



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Seung Hye Choi	Project Number S0601
Project Title Comparative Studies of Gold Nanoparticles as Chemical Sensing Materials: Electronic Tongue vs. Electronic Nose	
Abstract Objectives/Goals The main goals of my project are (1) to develop simple, cost-effective, reusable electrochemical sensor arrays (electronic tongue and electronic nose) that can simultaneously detect Be^{2+} , Cd^{2+} , Hg^{2+} , and Pb^{2+} in water and ethanol, dichloromethane, and carbon monoxide in the air and (2) to evaluate and compare sensing performances (e.g., detection limit, selectivity, and sensitivity) with respect to film morphology and the type of samples. Methods/Materials Gold nanoparticles (Au NPs) with ~1.6 nm core diameter were synthesized by a literature method. The synthesized Au NPs were functionalized with six different types of thiols (4 different crown ether thiols, thiolated polyethylene glycol, and mercaptoundecanoic acid) by ligand exchange reactions. The thin films of seven different types of Au NPs (six functionalized and one unfunctionalized) were individually casted on each of interdigitated array electrodes or high pressure electrodes to build electronic tongue or electronic nose. Results Both electronic tongue and electronic nose showed linear responses with specific metal ions and gas/vapors, respectively. The electronic tongue could simultaneously detect cadmium, mercury, lead, and beryllium at 0.1 - 2.6 ppb levels, while the electronic nose can simultaneously detect carbon monoxide, ethanol, and dichloromethane at 5.0 - 12.5 kPa levels. Selectivity was determined by calculating selectivity coefficients (ratios of interference response to analyte response). Both electronic tongue and nose could be reusable when they were cleaned with 0.1M EDTA solution (electronic tongue) or N_2 gas (electronic nose). Conclusions/Discussion Compared with the previous year's electronic tongue (a non-linked film by drop-cast), the current year's electronic tongue (a linked film by self-assembly) showed better sensitivity, selectivity, and stability but similar detection limits and narrower dynamic range. The electronic tongue displayed better sensitivity and selectivity than the electronic nose. The response of electronic nose was less linear than that of electronic tongue. Based on the observed data analysis, it was concluded that (1) gold nanoparticles are versatile materials for chemical sensing, (2) the self-assembly technique is preferred to develop a better electronic tongue, and (3) the electronic tongue provides more reliable data than the electronic nose.	
Summary Statement I have developed electronic tongue and electronic nose that can simultaneously detect toxins in either water or air, respectively.	
Help Received All experiments were conducted at California State University - Fresno under the supervision of Drs. Hasson and Choi.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Shawn P. Cogan	Project Number S0602
Project Title The Effect of Rocket Fuel Ratios on Burn Rate	
Abstract Objectives/Goals The objective of this experiment is to analyze the combustion rates of several ratios of procket fuel and oxidizer, to see which one had the fastest burn rate. Methods/Materials Basic homemade rocket casings, potassium nitrate and sugar, and an ignition switch was used to burn five different ratios of fuel. While volumes differed slightly, density of the different rockets were kept constant. The burn time in cm ³ per second was determined for each ratio, and analyzed on a graph. Results The mixture with the most rapid burn rate was determined to be about 35% sugar and 65% potassium nitrate. However, the burn rate did not decrease equally in both directions of this median. The ratios with excess oxidizer burned faster in comparison to the ratios with excess fuel. Conclusions/Discussion This ratio, although found with Potassium Nitrate as the oxidizer and sugar as the fuel, can be applied to many other concepts, because the same rough ratios applies to similar fuels, including the one used in the solid boosters of the space shuttle. Furthermore, by knowing the correct ratio, the temperature, pressure, and length of the reaction can be found, and used to calculate the most efficient rocket nozzle design for that fuel.	
Summary Statement This project in its present form analyzes the combustion of five different rocket fuels to determine the most rapid burn rate.	
Help Received N/A	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Desten Davies; Dalton Leighton	Project Number S0603
Project Title Flames, Flames, and More Flames	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of our project is to find the most flammable chemical between nail polish, rubbing alcohol, and hand sanitizer. We wanted to test and show people how dangerous some household chemicals are. We hypothesized that rubbing alcohol would be the most unsafe because it has the lowest ignition temperature.</p> <p>Methods/Materials First we measured one ounce of each chemical. We put each chemical in the pans individually, and bleached the pan in between uses. To ignite the chemicals we used a barbecue lighter. We used a stopwatch to measure how much time passed between contact with the open flame and total ignition of the chemical.</p> <p>Results Hand Sanitizer lit the quickest at .1 second. Rubbing alcohol was the second fastest to ignite at .74 second, and nail polish was the slowest at 1.32 seconds. Our hypothesis was proved wrong.</p> <p>Conclusions/Discussion Hand sanitizer was the quickest to ignite because it contained the highest concentration of the chemical Isocerphyl. These findings are important because people use these chemicals every day and likely don't know how dangerous they are.</p>	
Summary Statement This project researched the quickest household item to ignite when exposed to an open flame.	
Help Received	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Ishani N. Desai	Project Number S0604
Project Title The Science Behind the Stretch	
Abstract	
Objectives/Goals To find which cheese, made from different fat percentages of milk (3.5% milk, 1.75% milk, < 0.1%) results in the longest stretch of cheese.	
Methods/Materials <ul style="list-style-type: none">-1.5 gallon of whole milk-1.5 gallon of skim milk-1 1/4 teaspoon of citric acid-1/8 mL of rennet enzyme-Huge pot (big enough to hold 1 gallon of milk)-Colander-Thermometer-Weighing scale	
Results <p>In the first trial, whole milk stretched eight feet, and weighed 600 grams. The combination milk (half whole milk, and half skim milk) stretched 3.5 feet, and weighed 475 grams. The skim milk stretched 11 feet, and weighed 300 grams.</p> <p>In the second trial, whole milk stretched 9.25 feet and weighed 600 grams. The combination milk stretched 3 feet and weighed 575 grams. The skim milk stretched 7 feet and weighed 310 grams.</p> <p>The the third trail, the full fat milk stretched 7 feet and weighed 585 grams. The combination milk stretched 3 feet and weighed 575 grams. The skim milk stretched 7 feet and weighed 310 grams.</p>	
Conclusions/Discussion <p>The cheese made from skim milk was enable to stretch the most. On average, this is because when the cheese was stretched, the temperature was at the highest. This enabled the cheese the stretch the most because of the protein in the cheese likes the hot temperature to stretch. First, the milk must be at a certain pH in order for the proteins to precipitate. In order for the protein to precipitate, the milk must be brought to a certain temperature and must have a certain acidity. The citric acid added, and the heat was able to bring the pH to the desired level, about a 6. When that was done, the rennet was added. This rennet was necessary to break apart the casein (milk protein). This enables some of the whey and some of the moisture leave the milk. Removing partially, this whey leaves the basic components of cheese: protein, lactose, minerals, and vitamins. Adding a certain amount of heat, along with the protein and moisture in the cheese, makes the cheese stretchable.</p>	
Summary Statement <p>How does cheese, made from different milk fat percentages, affect how far the cheese itself is able to stretch.</p>	
Help Received <p>My father helped me with stretching the cheese because it was very hot and difficult to handle.</p>	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Amelia Dibbo; Heather Robinson	Project Number S0605
Project Title Effects of Temperature on Fruits and Vegetables Using a Vitamin C Titration	
Abstract Objectives/Goals Every day people manipulate fruits and vegetables in their diets. They are either eaten fresh, frozen for later use, or heated in the cooking process. The vitamins and nutrients that these foods supply are essential for human development. This experiment was designed to find out whether extreme temperatures, after being either heated or frozen, affect the amount of vitamin C in fruits and vegetables. Methods/Materials This investigation was conducted using a titration technique to measure the amount of vitamin C in tomatoes, kiwis, sweet potatoes, and red bell peppers. The vitamin C levels of the fruits and vegetables were tested at room temperature, after heating, and after freezing. The main materials used in this experiment were iodine, a juicer, an oven, a freezer, tomatoes, kiwis, sweet potatoes, and red bell peppers. Results Data interpretation showed little to no difference in vitamin C levels after manipulation. However, the red bell pepper did follow the trend we expected to see. This trend showed that after heating there was a decrease in the levels of vitamin C compared to the room temperature level. After freezing there was also a decrease, but less so than heating. Conclusions/Discussion Reliability issues with the technique used could have compromised results. The pigmentation of the foods caused difficulty when collecting qualitative data. Overall the project was able to show the flaws of the vitamin C titration technique. With the information gained it has allowed us to begin thinking of a new way to test for vitamin C in foods.	
Summary Statement The effect temperature has on the vitamin C levels in certain fruits and vegetables using a titration method.	
Help Received Friend's Grandmother lent us the juicer for experimenting.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Rochelle Ellison; Bernard Moon	Project Number S0606
Project Title The Effect of Various Human Body Conditions on the Racemization of Doxylamine Succinate	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective of this project was to demonstrate the racemization of Doxylamine Succinate, an active ingredient of NyQuil, when exposed to simulated human body conditions including body temperature, liver enzymatic action and stomach pH.</p> <p>Methods/Materials Aliquots of Vicks NyQuil Cough Syrup were incubated for 48 hours at 37.5°C with: no treatment, mouse liver extract, or 3.0M HCl (pH 1.5). These samples, controls, and doxylamine succinate standards were prepared in 100% ethanol. Samples were analyzed by High Performance Liquid Chromatography with a Chiralcel OX-RH column to separate the enantiomers of doxylamine succinate. A mobile phase of 10:90 (v/v) 100% isopropanol and hexane with 0.1% Diethanolamine was used at a flow rate of 1 mL min⁻¹. The eluent was monitored at 258 ± 4 nm and run for 15 minutes. Chromatograms and 3D spectra were used to analyze the enantiomers based on retention time and peak area.</p> <p>Results NyQuil (no treatment) presented the enantiomer S(+). Nyquil incubated at 37.5°C or in presence of mouse liver enzymes for 48 hours showed no racemization. However, it racemized when incubated in the presence of 3.0M HCl. 42.9 % of the R(-) and 57.1% of S(+) were found in the 2 peaks that corresponded to each enantiomers (appropriate retention time and wavelength absorption when compared to doxylamine succinate enantiomers retention time). Enantiomeric excess after exposure to HCl was calculated to be 14.2%.</p> <p>Conclusions/Discussion This experiment showed that prior to consumption the active enantiomer, S(+) doxylamine succinate, is present in NyQuil. However, a racemic mixture was created as a result of exposure to simulated stomach acidity. This may have occurred due to reactions between the acids H⁺ ions, which dissociate in solution, and unstable chiral center of NyQuil. The molecular bonds of the doxylamine succinate break and when reformed both enantiomers were produced. Yet in conflict with our hypothesis were results that demonstrated that human body temperature and mouse liver enzymes did not cause racemization. Nevertheless since the NyQuil must pass through the stomach during the digestion process, it is exposed to this acidic pH and racemization likely occurs. The presence of the R(-) enantiomer could make NyQuil either less active than intended or toxic. Further work conducted will examine the effect of each enantiomer on living organisms.</p>	
Summary Statement This project analyzes the degree of racemization of doxylamine succinate, an active ingredient in NyQuil Cough Suppressant, when exposed to various simulated human body conditions.	
Help Received Research was conducted in high school laboratory supervised by Dr. Nikki Malhotra; HPLC chiral column was donated by Amgen Inc; Doxylamine Succinate standard was given by Thermo Fisher Scientific.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Brynn E. Hansen	Project Number S0607
Project Title Effects of the Sun Protection Factor of Sunscreen on the Permeation of UV Radiation through Polyvinyl Chloride	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this experiment was to determine if wearing sunscreens with high sun protection factors provides users with more protection from ultraviolet radiation.</p> <p>Methods/Materials A thin sheet of polyvinyl chloride acted as a model for skin. Squares of polyvinyl chloride were coated with four sunscreens with different sun protection factors (4, 15, 30 and 50). 0.5 grams of sunscreen were applied to each square. The prepared square of polyvinyl chloride that was coated with sunscreen was placed over the sensor of an ultraviolet monitor to determine how much ultraviolet radiation permeated through the polyvinyl chloride. Five trials of this experiment were conducted.</p> <p>Results The sun protection factor of 4 showed that an average of 82 mW/m² of ultraviolet radiation permeated through the sunscreen and polyvinyl chloride. The permeation of ultraviolet radiation decreased as the sun protection factor increased. The sun protection factor of 30 had an average of 14 mW/m² permeate the polyvinyl chloride, while the sun protection factor of 50 had an average of 13 mW/m² permeate the polyvinyl chloride.</p> <p>Conclusions/Discussion The sunscreen with the sun protection factor of 4 offered minimal protection from ultraviolet radiation. The results from the sunscreen with the sun protection factor of 30 and the sun protection factor of 50 show that they offer almost the same amount of protection from ultraviolet radiation.</p>	
Summary Statement Sunscreens with different sun protection factor levels were coated on squares of polyvinyl chloride and placed over an ultraviolet monitor in order to determine how much protection they offer users from UV radiation.	
Help Received My mother and father helped me order an ultraviolet monitor. My chemistry teacher assisted me by suggesting a potential layout for one of my data tables.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Dhuvarakesh Karthikeyan	Project Number S0608
Project Title Utilizing Emerging Bio-Metallic Properties to Enhance Power Production and Cost Efficiency of a Biochemical Fuel Cell	
Abstract Objectives/Goals To discover and harness latent properties that exist between exoelectrogenic communities in a biochemical fuel cell and their organic interactions with different types of electrode material. New methods of increasing fuel cell efficiency are urgently needed as current labs, in looking for breakthroughs, focus solely on the mechanical aspect of engineering solutions, completely overlooking the fact that efficiency is tied inextricably to the living populations. By focusing engineering efforts around the organic facet of the system, I aim to reinvent the concept of the bio-fuel cell as a dynamic system with unique parameters dependent upon the biological agents powering it. Methods/Materials The electrogenetic efficacies of four cost-effective and catalytic transition metals (Co-59, Zn-65, Ni-59, and Cu-54) were tested against each other and against a graphite control which was employed to establish a baseline for results. The transition metals were ionized by splitting metal anhydrites in solution and the resulting cations were reduced at the cathode by means of an external power source therein electroplating these metals onto non-corrosive graphite rods. These electroplated graphite rods served as the anodic electrode for the fuel cells while the standard graphite rod was used for all the cathodes. Benthic mud samples served as the source of exoelectrogenically active anaerobes and were inputted into each of the fuel cells. Results were taken every 12hrs including and after the initial setup of the fuel cells for a total of 144 hours. Results Both Zn and Co plated electrodes gave a significant 80%-160% increase in overall power production over the control graphite. The Cu fared far worse than even the graphite at 22% the capability of the control. The Ni-plated electrode outperformed all of the other electrodes with a 207% increase in power production. Conclusions/Discussion I successfully identified and tested select transition metals in the sphere of fuel cells with potential in utilizing biochemical pathways to optimize bacteria function and bring newfound emphasis on their role in these dynamic systems. Furthermore, using properties that exist between metals of varying potential in galvanic series and coupling this phenomenon with existing biochemical relations, I was able to achieve a statistically significant increase in power production while simultaneously increasing cost efficiency.	
Summary Statement By combining chemical properties unique to only metals and biological fuel cells, I identified novel interactions between exoelectrogenic populations and optimized their coulombic output in a scalable and practical fuel cell application.	
Help Received All research and experimentation was conducted autonomously; sister and mother helped with board construction	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Matthew C. Krock	Project Number S0609
Project Title Use of Period IV Transition Metal Salts to Optimize Solar Powered Electrolysis of Water for Hydrogen Gas Production	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective is to expand upon previous personal research and focus on a comparison of the electrical efficiency of iron (III) and copper (II) salts in phosphate solutions with the intent of optimizing the solar powered electrolysis of water for the production of hydrogen gas. This in turn may be subsequently used to produce electrical power through the use of fuel cells in the absence of sunlight.</p> <p>Methods/Materials 0.1 M solutions of iron (III) nitrate and copper (II) nitrate were added to 0.1 M solutions of monobasic potassium phosphate (KH₂PO₄) to form a combined solution. Electrical current was supplied to 50 mL samples of the combined solutions via a 12v power supply in order to produce hydrogen gas, which was collected by the displacement of water. Input energy was calculated by the equation $E=IVt$. The amount of hydrogen gas was computed by the equation $PV=nRT$, and the potential output energy that could be obtained from a fuel cell was calculated by multiplying the moles of hydrogen gas by the molar Gibb's Free Energy of the synthesis of water. The input energy was compared to the output energy in order to calculate the efficiency of using each combined solution for the electrolysis of water.</p> <p>Results While the iron (III) solution produced a peak of 0.00042 moles of hydrogen gas at 100 mA, the copper (II) solution produced a peak of 0.00017 moles of hydrogen gas. As a result, the iron (III) solution proved to be more effective at producing hydrogen gas. Despite the success of the iron (III) solution, however, the copper (II) solution had the capacity to convert 14 percent of its input energy into output energy similar to the iron (III). This suggests that the copper (II) solution's efficiency is equal to that of the iron (III) solution, but at lower currents. Based on this, the copper (II) is optimal for conditions of low sunlight while the iron (III) is optimal for conditions of high sunlight.</p> <p>Conclusions/Discussion Because the iron (III) solution conducted twice as much current and produced twice as much gas as the copper (II) solution, this supports the hypothesis that salts with cations possessing more numerous oxidation states are better suited for use as catalysts for the electrolysis of water. Future experimentation may look into cations with more numerous oxidation states than iron, such as manganese.</p>	
Summary Statement Optimization of phosphate-buffered transition metal catalysts for the efficient solar powered electrolytic generation of hydrogen gas to be used in hydrogen fuel cells as a renewable power source in the absence of sunlight.	
Help Received Chemicals were supplied by Norco High School, glassware, advice, and facilities were supplied by my father	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Mihoko Kubo	Project Number S0610
Project Title Detection and Comparison of Heavy Metals in Dog Foods Using Flame Atomic Absorption Spectroscopy	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective of this research was to detect and quantify three heavy metals (cadmium, lead, and chromium) in dry dog foods in order to investigate if a heavy metal was present in the foods. Dogs are important members in many families across the U.S., and their health is significantly linked to their food consumption. Because pet illnesses are often assumed to be caused by food intake, it is possible that chemicals exposed from pet food manufacturers are mixed into the products. The goal in this research is to accurately measure the amount of heavy metals in different brands of dog food through the flame atomic absorption spectroscopy.</p> <p>Methods/Materials Sixteen different samples from various brands of dry dog food were obtained. Approximately 0.5 g samples of dog food were placed in a 100 mL Teflon reactor, followed by 5 mL of ultra-pure nitric acid and 2 mL of 30% hydrogen peroxide. Three replicates of each dog food were prepared simultaneously. Using a Mars6 microwave sample preparation, the samples were heated up to 180° for 10 minutes. The solutions were diluted to 50 mL. A Shimadzu AA-7000A atomic absorption spectrometer equipped with a 10 cm air-acetylene flame head was used for flame atomic absorption spectroscopic measurements. A small amount of each standard or sample was transferred to a 5 mL auto-sampler vial and placed in the auto-sampler rack. Determinations were performed in triplicate on each sample.</p> <p>Results Neither cadmium nor lead were detected in any of the sixteen samples tested. The flame atomic absorption spectrometer detected traces of chromium in the range of 5.0 ~ 21.5 µg/g in each of the dog food samples.</p> <p>Conclusions/Discussion Three of the samples tested exceeded the FDA approved maximum tolerable limit of 10.0 µg/g (ppm), and three other samples were close to this 10.0 µg/g chromium concentration limit. Although there were no specific patterns regarding the concentration of chromium to the price of the sample, there was a small correlation as the cheapest sample contained the most chromium amount. Exceeding the maximum tolerable limit of chromium in foods can affect the kidneys in most canines.</p>	
Summary Statement This research investigated the presence and amounts of heavy metals (cadmium, lead, and chromium) in several brands of dry dog foods using the flame atomic absorption spectroscopy.	
Help Received Dr. David Green, professor of chemistry at Pepperdine University, provided a lab facility and supervised the use of the flame atomic absorption spectrometer and the microwave-assisted acid digestion system.	



CALIFORNIA STATE SCIENCE FAIR 2015 PROJECT SUMMARY

Name(s) Gha Young Lee	Project Number S0611
Project Title Novel Self-Reporting Photonic Crystal Nanosensor: Controllable Hydrophobicity, Flexibility, and Chemical Resistance	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective is to develop and optimize a protocol to make instantaneous, self-reporting, color-changing chemical nanosensor that is commercially and practically viable. A method to have a such a sensor that is stable, reproducible, and chemically and mechanically sturdy will have immense commercial potential in medicine, military, laboratories, and households. The project intends to also add aspects that would enhance the end product even more - flexibility (which adds so much more mechanical durability and also adds potential as stable wearable sensors) and enhanced hydrophobicity (to be able to filter out small amounts of chemicals from dilute solutions and to avoid damage by humidity).</p> <p>Methods/Materials Porous silicon was electrochemically etched to have nanopores that display Fabry-Perot interference. Fluoropolymer PVDF (poly(vinylidene)-fluoride) was melt-casted into the pores with a 200g weight on, and the composite was then dissolved in dilute KOH to eliminate the template nanoporous silicon. The remaining polymer is characterized via optical spectrophotometry, FTIR, and contact angle measurement.</p> <p>Results A successful, novel stable porous silicon-templated nanosensor is developed. The nanosensor demonstrates instantaneous color change in presence of chemicals, is flexible, has an improved near-superhydrophobicity that is found to be controllable, and has unprecedented chemical resistance.</p> <p>Conclusions/Discussion The optimal melt-cast setting of the PVDF is 230°C for 2 hours, with 200g weight on top. Molecular weight and thus viscosity of the polymer was one of the biggest factors in determining replication success. The polymer's natural hydrophobicity drastically increased with the nanostructure to almost superhydrophobic, and the duration the silicon-polymer composite was left in the dilute KOH was able to alter the hydrophobicity of the sample. That, along with the flexibility, holds much promise in manufacturing, future research, and as wearable sensors. This product's most useful application is as a medical device coating to determine whether devices such as needles or catheters have been sterilized. The PVDF can serve as a precedent for other hydrophobic and chemically resistant polymers, and perhaps PTFE can be used to achieve superhydrophobicity and even more chemical resistance.</p>	
Summary Statement A successful, novel stable nanosensor is developed that can instantaneously change color in presence of chemicals, is flexible, has a controllable near-superhydrophobicity, and has unprecedented chemical resistance.	
Help Received Participant and Project Leader at the UCSD Summer School for Silicon Nanotechnology, and learned useful materials; Used lab equipment and chemicals of UCSD under the supervision of Dr. Michael J. Sailor; Lab's Ph.D student Ms. Joanna Wang helped with etching since I am a minor, and also took SEM	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Marcus Luebke	Project Number S0612
Project Title Running on Water: Real Time Production of Hydrogen and Oxygen Optimized to Power a Motor	
Abstract Objectives/Goals The objective of this research was to demonstrate that real-time production of hydrogen & oxygen could safely and efficiently be generated using electrolysis, and to identify design factors to optimize production to power a motor. Methods/Materials A custom device was designed to allow for easy and repeatable adjustment of experimental inputs (voltage, electrolyte, water temperature, water flow rate) and measurement of the resulting hydrogen & oxygen production rate. In addition, the experimental setup was designed to safely produce and capture high rates of hydrogen & oxygen gas, and redirect that gas to a motor for real-time combustion. Results The results demonstrated a significant increase in production by increasing voltage, water temperature, electrolyte and in some cases flow rate. Both voltage and temperature drove a linear increase in production rate, when other variables were held constant. Increasing electrolyte concentration drove an exponential increase in production rate. Flowing water through the plates increased production rate when the electrolyte was near or above the saturation point, and had no impact at lower electrolyte levels. Conclusions/Discussion As we struggle to reduce carbon emissions, hydrogen offers a promising alternative to gasoline but poses concerns as hydrogen storage is considered unsafe. However, using real-time production of hydrogen and oxygen minimizes this concern. In this experiment, I leveraged this technique to safely power a small motor, using a water temperature of 50 degrees Celsius, non-reactive washing soda (10 mL NaCO ₃) as the electrolyte, and a 12 volt car battery to power the electrolysis. In addition, I created a novel innovation, running water through the system to clear gas bubbles from the plates so more reactions could occur, improving the production rate when near or above the saturation point of the electrolyte. Future research is needed to collect more data to validate and fully understand this effect.	
Summary Statement In this research, I demonstrated that real time production of hydrogen & oxygen could safely & efficiently power a motor, optimizing the system and creating the novel innovation of flowing water to clear bubbles, enabling more reactions.	
Help Received Dr. Margo Stand for teaching me the chemistry of electrolysis. My father for coaching in safety procedures & providing supplies. My mother for coaching in data analysis, poster preparation & presentation. The Tech Shop for the equipment for me to manufacture my setup.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Jennifer A. McCleary	Project Number S0613
Project Title Correlating the Bandgaps of Earth-Abundant Metal Oxides to Photocurrent Generation for Water Splitting Applications	
Abstract Objectives/Goals Solar-driven water splitting with earth-abundant, efficient and robust photoelectrode and catalyst materials can meet the challenges of providing sustainable energy globally. In my experiment, I sought to determine the correlation between the bandgaps of mixed metal oxide photoanodes for a photoelectrochemical cell and their photocurrent generation under visible light illumination. Methods/Materials Chemicals used were iron (iii) nitrate, zinc nitrate, sodium molybdate, copper (ii) nitrate, cerium nitrate, bismuth (iii) nitrate, vanadyl acetylacetonate, 2,4-pentanedione, sodium tetraborate decahydrate, and boric acid. Materials used to prepare metal oxide electrodes were FTO (fluorine-doped tin oxide) conductive glass plates, black spray paint, silver paint, glass tubing, wire, epoxy, and a kiln. Equipment used for photocurrent generation included an Ag/AgCl reference electrode, a Ni mesh, a potentiostat, and a light bulb. A UV-visible spectrophotometer equipped with an integrating sphere was used for bandgap measurements. Six earth-abundant mixed-metal oxide materials were prepared on FTO glass plates and made into electrodes. The materials# bandgaps were obtained from Tauc analysis of diffuse reflectance spectra that were measured in a spectrophotometer with integrating sphere. Photoelectrochemical performance was experimentally determined using cyclic voltammetry in aqueous electrolyte and under simulated sunlight illumination. Generated photocurrents were correlated with the materials# bandgaps and compared to a prediction of how efficiency depends on bandgap. Results Bismuth-containing metal oxides followed the predicted trend that materials with mid-range bandgaps (in this case, a bandgap of around 1.95 eV) produced the highest photocurrents, while materials with larger and smaller bandgaps produced smaller photocurrents. The iron-containing metal oxides all produced small photocurrents that did not follow the predicted trend, which could be due to other limiting factors such as carrier lifetime. Conclusions/Discussion Experimental data indicated that photoanode materials not based on iron oxide, such as doped bismuth vanadates, followed the theoretically predicted photocurrent densities that peak at an optimal bandgap of ~2.0 eV. Materials with bandgaps both larger and smaller than this value showed, as expected, lower maximum solar photocurrent densities.	
Summary Statement The purpose of my project is to characterize metal oxides that can serve as anodes for the oxidation of water under visible light illumination to produce hydrogen as a clean fuel source.	
Help Received Used lab equipment at Caltech under the supervision of Dr. Astrid Mueller.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Andrew T. Ostrom	Project Number S0614
Project Title Edible Fuels	
Abstract Objectives/Goals The purpose of this project was to determine which type of food oil makes the best biodiesel fuel. Methods/Materials Five different types of edible oils were used in this experiment: soybean oil, olive oil, peanut oil, canola oil, and corn oil. The oils were refluxed at 60 degrees Celsius with methanol and potassium hydroxide as a catalyst to synthesize the biodiesel. The triglycerides in the oils reacted with methanol to produce glycerol and a methyl ester (biodiesel). This process is known as transesterification. The biodiesel was separated from the glycerol and its cloud point was measured. The best biodiesel was determined by the lowest cloud point. Results My hypothesis was that canola oil should have the lowest cloud point, which would make it the best oil to use to make biodiesel. This is because canola oil has the highest percentage of unsaturated fats, which have a lower melting point than saturated fats. The results of my experiment showed that the corn oil was the best biodiesel because it had the lowest cloud point temperature. Conclusions/Discussion Based on cloud point, corn oil makes the best biodiesel. Canola oil was the next best by 0.55 degrees Celsius. This difference could be due to some contaminants in the oil. The rest of my data followed the trend of percent unsaturated fats in the oils tested.	
Summary Statement My project synthesizes biodiesel from edible oils by a process known as transesterification and compares the products using a cloud point measurement to determine which oil makes the best biodiesel.	
Help Received My father supervised the experiments and helped me fill out this form. My mother helped me assemble the project board.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Diana M. Palma	Project Number S0615
Project Title Polystyrene and Its Effectiveness in Removing Calcium from Water	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals Hard water contains a high concentration of calcium and magnesium ions usually obtained by the mineral build ups in pipes. While not hazardous to Heath, the hard water can cause issues in industrial settings. Filters used in treatment are very expensive, short term, not very effective. My goal was to determine is polystyrene could be a viable material to be used in the process to remove water hardness.</p> <p>Methods/Materials Materials -polystyrene (styrofoam and soda dividers) - sulfuric acid -EDTA First I tested the hardness of the water samples created using titration. Then created the polystyrene resin using sulfuric acid and agitating it for varied time. I then tested that resin against a reverse osmosis filter which was my control, by titrating samples passed through the filters.</p> <p>Results The average amount of .01 M EDTA Solution used in the test with the polystyrene filter and the reverse osmosis filter will determine how effective the polystyrene filter is. Through the data collected it is revealed that the both polystyrene filters have a lower average of EDTA usage compared to the reverse osmosis filter which is the control. The lower the amount of EDTA, the quicker the reaction reached the endpoint which means that the calcium transformed into chelates faster. This means that the polystyrene removed the calcium because there were less calcium ions in the sample than reverse osmosis sample</p> <p>Conclusions/Discussion In conclusion, my experiment the polystyrene was a more effective material to use in a filter. For both samples the EDTA was lower than the control which means that more of the calcium was removed. In the future, I plan to further the project by utilizing the data and the information collected to create a filter usable for large scale.</p>	
Summary Statement Determine if polystyrene is a viable option to remove calcium from water.	
Help Received Received help from Dr. Grant in lab.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Sarah Porter; Zach Wright	Project Number S0616
Project Title Measuring the Effect of Coating on Ibuprofen with Dissolving Rate in Stomach Acid	
Abstract	
Objectives/Goals The objective of our project is to determine what coating on Ibuprofen will dissolve the fastest, to release the Ibuprofen inside the pill first.	
Methods/Materials We used .1 molar HCL to simulate the acid in the stomach. We had 3 different forms of Ibuprofen that we tested. The first was the regular tablets, the second Gel Capsules, and the third regular Caplets. We ran 5 different trials for each pill. In five 50 ml beakers we filled 15 ml of the HCL in each. We dropped an individual pill into each and timed how long it took for the coating to dissolve and movement to stop. We repeated this for the last two types of ibuprofen.	
Results Our results supported that the Caplets took the least amount of time to dissolve the coating and release the Ibuprofen. It took an average of 20 min/gram. The Gel Capsules took on average 126 min/gram and the tablets took 26 min/gram. Our results supported that it took the most amount of time to dissolve the Gel Capsules.	
Conclusions/Discussion The purpose of the experiment was to investigate the effect of coatings on the release of ibuprofen in stomach acid. This was tested by having 3 types of ibuprofen pills: Gel Capsules, Caplets, and Tablets. We would have had a control of a non coated pill, however none are available except for in prescriptions. We used 15 ml of .1 molar HCL acid and dropped each pill in to investigate the time it would take to dissolve the coating, making the ibuprofen available. The differences we found are stunning. We were told that the ibuprofen in the Gel Capsules would be available first, however our data proves otherwise. The Gel Capsules took on average 126 min/g to become available. The tablets took 26 min/g on average for the ibuprofen inside to become available. The average of the Caplets was 20 min/g. Our data shows that the Caplets worked the fastest, and the Gel Capsules worked the slowest. We found out later on that the Tablets and the Caplets are coated with the same coating. Our data for the tablets only support that the caplet shape worked faster than the tablet shape. This does not support our experiment on what coating dissolves the fastest. Our hypothesis was that the ibuprofen in the Gel Capsules would become available faster than the sugar coated Caplets and Tablets. Our hypothesis was not supported by our data. We used .1 molar HCL acid because we wanted to simulate the acid in our stomachs.	
Summary Statement To investigate the time it takes for coating on Ibuprofen to dissolve	
Help Received We used the schools equipment.	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Logan E. Prock	Project Number S0617
Project Title The Effect of Storage Temperature on the Decomposition of Sodium Hypochlorite in Household Bleach	
Objectives/Goals The purpose of this project was to determine the effect of storage temperature (3° Celsius, 20° Celsius, and 40° Celsius) on the decomposition of sodium hypochlorite.	
Abstract It was hypothesized that with each increase in temperature, there would be an increased rate of decomposition of sodium hypochlorite resulting in a lower percentage of NaOCl remaining in the bleach.	
Methods/Materials Three 350 mL samples of bleach were stored for a week in the manipulated storage temperatures, one at 3° Celsius in a refrigerator, 20° Celsius at room conditions, and 40° Celsius in a Model 10 Quincy Lab Oven. For each bleach sample, 5.00 mL of concentrated bleach was pipetted into an 100 mL volumetric flask and was diluted with distilled water. For four trials per bleach sample, 2 grams of potassium iodide, 25.00 mL diluted bleach, 2.00 mL 3 M hydrochloric acid, and 25.00 mL distilled water were combined in an Erlenmeyer flask. This solution was titrated with .100 M sodium thiosulfate solution until it was clear, as determined by a starch indicator. By recording the volume of .100 M sodium thiosulfate solution used in order to make the solution clear, calculations were completed to determine the remaining percent sodium hypochlorite in each trial.	
Results The mean of the bleach samples stored at 3° Celsius was 8.26 percent sodium hypochlorite. The mean deviation was 0.07 percent sodium hypochlorite. The percent deviation was 0.85 percent. The mean of the samples stored at 20° Celsius was 8.04 percent sodium hypochlorite. The average deviation from the mean was 0.08 percent. The percent deviation was 0.99 percent. The mean of the samples stored at 40° Celsius was 2.90 percent sodium hypochlorite. The results deviated from the mean an average of 0.11 percent sodium hypochlorite. The percent deviation was 3.79 percent.	
Conclusions/Discussion The hypothesis was conclusively supported by the data collected from experimentation. With each increase in temperature, the percentage of remaining sodium hypochlorite decreased. The results were conclusive due to the high precision of the data, as determined by a T-test and deviation calculations. The data reflection exponential decomposition. The results of this experiment can be applied to both the industrial and domestic storage of bleach.	
Summary Statement The purpose of this project was to determine the effect of prolonged storage temperature on the decomposition of sodium hypochlorite.	
Help Received Equipment obtained from Mr. Mike Antrim's high school chemistry lab; Photos of trials taken by parents	



CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s) Nicholas Tran	Project Number S0618
Project Title Do Different Salts Have Different Levels of Electrical Conductivity?	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals What are the relative conductivity of salts compared to one another? Is there a conductivity trend across the periodic table among the cations of salts? Theoretically, electrical charge between the cation and anion of an ionic compound should increase if the number of valence electrons donated and accepted among the two increased.</p> <p>Methods/Materials 1 M LiCl, Gel electrolysis box, 1 M CaCl₂, Power Supply, 1 M AlCl₃, Four 15-mL conical tubes, 1 M CuCl₂, Analytical balance</p> <p>Results The conductivity levels increased from LiCl with an average 0.17 Amps to CaCl₂ which had an average .38 Amps but AlCl₃ had a lower average .25 Amps. However, CuCl₂ had an average .43 Amps, making it the most conductive salt out of the four.</p> <p>Conclusions/Discussion In conclusion, while the number of valence electrons donated and accepted does greatly impact conductivity, other lurking variables such as bond strength might have impacted conductivity as well. Interestingly, a precipitate formed on the cathode side of the gel box when it was running CuCl₂. This must have been a result of OH⁻ from the lysis of water combining with Cu²⁺ ions, becoming copper (II) hydroxide.</p>	
Summary Statement The purpose of my project is to test if a trend exists across the periodic table concerning electrical current produced after ionic compounds are disassociated.	
Help Received Used lab equipment from my high school's chemistry lab	



**CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY**

Name(s) Michael D. Wu	Project Number S0619
Project Title A Systemic Spectra Analysis of Organic Aerosols after Ozonolysis and Their Effects on Climate	
Abstract Objectives/Goals With global warming taking the center stage, more and more research is being done on CO ₂ and greenhouse gases. However, another lesser known, but equally important contributor to global climate systems comes from aerosols, solid or liquid particles suspended in the air. White or clear aerosols, the most common type, scatter and reflect solar radiation, contributing to global cooling. Certain classes of aerosols, such as black and brown carbon produced by combustion processes, heavily absorb light leading to atmospheric warming. One of the unresolved questions in aerosol science is to what extent white, non-absorbing aerosols can become colored and absorbing as a result of interactions with atmospheric oxidants.	
Methods/Materials Eight environmentally relevant and ozone-reactable compounds were chosen: most important were indole, imidazole, gallic acid, and 2, 4-DNP. Once chosen, the compound was absorbed onto a Teflon filter and placed inside an impactor. Here it was exposed to a constant flow of ozone. Each compound was tested twice, more if necessary. After ozonolysis, the compound's optical properties were analyzed with a UV Spectrometer. The absorption spectra were translated into universal terms with the Mass Absorption Coefficient (MAC), derived from Beer's Law. MAC is wavelength dependent and considers concentration and cuvette length. Extraction efficiency was also measured to ensure there were no residual chemicals on the filter after the extractions.	
Results Gallic acid and imidazole both displayed large increases in the UV range and small changes in the visible region. 2, 4-DNP absorbed significantly less in the visible region. Indole increased 5,000 MAC in the visible region equating to a change from white to a deep green. The fact that indole absorbs so heavily in the visible regions is alarming because that means that it will absorb visible light, 50% of the Sun's rays, contributing to global warming.	
Conclusions/Discussion This project confirmed the notion that compounds undergo changes upon exposure to ozone, altering their optical properties. Most alarming are the results from indole, which suggest that initially colorless compounds may become absorbing after atmospheric oxidation, trapping solar radiation and contributing to climate warming. This is an important observation of a new phenomenon that is currently not being considered by climate researchers.	
Summary Statement My experiment focuses on aerosols, their reactions with ozone and how these reactions affect global climate systems.	
Help Received Used laboratory equipment at UCI under the supervision of Professor Nizkorodov, Dian Romonosky for her help with editing and general guidance, Mom and Dad for their help with editing of paper	