosen more carefully, the world could have more water, and California might stop a drought. This is why the results of my project on soil capillarity and absorption are important and can affect us in many ways.

Summary Statement

I discovered that the loam soil had the highest absorption and capillarity results and temperature did not really affect my results in a consistent manner.

Help Received

Jewely Lickey, Science teacher at Sanger Academy Charter School provided lab equipment Robert Nelson, Science teacher at Sanger Academy Charter School provided soil samples

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

James L. Pinto

Project Number

J0812

Project Title

Did Juvenile Spinosaurids Spend Time in the Water?

Abstract

Objectives/Goals

I wanted to find out if juvenile Spinosaurus dinosaurs spent a higher amount of time than most dinosaurs in ocean water.

Methods/Materials

Five juvenile Spinosaurus tooth fossils, one Deltadromeus tooth, one Mosasaur tooth, isotope ratio mass spectrometer, freeze dryer vacuum chamber, vacuum roaster. The ratios of oxygen isotope 16 and oxygen isotope 18 were compared in each of these teeth.

Results

The oxygen isotope ratios of the Spinosaurids exhibited extreme variance compared to the Deltadromeus and the Mosasaur, which implies that, depending on where they lived, Spinosaurids may have spent time in oceans and/or freshwater lakes and rivers.

Conclusions/Discussion

The data I obtained did not completely support my hypothesis. I thought that the Spinosaurids would all have oxygen isotope ratios closer to the oceanic creature, the Mosasaur, but they instead had extremely varying oxygen isotope ratios. This data adds to evidence about how the Spinosaurus lived, and how it fit into its ecosystem along with all of the other dinosaurs it lived with.

Summary Statement

By comparing the oxygen isotope ratios of fossilized dinosaur teeth, I found that Spinosaurus dinosaurs spent varying amounts of time in oceans and rivers depending on where they lived.

Help Received

Used lab equipment from the University of California, Santa Cruz under the supervision of researchers Dyke Andreasen and Colin Carney.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Ayah H. Shalabi

Project Number
J0813

Project Title
Brine Exclusion and Thermoclines

Abstract

Objectives/Goals
My hypothesis was that as sea ice begins to melt, the salt water density will increase. As the sea ice melts, the exothermic energy will create a thermocline. The thermocline and densities will suspend particulate matter in a layer and change the density and thermal structure of the water.

Methods/Materials
First, I filled an 110 L aquarium nearly full with salt water (Instant Ocean) @ 1.0 refraction. I positioned thermometers at 0 cm at the top, 5 cm, 10 cm, 15 cm, and 20 cm near the bottom. Then I recorded temperatures and sample salinity with a pipette at each of the respective depths. After this, I placed 5 kg of the brine infused ice in the water. After I recorded temperatures as before, I inoculated the salt water with 20 ml charcoal/clay dust laced salt water. Then I observed any changes.

Results
After doing all the procedures, a thermocline was created. Layers in 5 cm increments exhibited 1 degree Celsius, 5 degrees Celsius, 15 degrees Celsius, 21 degrees Celsius, and 21 degrees Celsius with a refractive index respectively of 0.4, 0.8, 1.3, 1.9, and 6.0 after 48 minutes.There was a visible layer of the particulate matter at 10 cm. This layer was one of the middle areas. The refractive index of salinity was 1.3 and the temperature was 15 degrees Celsius within this layer.

Conclusions/Discussion
In conclusion, my hypothesis was correct. As the sea ice began to melt, the salt water density increased, and the exothermic energy created a thermocline. The thermocline and densities suspended particulate matter in a middle layer and changed the density and thermal structure of the water. The layer with the most salt appeared to be one of the lower areas of the water. The implications are that if this plume were able to sustain for a longer period of time, the suspended particulate matter may be able to absorb light energy and further heat the plume of sea water disrupting normal patterns of currents, weather, fish migration patterns and feeding, etc.

Summary Statement
This project examines brine exclusion and the formation of thermal layers that are able to suspend particulate matter.

Help Received
My teacher assisted with supplies and equipment and help me with an extra set of hands in doing multiple measurements.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Anika C. Stickney

Project Number
J0814

Project Title
Heat Absorption and Retention of Carbon Dioxide and Other Atmospheric Gases

Abstract

Objectives/Goals
Measure the absorption and retention of light heat by various atmospheric gases. I hypothesized that carbon dioxide would have the most absorption and heat retention of the four gases tested.

Methods/Materials
I placed four identical thermometers into four 1-gallon mason jars filled with either carbon dioxide, nitrogen, water vapor, or room air. I put each jar in front of its own identical heat lamp, and checked and recorded the temperature every half an hour. After an hour I turned off the heat lamps and observed the temperature every fifteen minutes for an hour and a half.

Results
Nitrogen and carbon dioxide had the highest rate of heat absorption with slopes of 0.47°C per minute and 0.48°C per minute respectively, while air and water vapor had the lowest rate of absorption with slopes of 0.42°C per minute and 0.43°C per minute respectively. However, carbon dioxide and water vapor had the highest rates of retention with slopes of -0.077°C per minute and -0.084°C per minute respectively, while nitrogen and air had the lowest rate of retention with slopes of -0.074°C per minute and -0.075°C per minute respectively.

Conclusions/Discussion
Out of the gases tested, carbon dioxide was the only gas that absorbed and retained heat well. Nitrogen was able to absorb heat well, but it did not retain it. Water vapor retained heat the best out of all the gases tested, but it did not absorb the heat very well. Air did not absorb or retain heat well. One factor as to why water vapor and carbon dioxide retained heat the best is because both are greenhouse gases. However, this experiment did not test for the greenhouse effect. Future climate modeling to include both the direct effect and greenhouse effects may yield more accurate climate models. Future investigation using various wavelengths of light should also be conducted, but were outside of the funding budget of this project.

Summary Statement
I measured that atmospheric gases have different direct absorption and retention of heat; carbon dioxide absorbed heat the best, and was second only to water vapor in retention of heat.

Help Received
I designed and built the experimental apparatus, and performed the experiments myself. My parents funded and advised on technical setup of project.