



CALIFORNIA STATE SCIENCE FAIR 2004 PROJECT SUMMARY

Name(s) Lydia Bates; Toni Ward	Project Number S0801
Project Title What's in That Water? A Study of Water Filtration in a Wetland Ecosystem	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this experiment was to determine whether the natural purification action of a wetlands ecosystem causes a measurable improvement in the water quality. Water quality was defined in terms of copper, nitrate, dissolved oxygen (DO), total dissolved solids (TDS), and pH.</p> <p>Methods/Materials Tests were performed at two housing areas to establish a baseline for pH and chlorine and to familiarize the scientists with the equipment. Field tests were also conducted for pH and chlorine to insure relative pH stability between when the samples were taken and when they were measured in the lab and to check for chlorine as chlorine assists in water purification. A minimum of five samples from sites at Piute Pond were then taken on four consecutive weeks. The sites were selected based on three factors; they were in different portions of the ecosystem, restrictions on water surface travel and, the recommendations of the Edwards AFB Environmental Engineer. Lab analyses for DO, TDS, pH, nitrates, and copper were performed on all field samples. A control sample was taken during week one and tested with samples obtained during each of the three subsequent weeks.</p> <p>Results Water quality measured between inlet and outlet did not improve in relation to tests that were performed. The DO level decreased by 15%, TDS decreased less than 3%, and pH levels remained constant. There was less than 1.3% difference in nitrate levels and a 2.5% difference in copper levels between sample locations. Two probable reasons for this exist. One, the vegetation that serves as the water filtration device is located near the inlet and not evenly spread throughout the ecosystem. This does not allow the vegetation to completely perform its filtration. Second, research indicates that the depth of the pond is a factor in filtration capability due to the differing types of vegetation that exist at deeper levels. Piute Pond is very shallow throughout inhibiting filtration capacity. However, in the vegetated areas of the wetland, copper levels decreased 60% and nitrate levels decreased 70%.</p> <p>Conclusions/Discussion The data indicated that the hypothesis was correct. In evaluating the data it was found that water quality did not improve significantly from the inlet to the outlet. In conclusion, Piute Ponds is not efficient in improving the water quality of the water from the water treatment plant.</p>	
Summary Statement The purpose of this experiment was to determine whether the natural purification action of a wetlands ecosystem causes a measurable improvement in the water quality.	
Help Received Used bioenvironmental laboratory at Edwards AFB under supervision of Mr. Lynn Coffey. Father helped type report.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Risha R. Bera	Project Number S0802
Project Title A Comparison of Traffic Resulting in Heavy-Duty Diesel Truck Emissions on Highway 91	
Abstract Objectives/Goals This study examined a strategy for increasing the efficiency of trucks and reducing the toxic emissions of acetaldehyde, formaldehyde, 1,3-butadiene, and benzene. The hypothesis stated that most reductions would occur from driving during the afternoon hours. Methods/Materials A five-minute segment of the 91 Freeway Westbound was taped hourly from 7 AM to 9 AM, and 3 PM to 7 PM, for seven days. Truck/trailer units were observed for the seconds seen in the visual frame. An average number of seconds was then determined for each time period, and then classified under three driving modes of cruise, transient, and creep. Results Calculating a distance of 240 feet in the visual frame, the average speeds of the vehicles (miles per hour) were estimated. Congestion rates and amounts of pollution caused were calculated also. Generally, the elimination of truck/trailer units resulted in 1/3 less congestion at both transient and cruise modes. Conclusions/Discussion Going from creep to transient/cruise mode achieved emissions reductions over 90% and progression from transient speed to cruise speed achieved 60% or more reduction. The most reductions that occurred at 7 PM were over 90%. Implementing programs encouraging trucks/trailers to drive during off-peak periods can realistically achieve these reductions not only for commercial vehicles but passenger vehicles also.	
Summary Statement This study examined a strategy for increasing the efficiency of trucks and reducing toxic emissions by studying time periods on the 91 Highway Westbound.	
Help Received Recieved emissions data from Dr. Joseph Norbeck at University of California, Riverside; Borrowed videocamera from Rajesh Bera	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Ralph T. Boyajian, Jr.	Project Number S0803
Project Title Methane Emissions Control and Energy Capture on Dairy Waste Lagoons	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals Current dairy waste lagoon design often consists of flushing manure through solids settling ponds and then partial bacterial digestion in large, open-air lagoons. The high amount of dissolved oxygen present in the upper regions of these lagoons allows aerobic bacteria cultures to thrive in the warm, nutrient-rich portion of the lagoon, while anaerobic bacteria cultures migrate to lower regions of the lagoon because of the low dissolved oxygen present there. My project attempts to create a model for dairy waste lagoon design that can create an anaerobic environment in the lagoon that allows for higher methane yields, which can then be captured and combusted for electricity. Controlling the methane emissions through capture would also help prevent methane pollution on dairies.</p> <p>Methods/Materials Liquid dairy waste, to be used for testing, was collected on a dairy at a location where it was exiting the solids settling pond and prior to entering the waste lagoon. A method for testing the methane yields from the dairy waste under different conditions was designed and constructed. The testing apparatus consisted of 1-gallon jars, filled with dairy waste, controlled at different temperatures that simulated the relative position of the anaerobic bacteria in the lagoon; in this instance those conditions included: cold (43-45F); ambient (70-75F); hot (90-95F)--which would depend on the dissolved oxygen. An anaerobic condition was created at the various temperatures and methane yields were collected and measured with digestion times ranging from 3-6 days, to simulate differences in influent and effluent movement in the lagoon. The methane was collected over a vacuum, where it was measured three times a day.</p> <p>Results The dairy waste undergoing anaerobic digestion at the hot conditions showed methane yields of 15 cm, while the ambient and cold digesters yielded closer to 2 cm. Length of digestion time maintained a steady slope of increase methane yield.</p> <p>Conclusions/Discussion The test results suggested that allowing for an anaerobic environment in the dairy waste lagoon--which would allow for anaerobic bacteria cultures to undergo anaerobic digestion in warm conditions--would have a methane yield several folds that of current conditions. Methane could then be captured and combusted providing a clean burning alternate energy source which would limit harmful methane emissions into the atmosphere.</p>	
Summary Statement My project attempts to provide a practical way of increasing anaerobic digestion on dairy waste lagoons, capturing that methane, and combusting it for electricity, inhibiting methane escape/pollution into the atmosphere	
Help Received Father helped edit written documentation; Professor Charles Krauter of California State University , Fresno (Plant Science Department) engaged in dialogue with me concerning the project; Mr. Wayne Garabedian gave suggestions on display and presentation	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Garen M. Checkley	Project Number S0804
Project Title Does It Matter What Plants Grow in California Salt Marshes?	
Abstract Objectives/Goals California wetlands have declined by 90%. Those wetlands that occur in open lagoons support a variety of plant species, mainly Salicornia (Pickleweed) and Spartina (Cordgrass). But lagoons that close regularly do not support Spartina and are dominated by Salicornia. Both of these plant genera are nesting sites for endangered bird species. Methods/Materials This study, conducted in Mission Bay, California, examined the effects of these two dominant genera on the underlying sediment environment, and compared them to sediment lacking vegetation. Results Percent plant cover and corresponding light reduction were significantly different among the three treatments. Soil temperature and salinity were lower in vegetated than unvegetated sediments, but similar beneath Spartina and Salicornia. Chlorophyll a concentration in sediments, representing microalga biomass, was variable. The mean concentration for vegetated sites was over twice as high as that for unvegetated sites, although the results were not statistically significant. Soil conditions (salinity, temperature, microalgae) were correlated with percent plant cover and light reduction based on regression analysis. Although Spartina was taller (56.5 cm mean) than Salicornia (33.9 cm mean), many measured values of sediment conditions were similar, possible because Spartina had a lower percent cover (50.5%) than Salicornia (91.7%), letting these two factors balance out in terms of environmental effects. Conclusions/Discussion These plants affect the ecosystem by reducing stressful conditions, such as high salinity and high temperature, promoting microalgae, which are the base of the wetland food chain. This study suggests that vegetation matters, and that in wetland restoration, a large emphasis should be placed on vegetation.	
Summary Statement The effects of the nearby environment on wetlands successfulness	
Help Received Worked under the supervision of Prof. Lisa Levin and Christine Whitcraft; father helped with board adhesives.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Gina C. Chien	Project Number S0805
Project Title Testing CO Levels During Car Warm-Up	
Abstract Objectives/Goals To find out whether the level of Carbon Monoxide emitted from car warm-up is hazardous to health. Methods/Materials MATERIALS: Safety Gas Mask; Carbon Monoxide Detector; Garage; 3 Test cars with Valid California Smog Certificates; Timer. METHOD: PART I # Open Garage vs. Closed Garage 1. The CO level of each car was obtained right after the car was started (before engine has warmed up), and after the car has warmed up. The CO concentration was obtained by placing the Carbon Monoxide detector about 4 inches away from the exhaust pipe. 2. The results were obtained from the three test automobiles in a closed garage environment, and an open garage environment. PART II # Simulation of a human next to a car during warm-up in a closed garage 1. The carbon monoxide levels in the engine exhausts of each test cars were measured by holding the CO Detector about four inches away from the engine exhaust pipe. 2. The CO detector was placed on the front passenger side roof. 3. The car engine was started from a cold engine to simulate a typical warming up. 4. The CO concentration and engine temperature were recorded as time elapsed. These same steps were repeated to each test automobile. Results Carbon monoxide emitted from a warming up car in a closed garage is very dangerous to human health. The Standards of California Smog Emission Check apparently has not put human health into its consideration. Results showed that the amount of CO generated from a warmed up engine running for twenty-four hours is less than the amount of CO generated from a cold started engine running for five minutes. The amount of Carbon Monoxide emitted relates to how fast the engine warms up. Conclusions/Discussion Results showed that Carbon Monoxide emission from car engine (especially in a closed garage) is very dangerous to human health. However, a way to minimize this health risk is by opening the garage door before starting up the car engine, or even better, not warming up car in a closed garage. Since the Catalytic Converter can only convert Carbon Monoxide to Carbon Dioxide when the engine reaches the temperature of 500 degrees Celsius, it is recommended for car manufactures to include a pre-heater for the catalytic converter so the mass emission of CO can be reduced at the beginning of car warm-up.	
Summary Statement Finding the method to avoid dangerous Carbon Monoxide level during car warm-up.	
Help Received Father bought materials, and supervised during the process of the experiment.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Sanjit Datta	Project Number S0806
Project Title Using Nitrifying Bacteria to Reduce Levels of Nitrogen Compounds in Madrona Marsh	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals Madrona Marsh, a vernal marsh in Torrance, California, has occasionally altered water quality in which there are raised levels of several nitrogen compounds. A possible solution to this challenge is the use of Nitrobacter and Nitrosomonas, two genera of nitrifying bacteria that are commercially available. The objective of this project is to test these bacteria and determine whether they would lower the level of nitrogen compounds in the Madrona Marsh Sump during periods of altered water quality.</p> <p>Methods/Materials The experiment was done by first collecting twenty gallons of Sump Water at the Marsh. This water was then divided into two tanks, one for the Experimental Group and the second for the Control Group. The water in each tank was tested each week for ammonia, nitrate, and nitrite concentration. Commercially purchased Nitrobacter and Nitrosomonas were added to the water after the water had been allowed to stabilize in the lab for one week. At the end of that week, the water was tested twice more. Another set of water samples was then collected from the same place in the Sump, in order to establish statistically reliable data. Exactly the same experimental procedure was followed for the second set as for the first.</p> <p>Results The bacteria were found to do an effective job of reducing the levels of ammonia, nitrate, and nitrite in the Madrona Marsh Sump water. Many of the levels in the Experimental Group stabilized with concentrations recorded in the Control Group - but in certain cases, the added bacteria reduced the amount of the nitrogen compounds much faster than they decreased naturally.</p> <p>Conclusions/Discussion The results show that the bacteria could be used to quickly reduce the concentrations of these compounds, and thus help to remediate one aspect of the water quality challenge at Madrona Marsh, when necessary. The results suggest that the concentrations would naturally be lowered (by bacteria already in the water), but reduction by the artificial addition of Nitrobacter and Nitrosomonas would quicken this process and allow the Manager/Naturalist at Madrona Marsh to reduce the amount of nitrogen compounds in the Sump water of Madrona Marsh. The addition of naturally occurring bacteria to accelerate these processes may undergo further research and possibly become a widespread technique of quickly lowering levels of ammonia, nitrate, nitrite, and other inorganic nitrogen compounds in freshwater bodies.</p>	
Summary Statement I used nitrifying bacteria to reduce concentrations of ammonia and solve water quality problems in Madrona Marsh.	
Help Received Father and siter helped create board; Mr. Carr helped design and execute project; Mother provided transportation to research site.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Hanh Do; Jessica Ng	Project Number S0807
Project Title Phytoremediation: The Efficiency of Arsenic Removal from Soil Based Upon the Origin of the Brake Fern	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals Phytoremediation has provided a safe and inexpensive mean of removing toxic chemicals from soil through the use of plants. A research on this topic done by Dr. Lena Ma of the University of Florida experimented with the China Brake Fern's ability to uptake arsenic. The purpose of our experiment, as an extension of this research, was to compare the China and Georgia Brake fern's efficiency of arsenic uptake based upon its differing orgin. We hypothesized that the China Brake fern would uptake higher levels of arsenic when contrasted to the Georgia fern based upon the available research done on the China fern.</p> <p>Methods/Materials A pair of China Brake Ferns and a pair of Geogia Brake ferns were acquired. The soils of like ferns were combined. As a control, soil and leaf samples were taken before any artificial addition of arsenic was made to ensure that all variables remained the same. Both soils were then spiked with 0.068 grams of arsenic. After even distribution, soil and leaf samples were taken every two weeks and sent to the Environmental Quality Institute of South Carolina, where the samples were tested for arsenic.</p> <p>Results The data collected showed a steady decline of arsenic concentration in both the soils and an increase of concentration in the leaves, indicating that indeed the ferns were hyperaccumulating the toxin from the soil into their frond system, as was concluded by Dr. Lena Ma's experiment. What was found to be significant to OUR experiment was the continual observation of significantly higher levels of arsenic concentration in the China fronds. The arsenic amount accumulated by the pair of China ferns over the course of two months was approximately 133 times more than that of the Georgia pair, with the concentration of arsenic found in the China ferns totaling a 1595.9 mg/kg while the Georgia ferns had a mere 12.4 mg/kg. The amount of arsenic uptaken and removed from the soil by the China ferns was also significantly higher than that of the Georgia. A total of 31.9 mg/kg of arsenic was removed from the China soil, and 24.5 mg/kg of arsenic from the Georgia soil.</p> <p>Conclusions/Discussion The data collected and analyzed therefore supported the hypothesis that the China Brake Fern uptakes arsenic much more efficiently than that of the Georgia brake fern.</p>	
Summary Statement The China Brake fern was determined to be the better hyperaccumulator of the toxin arsenic when compared to its cousin the Georgia Brake fern.	
Help Received Supervision done by Mr. Mark Okuda, labwork and experiment done at Silver Creek High science lab; arsenic testing done by Environmental Quality Institute	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Crystal Espinosa; Yesika Jimenez	Project Number S0808
Project Title How Clean Is the Stream?	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals We wanted to determine how healthy the creeks in Anderson Valley are and which feeder creek contributes the most pollution into Anderson Creek. We thought that Con Creek would contribute the most pollution because there is agricultural land where chemicals are used surrounding the area.</p> <p>Methods/Materials To determine the pollution in the creeks, we looked at the dissolved oxygen levels and the temperature at each site. We also gathered macroinvertebrates, small insects without backbones that indicate stream health, by a person holding a net in the creek downstream from a helper who kicked and scrubbed rocks. Then we identified each insect and qualified it under pollution tolerant, wide range, or pollution intolerant categories. We used Rubber boots, thermometer, stopwatch, home-made net, forceps, magnifying glasses, "CHEMets" Dissolved Oxygen Kit, plastic bottles with caps, cleaning brush, petri dishes, small fishnets.</p> <p>Results We found that Con Creek had the least amount of dissolved oxygen and the second least amount of macroinvertebrates. Rancheria Creek had the least amount of macroinvertebrates but a reasonably high amount of dissolved oxygen. Also, all the streams had a high amount of pollution intolerant macroinvertebrates and very few pollution tollerant macroinvertebrates.</p> <p>Conclusions/Discussion Based on our results, our hypothesis was partially right. Con Creek had the second lowest amount of macroinvertebrates as well as the lowest amount of dissolved oxygen. However, Rancheria Creek had the fewest macroinvertebrates. Rancheria Creek flows through many cattle ranches and through vineyards as well, whose runoff of dirt and chemicals may account for this reduced population of macroinvertebrates. For the most part, our results support the claim that all the creeks in the valley are healthy. We always found pollution intolerant macroinvertebrates in our samples and very few pollution tolerant macroinvertebrates were collected. Levels of dissolved oxygen in our streams are high, and the streams maintain a consistent and relatively cool temperature. Projects like ours that monitor different physical and biological aspects of stream ecology are important for establishing and maintaining conservation and restoration efforts.</p>	
Summary Statement We determined the stream quality of local creeks by examining levels of dissolved oxygen and classifying macroinvertebrates by pollution tolerant groups.	
Help Received Our Science teacher monitored our science project and watershed restoration manager drove us to take our creek samples	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Lauren E. Fukumoto	Project Number S0809
Project Title Localized Gamma-Ray Spectrometry Measurements of Schools in the PVPUSD, Palos Verdes Estates, California	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The first objective was to quantify soil uranium concentrations at school in the Palos Verdes Peninsula Unified School District (PVPUSD) for comparison with classroom radon levels and geologic subunits that comprise the peninsula. A second objective was to sample uranium concentrations of similar soils in Los Angeles County to estimate the potential for elevated indoor radon in those areas.</p> <p>Methods/Materials Two portable gamma-ray spectrometers were used to measure the equivalent uranium, thorium, and potassium concentrations at each school in the PVPUSD and at selected areas of Los Angeles County. Six to seventeen ground measurements and representative soil samples were taken from each school site. The portable spectrometers were calibrated against a much larger, fixed gamma-ray spectrometer located at the United States Geological Survey (USGS) headquarters in Reston, Virginia. Ground measurements from other areas of Los Angeles County were then compared with the indoor radon and soil uranium results from Palos Verdes.</p> <p>Results The average uranium concentration at the seventeen schools ranged from 1.4 to 10.4 ppm, and for those schools with average readings greater than 2 ppm, there was a high probability of finding at least one classroom exceeding the US EPA action level of 4 pCi/L. Ground measurements taken from similar soils in central Los Angeles County ranged from 3.1 to 8.0 ppm, indicating a significant potential for elevated indoor radon in those areas.</p> <p>Conclusions/Discussion For schools with average soil uranium concentrations of 2 ppm or less, none had classrooms that approached the US EPA action level of 4 pCi/L. In contrast, the majority of schools with uranium concentrations greater than 2 ppm were found to have at least one classroom with levels exceeding 4 pCi/L. The current data demonstrate that a boundary value of 2 ppm soil uranium can be used to separate sites of higher and lower measurement priority, and that site-localized gamma-ray spectrometry can serve as a tool to rapidly identify sites with the potential to generate excessive indoor radon. Furthermore, zip code population statistics combined with gamma-ray field measurements in central Los Angeles County alone indicate that over 700,000 residents could be exposed to elevated indoor radon.</p>	
Summary Statement Soil uranium concentrations were compared with a radon database for the PVPUSD resulting in a 2 ppm priority measurement level and indicating that over 700,000 residents in Los Angeles County may be exposed to elevated indoor radon.	
Help Received Used gamma-ray spectrometer under supervision of Dr. Joseph Duval; PVPUSD provided access to all school sites; father helped edit presentations.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Etta Grover-Silva; Kaela Jorgenson	Project Number S0810
Project Title Rapid Bioassessment Macroinvertebrate Madness	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals Our project's objective was to determine the effect of stream restoration on the aquatic macroinvertebrate community of Cummings Creek, Humboldt Co. CA. We predicted that the restoration projects completed on Cummings Creek would have a positive effect on the aquatic community. We predicted increased macroinvertebrate abundance and biodiversity.</p> <p>Methods/Materials We used the California Stream Bioassessment Procedure to obtain macroinvertebrate samples from Cummings Creek in 2000 and 2003. One sample was taken from each of the six established sampling sites from both 2000 and 2003. We extracted all of the macroinvertebrates from each sample and identified them to order and family in the laboratory to acquire macroinvertebrate abundance, species richness, and biodiversity estimates.</p> <p>Results Statistical analyses of the data suggested that the species richness, community diversity, and total abundance of macroinvertebrates increased following restoration efforts. There was a drastic increase in abundance of important water quality indicator taxa along with significant increases in richness and diversity. This data shows that the stream restoration projects had a positive effect on the aquatic community.</p> <p>Conclusions/Discussion Our results indicate that the restoration projects conducted on Cummings Creek between 2000 and 2003 improved habitat for the aquatic macroinvertebrate community, suggesting improvement in the health of the stream. It is important to measure the effect of these restoration projects because recognizing the effects of stream restoration on aquatic communities is important for planning future restoration efforts.</p>	
Summary Statement Our project's objective was to determine the effect of stream restoration on the aquatic macroinvertebrate community of Cummings Creek, Humboldt Co. CA.	
Help Received Karen Lamoncha oversaw our work; Mother called contacts; Mike Camann assisted with statistical analysis; used Humboldt State University laboratory.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Jason B. Harrell	Project Number S0811
Project Title Comparing Nitrate Runoff on Organic and Conventional Fertilizer: Can We Reduce Excess Nitrate Runoff?	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals In my project, I am trying to determine which fertilizer (conventional or organic), used on festuca elatior, results in the greater amount of nitrate runoff. In doing so, I hope to discover which fertilizer is the least harmful for the environment.</p> <p>Methods/Materials In the experiment, I have set up three containers containing grass, including reservoirs to catch unutilized water. I will only be using fertilizer on two containers, and one container will be my control. A lab will test the water and the grass for nitrate regularly.</p> <p>Results In my experiment, I have discovered that the conventional fertilizer had the most nitrate runoff.</p> <p>Conclusions/Discussion The results of my project agreed with hypothesis, because I said that the conventional fertilizer would have the most nitrate runoff because the nitrogen is refined, so the nitrogen would break down and become nitrate more easily, thus causing more runoff.</p>	
Summary Statement My project will determine whether organic or conventional fertilizer has a greater runoff, thus deciding which one is least harmful the environment.	
Help Received I talked with a farmer with experience in using organic fertilizer to grow crops, and a teacher to determine the best method to test for nitrate. I also used a lab to perform the tests.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Clayton S. Johnson, Jr.	Project Number S0812
Project Title The Effect of Hyperaccumulators on Zinc-Contaminated Soil	
Abstract Methods/Materials I tested to see if growing Zinc absorbent plants is effective at reducing the large quantities of Zinc in the soil. My two treatment plants were Thlaspi and spinach and I hypothesized that Thlaspi would be more effective at cleaning up zinc-contaminated soils because even though it has a lower plant growth, its zinc absorbency is higher than spinach. I had three treatments: control, soil with 600-ppm zinc, and soil that contained 1800-ppm zinc. For each treatment, I planted one set of Thlaspi seeds and one set of spinach seeds. After the plants had grown I measured the amount of zinc in each plant. Results My data showed that the Thlaspi did a better job than spinach at absorbing the zinc from the soils. The Thlaspi also ended up storing more zinc even though the spinach had a larger growth rate. Conclusions/Discussion I concluded that Thlaspi would be more effective at removing zinc from soil than spinach. However, in the long run, using plants to clean soil will not be very effective because although the Thlaspi did a good job at removing zinc from the soil, it was still not a significant amount.	
Summary Statement My project is about cleaning zinc-contaminated soil and comparing plants to see which accomplishes this the best.	
Help Received Leon Kochian donated Thlaspi seeds; Father took dry weights of zinc; Mother helped put together board; Nat Dellavalle analyzed zinc in Dellavalle Lab	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Brian C. Ladd	Project Number S0813
Project Title The Comparative Study of Erucic Acid Rapeseed Oil in Varying Aquatic Environments	
Abstract Objectives/Goals Crude oil is found in natural deposits and seeps all around the world. Crude oils are toxic and will affect the nervous system of animals that come in contact with it. I wanted to understand how nature eliminates crude oil that has been spilled. I substituted low erucic acid rapeseed oil (canola oil) for crude oil so that the hazard of my experiment would be set at a minimum. Canola oil is not a petroleum oil, but it is a light oil so it is still an accurate substitution. My hypothesis was that the naturally occurring microorganisms in bay and creek water would biodegrade the oil. I thought the creek water would support the most bioremediation because it would have the most microorganisms in it. I thought that the less concentrated the water was with oil, the more remediation would occur. Distilled water should have no microorganisms therefore no bioremediation will occur, and it serves as a control. To avoid needing to ensure a homogeneous mixture in a large tank to take samples, I designed my setup to use multiple small containers. Each test used the entire contents of the container. I developed the method for measuring the amount of oil in a sample and calibrated it to make sure that it would work. Boiling the water while leaving the canola oil is possible because of canola oil's high flash point (275-290 Celsius)	
Methods/Materials To run my experiment, gather samples of bay and creek water. Set up 20 sample containers each with 400mL of bay, creek and distilled waters. Add 4mL of canola oil to half the samples and 20mL to the other half. Measure the amount of oil in two of each type of sample weekly for five weeks to measure progress in the bioremediation using the #Procedure for Measuring the Weight of Oil Remaining#.	
Results The results of my experiment were the distilled water had very little bioremediation, the creek water bioremediated two or three grams of oil, while the bay water samples degraded one or two grams. This shows that bioremediation will occur whenever there are microorganisms present, and the type of water did not affect the degradation. Both the 20mL of oil and the 4mL of oil biodegraded about the same, allowing me to conclude that the amount of oil doesn't affect the remediation within the range tested.	
Conclusions/Discussion see results	
Summary Statement This experiment compares the natural reaction of water to oil in varying water types and oil concentrations.	
Help Received Dr. Sarah McMillen helped fine tune my procedure.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Beyang Liu	Project Number S0814
Project Title Oil in Soil: A Study into a Method of Agricultural Water Conservation	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals Does adding oil to the top layer of soil reduce water loss from the soil? In arid regions such as southern California, water conservation is a vital issue. Applying the concepts of capillary rise and interfacial tension, this project focuses on using vegetable oil as a way to reduce water evaporation from soil by slowing the flow of underground water to the soil surface.</p> <p>Methods/Materials Dry soil was ground into a fine powder. 3000g of the dry soil was mixed with 500g of water to create pre-moistened soil. 200g of the pre-moistened soils were placed in each of 15 cups. The 15 cups containing the moistened soils were split into three trials of 5 variables (3 X 5). 50g of dry soils treated with 0, 2.5, 5.0, 7.5, and 10 g oil (PAM cooking spray) were added to the top of each of the 15 cups to form the top layer of soil. The sample containing 0 g of oil was used as the control. All of the samples were placed outside during the daytime in the same location. The mass of each sample was recorded daily. Mass loss signified water loss.</p> <p>Results The water loss in the samples treated with vegetable oil was significantly lower than that in the control without oil. The amount of water lost was inversely associated with the amount of oil added into the top layer of soil. However, there was no significant statistical variation in water loss between samples treated with different amounts of oil</p> <p>Conclusions/Discussion Vegetable oil in the top layer of soil changes the interfacial tension between the top layer of soil and water in the lower layer of soil (the lower layer was not treated with oil). It also increases the interfacial tension with water inside the tiny holes in soil that act as capillaries for the water to rise through. Vegetable oil therefore counteracts the force (capillary rise) pushing water towards the surface. As a result, less water is lost due to evaporation. Treating topsoil with biodegradable vegetable oil is a possible and superior alternative to the current water conservation methods such as plastic tarp coverings, which are not biodegradable and require more labor to deploy and maintain. The best concentration of oil in the top layer of soil in an agricultural application is 5%, because at this level, the physical properties of soil are maintained while water loss is reduced by 25%.</p>	
Summary Statement This project seeks to study the relationship between the amount of vegetable oil in the top layer of soil and the amount of water lost from that soil, so that water can be more efficiently conserved in agriculture.	
Help Received	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Smita Mascharak	Project Number S0815
Project Title Phytoremediation of Lead Using Brassica nigra: A Solution for the Fort Ord Clean-Up?	
Objectives/Goals Some plants (called hyperaccumulators) have been shown to accumulate heavy metals from soil. The purpose of this experiment was to find out if lead in soil could be phytoremediated using Brassica nigra (black mustard) and if the addition of EDTA sped up this process. I hypothesize that the plants will accumulate a substantial amount of lead and that the addition of EDTA will increase the total amount of lead collected by the plants.	
Abstract Methods/Materials A set of one hundred seedlings of B. nigra was grown in a greenhouse at UCSC. The plants were divided into 5 sets of 16, properly marked, and then lead (as lead nitrate) was added to the soil as follows: A (control), B1 (400 ppm lead, no EDTA), B2 (400 ppm lead, EDTA), C1 (2000 ppm, no EDTA), and C2 (2000 ppm, EDTA). After regular feeding and watering for 4 weeks, the first "harvest" of plants collected, dried and ground to obtain samples for lead analysis. Aliquots of 50 mg of the dried samples were digested in 2 mL of 1:1 HNO ₃ : HCl mixture, diluted and the amounts of lead present in the sample solutions were determined by Atomic Absorption Spectroscopy. The whole process was repeated with samples of the second "harvest" (collected after 8 weeks). One C2 sample from the second harvest was separated into stem, root, seedpod and leaves/flowers and each part was separately analyzed for lead. The roots from each category from the third harvest (collected after 12 weeks) were also analyzed.	
Results As hypothesized, the B. nigra plants showed a steady increase of lead accumulation throughout the first two months. EDTA facilitated the process of lead accumulation. The amount of lead in the plants was proportional to the concentration of lead in the soil. The roots contained the highest amount of lead. However, significant amounts of lead accumulated in the portion of the plant above ground as well.	
Conclusions/Discussion The results of this experiment demonstrate the feasibility of phytoremediation in relation to the high concentration of lead in the soil of Fort Ord.	
Summary Statement The purpose of this experiment is to find out if lead in soil can be phytoremediated using black mustard.	
Help Received Jim Velzy and Linda Locatelli provided greenhouse facilities at UCSC; Matt Hurst helped me in the lead analysis by AA Spectroscopy; My father, Pradip Mascharak, helped with the background information and in assembling the poster; Lynda Rogers oversaw the progress of the whole project.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Yo Miyamoto; Shane Suazo	Project Number S0816
Project Title Moringa oleifera: Nature's Coagulant	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this project is to evaluate the coagulating properties both Moringa Oleifera seed kernel powder and Moringa Oleifera De-oiled seed powder and compare their effectiveness to common coagulants. #Effectiveness# was determined within each coagulants respective optimum conditions, and based on the following criteria: turbidity, and removal of coliform bacteria. The vast majority of our experimentation was comprised of a series of jar tests on synthetic water samples, followed by screening of the samples for various impurities. The primary focus of this project is its application to the third world; in reference to the coagulant#s potential to prevent the spread of waterborne diseases.</p> <p>Methods/Materials In order to test our hypothesis, we first determined the #optimum# operating conditions for each coagulant. Using these optimum conditions, an additional series of jar tests was conducted for each coagulant on waters of varying turbidities. In addition to these tests, water samples synthetically #contaminated# with e. coli cultures were screened before and after coagulation for total coliform populations. In this manner, the coagulant#s anti-bacterial qualities were quantified.</p> <p>Results Both moringa Oleifera seed kernel powder and moringa oleifera de-oiled seed powder effectively lowered turbidities of cloudy waters. Their effectiveness, although not quite as robust as conventional coagulants, proved comparable. As predicted, the de-oiled version of the seed powder proved more efficient than the original version. Also it was observed that both moringa coagulants were more effective in more turbid waters. The coliform tests didn't display bacteria-removal capabilities in either moringa coagulant; this however, may be a result of the preparation of synthetic turbidity.</p> <p>Conclusions/Discussion Although not quite as effective as commercial coagulant, the moringa coagulants proved an effective alternative. The coagulating properties of the moringa powder are sufficient to produce clean drinking water; and could effectively improve water-sanitation in third-world countries at a low cost.</p>	
Summary Statement Our project evaluates the effectiveness of both moringa oleifera seed powder and moringa oleifera de-oiled seed powder in removing turbidity and coliform bacteria from drinking water supplies.	
Help Received Borrowed equipment from South Bay System Authority; Used lab facilities of Hillsdale High School; under supervision of Stephen Maskel and Charlie Bissell	



CALIFORNIA STATE SCIENCE FAIR 2004 PROJECT SUMMARY

Name(s) Caelan O'Sullivan; Shelley Patel; Shivani Softa	Project Number S0817
Project Title The Prediction and Variability of Ozone Levels during Episodes of Severe Air Pollution in the Southern San Joaquin Valle	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals As no specific method of ozone prediction previously existed, we wanted to create one for use on high ozone days so it could be determined which hours of the day were safer than others to be outside. Increased public awareness of the hourly variations of ozone could lead to a heightened interest in improving air quality, so an experimental analysis of ozone variations was deemed appropriate, and, moreover, necessary.</p> <p>Methods/Materials We obtained the 2001 ozone readings from the Air Resources Board on CD-ROM format and organized it by date and hour. We color-coded our 2001 ozone readings chart, and used the information derived from it to formulate graphs. We created individual graphs for each of the seven ozone-measuring stations in the southern San Joaquin Valley, our subject of study (its ozone rating is within the top three worst in the country). Based on the images, unique patterns were distinct for each location, so we reasoned that a system of prediction was definitely possible. We generated more graphs with different combinations of the data to try to produce more patterns. After more organization, we obtained equations for our graphs depending on which time of day and year was in question. A second method, a type-curve, was used to obtain another set of graphs based on time of year, time of day, and predicted temperature against ozone concentration.</p> <p>Results The culmination of the project resulted in several notable findings. We discovered that since every station with the confined region of the southern San Joaquin Valley has its own unique trend in ozone variation, it is impossible to designate a generalized time period to the entire nation in which it is #unhealthy to exercise#. The Air Resources Board of America had incorrectly proposed that people not exercise during the hours of 9 a.m. to 6 p.m. during (unidentified) times of high ozone levels. Based on our graphs, we were able to develop specific rules for the curves in two methods.</p> <p>Conclusions/Discussion We determined that in the southern San Joaquin Valley, people should not exercise between the hours of 7 a.m. and 7 p.m. during times of the year up to 120 days before or after the summer solstice. Additionally, we developed two methods (trend-fitting and type-curves) of predicting ozone concentration, which we had been told by representatives of the Air Resources Board and the Air Quality Management Department was impossible to do.</p>	
Summary Statement The project's purpose was to analyze the effectiveness of existing recommendations as to when it is safe to exercise, as well as to develop a predictive method of determining ozone concentration.	
Help Received Dr. Deborah Drechsler of the Air Resources Board helped us interpret and de-code information; Kelli of the Air Quality Management Department (Fresno base) was interviewed about air quality and ozone formation.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Kimberly A. Sparks	Project Number S0818
Project Title What's In Your Water?	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals In this project I attempted to remove nitrites from water by designing a biological filter that would be able to oxidize nitrites into nitrates. The purpose of this project was to determine if biological filters could be used to remove nitrites from contaminated well water at treatment plants in Southern California.</p> <p>Methods/Materials Nitrite contamination in Southern California well water is common because the water has been polluted by agricultural activities, namely by chicken and dairy farms. As I did not have a likely chance of obtaining samples from closed wells, I instead used feeder fish to simulate high levels of nitrite concentration. I then designed a biological filter using ceramics and bacteria as the active elements that could oxidize nitrite into nitrate.</p> <p>Results Using nitrite test kits, I ran several simulations with the affected water in which I found that the biological filter, although it took a couple of days, significantly reduced the amount of nitrites in each sample. It did not, however, reduce the nitrite contamination to .1ppm, which is the EPA standard for drinking water.</p> <p>Conclusions/Discussion Biological filters might be used in combination with other nitrite treatments to purify water at treatment plants, but cannot be used as a sole method for reducing nitrite levels as I originally thought.</p>	
Summary Statement I attempted to remove nitrites from water by designing a biological filter that would be able to oxidize nitrites into nitrates in the hopes of salvaging polluted Southern Californian wells.	
Help Received My Dad helped me to select my materials and gave input on the primary design of my filter.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Joyce Truong	Project Number S0819
Project Title The Effects of Aquatic Plants on Algae Growth, pH, Nitrite, and Phosphate Levels	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this experiment was to observe the effect of Eichhornia crassipes and Cabomba caroliniana on algae growth as well as pH, nitrite, and phosphate levels in the water.</p> <p>Methods/Materials The materials included six clear, plastic containers, water, four Eichhornia crassipes, six Cabomba caroliniana, and six liters of water. Two containers were partially and completely filled with Eichhornia crassipes. These containers, along with a container without plants, were set outside in a sunny location. The same was done for the remaining containers using Cabomba caroliniana. Algae growth, pH, nitrite, and phosphate levels, in the water were checked every other day, along with temperature, sunrise and sunset times, along with precipitation.</p> <p>Results The containers completely covered by plants had a pH of at least 8.8, a nitrite level of 0 mg/L, a phosphate level of at least 1 mg/L, and 20 percent algae cover. Containers partially covered with plants had a pH of at least 8.8, a nitrite level of 0 mg/L, a phosphate level of 0.4 mg/L, and 20 percent algae cover. Containers with no plants had a pH of 8.5, a nitrite level of 0 mg/L, a phosphate level of at least 1 mg/L, and 8 percent algae cover.</p> <p>Conclusions/Discussion Algae growth was higher in the containers with plants because of algae's tendency to cling, such as roots, leaves, and stems. It was also higher because the high phosphate levels and because the plants served as a barrier, shielding out harsh weather and other disturbances. Phosphate levels were high because the plants were dormant and did not need phosphate for development or flowering at this time of year. They were also high from the dying parts of the plants and the decaying vegetation that fell into the containers. Nitrite levels were low because there was no nitrite to begin with, nor were there any new sources of nitrite. The pH levels were lower in the containers with no plants due to the exposure to rain, which is acidic. Phosphate levels were lower in the containers with no plants because there were no plants placed in it so the only source of phosphate was the decaying leaves that fell in from outside.</p>	
Summary Statement My project deals with the relationship of aquatic plants and algae growth, and their effect on pH, nitrite, and phosphate levels.	
Help Received My father helped me by purchasing the pH, nitrite, and phosphate kit as well as the aquatic plants.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Paul A. Westhart	Project Number S0820
Project Title The Effect of Ammoniated Cellulosic Material (Bagasse) on the Bioremediation of Oil Contaminated Water	
Objectives/Goals The objective of my experiment is to determine if the oil degrading activity of Pseudomonas bacteria can be enhanced by the introduction of ammoniated bagasse in an aquatic setting. Bagasse is an abundant byproduct of sugar cane processing.	
Abstract Methods/Materials Prepare white nutrient broth to culture Pseudomonas. Pour 200 mL of distilled water into 7 sterilized jars. Add 20 mL of distilled oil into each jar. Inoculate two jars with 7 mL of Pseudomonas culture, two jars with 7 mL of Pseudomonas culture and 3g of ammoniated bagasse, two jars with 3g of ammoniated bagasse and separate 1 jar containing distilled water and oil as control. Keep the jars together at room temperature. Check the pH of each jar weekly. Observe changes in density and/or turbidity in each sample. Count the bacteria colonies in each sample 3 times by using dilutions and plating-out procedures. Test each sample for oil degradation using a GC mass spectrometry apparatus. Observe the samples under the microscope. Observe the samples every two days during eight weeks.	
Results The oil degrading activity of the bacteria Pseudomonas mixed with ammoniated bagasse (#Mix#) was higher than the control and the other jars. The change in the bacterial population of the Mix was 85×10^6 compared to 80×10^6 for Pseudomonas alone and 4×10^6 for ammoniated bagasse alone. The decrease in the pH of the Mix was 0.6 compared to 0.3 for Pseudomonas alone and 0.1 for ammoniated bagasse alone. The mass spectrometry test confirmed that the oil degrading activity of the Mix was greater than the other samples. The holding capacity test showed that the bagasse absorbed 3 times its weight in water and oil.	
Conclusions/Discussion The data support my hypothesis that ammoniated bagasse enhances the biodegradation of oil by Pseudomonas. After 45 days, there was significantly more oil degradation in the samples containing the Mix compared to the other samples and the control. The higher bacterial count in the Mix is evidence that the ammoniated bagasse was effective in enhancing the environment for bio-remediation of oil in aquatic systems. The ammoniated bagasse provides oxygen, nitrogen and an increased oil surface area to the Pseudomonas. The acidic groups identified by mass spectrometry at the end of the hydrocarbon chain in the Mix are evidence of oil degradation because Pseudomonas add acidic groups to hydrocarbons during biodegradation.	
Summary Statement My project tests the effect of ammoniated bagasse on the bioremediation of oil spills by the Pseudomonas bacteria in water.	
Help Received My parents helped me obtain the necessary materials. Dr. Gardiner and Dr. Grun from UCI allowed me to use their lab's GC Mass Spectrometer under their supervision. They also helped me analyze the mass spectra.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Scott R. Wilson	Project Number S0821
Project Title Hydroponics and Aquaculture: Using Plants to Recycle Fish Ammonia	
Abstract Objectives/Goals Study if hydroponically grown plants (plants grwn in liquid media) can help recycle ammonia generated in fish-farming (aquaculture) operations. Methods/Materials The experimenter recycled ammonia generated by goldfish in a test aquarium and measured the amount of ammonia removed by hydroponically growing mint plants in the water and ammonia from the test aquarium. The experimenter compared the growth of mint plants fertilized with fish ammonia to the growth over the same time period of a control plant not provided the fish ammonia. Results Test plants removed ammonia from the test tank to safe levels for the fish. The fish ammonia and water from the test aquarium promoted growth of the test plants over the growth of the control plant. Conclusions/Discussion This study indicates plants such as mint plants grown hydroponically can benefit from the ammonia/water mixture produced by fish such as goldfish. More generally, aquaculture (raising fish such as goldfish) can produce ammonia by-products removable and usable by hydroponically grown plants (such as mint).	
Summary Statement Determine if hydroponically grown plants (plants grown in liquid media) can help recycle ammonia generated in fish-farming (aquaculture) operations	
Help Received Parents helped with typing and helped purchase supplies.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Megan S. Yoo	Project Number S0822
Project Title Chlorination: Saving Lives Everyday, or Is It? A Study on the Formation of Trihalomethanes in Natural Water	
Abstract Objectives/Goals The objective of my experiment was to note the trend in the formation of trihalomethanes (THMs), based on water type, incubation time, and the amount of sodium hypochlorite (NaOCl) solution spiked into the water source. Methods/Materials A calibration curve was created using different concentrations of the THM standard on the Varian GC/MS, for 2, 5, 20, 30, 50, and 100 ppb of THMs. For Experiment 1, water from various sources with different levels of organic content was spiked with varying levels of 6% NaOCl solution. DI water was used as a control. Experiment 2, after being slightly modified to test the hypothesis further, was conducted to validate the data found in Experiment 1. Two sets of each water sample were tested. The GC/MS was used to analyze the type and quantity of the THMs using 40 mL samples collected in amber vials for each water sample. The fluorobenzene internal standard#s ratios were checked to ensure that the results for the THM analysis were accurate. The amount of THMs in ppb formed in the water samples were recorded on the initial day of experimentation, and 1, 3, 5, and 7 days after the first day. Results Water with a high content of organic substances, such as water from the Santa Ana River and Prado Wetlands, had a significantly higher number of total THMs (TTHMs) than relatively clearer water, such as OC reclaimed water and OC groundwater. The more the water has been filtered, whether naturally through the soil layer, or through purification filters, the lower the amount of THMs present in the water. Conclusions/Discussion Trihalomethane formation is directly related to the organic content of water, the amount of chlorine spiked into the water, and the incubation period. The amount of TTHMs in water with large amounts of organic substances and a high concentration of NaOCl solution was drastically greater than water with few or no organic material and a low concentration of NaOCl solution. THMs, especially chloroform, are easily produced in many water sources after chlorination. THMs have been linked to bladder, colon, and rectal cancer, in addition to diseases in the kidney, liver, lung, and nervous system, and miscarriages. Known as toxins, significant amounts of THMs (over 60 ppb) can also cause large sores, in addition to the various diseases and illnesses. Both hard chlorine tablets and liquid forms of chlorine can cause THM formation in water.	
Summary Statement I determined that trihalomethane formation has a positive association with the amount of organic substances in water, the level of chlorine present in the water, and the incubation period.	
Help Received I received prior training on running and interpreting the GC/MS, available at OCWD, from Supervising Chemist Lee J. Yoo during the past three years. Lab work for detection of trihalomethanes was done in the organic laboratory of OCWD under the supervision of Lee J. Yoo.	



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

Name(s) Vinay Tripuraneni	Project Number S0899
Project Title CO₂ and the Greenhouse Effect: Can Highly Efficient Freshwater Phytoplankton (Algae) Reverse a Potentially Deadly Proces	
Abstract Objectives/Goals The basis of this project was to determine which algal species produces the most Oxygen, thereby removing an equal amount of Carbon Dioxide by means of Photosynthesis. Methods/Materials This two-part eight week study was conducted using a self-designed apparatus. The apparatus consisted of a 250 mL I.V. bag that connected to tubing. The tubing was then connected to a 100 mL gas measuring tube through a rubber stopper. Once the apparatus was constructed, 5 different 25%/100 mL algal cultures were injected into each I.V. bag along with 100 mLs of pond water and 50 mLs of a 2.5 % Sodium Bicarbonate solution. After all of the six assemblies were prepared (this includes a control) they were placed into an Environmental Chamber. The algae were allowed to photosynthesize for a period of two weeks, for 10 hours a day. Once the two week period concluded a syringe was used to measure the amount of Oxygen produced. Then each culture was extracted from the I.V. bag and the percent transmittance was determined through the use of a spectrophotometer. This experiment was repeated twice with two of each algal culture in each experiment; this totaled to four sets of data for each algal culture. Results From the data acquired from both two week studies Oscillatoria was determined to be the species that performed the best. Oscillatoria boasted a production series of {4.5,5.0,4.8,5.0} mL of oxygen (O ₂), while the next highest producer, Volvox, produced a respectable {4.7,4.7,4.7,4.6} mL of O ₂ throughout the experiment. Spirogyra was the third most productive producer, producing {4.6,4.2,3.8,4.2} mL of O ₂ . Chlorella and Anabaena were the least productive with an O ₂ output of {2.0,1.8,1.9,1.5} and {1.8,1.9,1.6,1.7} mL of oxygen respectively. The Chi#s Square method indicated that Oscillatoria performed much better than all the other species with a 99.0% confidence level. Conclusions/Discussion The final analysis showed that Oscillatoria consistently outperformed all of the other algal species. One of the possible explanations may be that Oscillatoria has the most efficient chloroplast. Oscillatoria must have an enzyme that is more effective at binding/transferring energy. This superior enzyme binds energy from the chloroplast to the H ₂ O molecules to split them much more efficiently. If this enzyme were manipulated the efficiency of photosynthesis in an algal cell could be greatly improved.	
Summary Statement This study focuses on determining which algal species is the most adept at producing O ₂ and removing CO ₂ by means of Photosynthesis.	
Help Received Conducted at Clovis West High School with on-site lab equipment. Mr. Wayne Garabedian and Dr. Bert Tribbey both provided invaluable advice. Father helped assemble board.	