



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Leslie Almaraz; Aliza Arya; Mckayla Vargas	Project Number S0601
Project Title Sustaining a Biodegradable Environment through the Use of Polylactic Acid and Compost	
<p style="text-align: center;">Abstract</p> <p>Objectives Creating a sustainable, biodegradable plastic six-pack ring made from polylactic acid with an added plasticizer and an alternate form made of compost.</p> <p>Methods Hydrochloric acid, Lactic acid, a plasticizer called Triethyl Citrate, compost, and multiple beakers. Multiple trials were conducted to see if varying the concentration or time would affect the results.</p> <p>Results Several trials were conducted at various times and concentrations in order to obtain the best type of plastic six-pack ring. Repeated trials were run to determine if an added plasticizer or ingredient affected the results. This difference in trials was used to eliminate methods that were not successful.</p> <p>Conclusions Repeated trials revealed that an added plasticizer created the most pliable plastic. Improvements in time of boiling the solution contributed to a plastic that was less tacky and more pliable. It is concluded that the type of plastic created can be used to create a six-pack ring. A six-pack ring was also created out of compost to propose an eco-friendly alternative.</p>	
Summary Statement Through a series of trials conducted, it can be concluded that a biodegradable plastic as well as a compost packed cardboard can create a biodegradable six-pack ring.	
Help Received Our chemistry teacher guided us when we conducted our experiments and helped us formulate a procedure that produced results. Archer School for girls gave us a research grant and funded our research.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Christina An	Project Number S0602
Project Title Building and Testing a Magnetic Multilayered Hydrogel Microsphere Crosslinked by Genipin for Targeted Delivery of Drugs	
<p style="text-align: center;">Abstract</p> <p>Objectives The magnetic targeted drug delivery system is one of the most promising strategies for delivering highly potent drugs, like the ones used in chemotherapy, to a specified site. Magnetic microspheres were developed to overcome two major problems encountered in drug targeting: reticuloendothelial system clearance and target site specificity. A magnet, placed outside the body, is directed to the target site. The magnet can be a rod-shaped permanent magnet of any size or can be contained in equipment that looks like an open magnetic resonance imaging scanner. The loaded microspheres are introduced into a blood vessel, and in as little as half an hour, they gather at the target site to emit drugs. This research project is a continuation of a project that focused on creating multi-layered microspheres through crosslinking with genipin.</p> <p>Methods Creating the individual spheres involved vortexing and cooling gelatin with olive oil and cyclopentasiloxane. Crosslinking the spheres with gelatin allows distinct layers to be formed. Magnetizing the microspheres involves infusing magnetite, Fe₃O₄, into the gelatin for the outer layer. The characteristics and the decay rate of each microsphere was studied using a microscope. The microspheres in this experiment has magnetite on the outer layer which means if a drug was actually used, it can be infused with nanoparticles into the layer inside.</p> <p>Results The decay rate of these microspheres were studied under three different pH levels: 2, 5, and 7.4. The lower the pH value in medium is, the faster the drug release from the microspheres. Although, the magnetization curve of the microsphere was less dramatic than the curve for pure magnetite, it still showed that the microspheres were able to be magnetized. The success rate of each layer went down after adding magnetite. This year's experiment was also able to improve upon the process of crosslinking through incubation.</p> <p>Conclusions Future research would involve using a multilayered magnetic microsphere with actual drugs and in in vivo research. A focus on how to prevent a premediated release of the drugs might involve looking for new materials or chemicals to bring in to the method. After gaining more data, the use of the Higuchian model to develop a mathematical analysis for decay is proposed. This experiment proved that magnetization of the outer layers of a microsphere is possible.</p>	
Summary Statement The purpose of my experiment was to create magnetized microspheres with multiple layers to increase the possibility of the targeted delivery of drugs in a multi-step medication process.	
Help Received I was able to receive access to a lab facility to continue my experiment.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Jacob Bright; Jeff Liu	Project Number S0603
Project Title Observing the Photoswitching Mechanism of Donor-Accepting Stenhouse Adduct (DASA) Molecules	
Abstract Objectives Drugs are mostly unsafe when used in the body. As a drug travels around the body, it could damage parts of the body that do not need the drug. Our project aims to observe the effects DASA molecules have in carrying these drugs as an inert medium, to a site that requires the drug. Methods The DASA molecule MAF was dissolved in both water and 0.1 M NaCl. These were run in a spectrophotometer and we observed the effects its absorption over wavelength all over 2 and a half hours. Results When unexposed to light, the DASA molecule absorption spectra mostly stays the same, however when exposed to light, the DASA molecule would rapidly decrease in absorption, meaning a chemical reaction has taken place. Conclusions We can clearly observe the photoswitching effect in the DASA molecules in the absorption spectra of these molecules. Because of this, we can see how the difference in the two isomerized form of the DASA molecules explains how the light-instituted reaction causes a chemical reaction.	
Summary Statement Observing how the properties of photoswitching molecules can revolutionize and create new methods in effective, safer drug delivery.	
Help Received Lab equipment and materials provided by Bardeen Group, Dr. Christopher Bardeen at University of California, Riverside Chemistry Building.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Emilio Cantu-Cervini	Project Number S0604
Project Title Mars Likes It Hot: The Effect of Temperature and Dust Storms on the Clay-Bicarbonate Reaction	
<p style="text-align: center;">Abstract</p> <p>Objectives Methane in the Martian atmosphere was first detected by a team at NASA's Goddard Space Flight Center in 2003. In 2014, the Mars Express Orbiter reported that concentration levels varied with the seasons, peaking during the summer. Proposed sources for its mysterious origin include geological (Fischer Tropsch type reactions and magma outgassing), cosmological (UV irradiation of meteoritic organics, and cosmic dust), and biological ones (present-day microbial activity). Recently, a new anoxic chemical reaction involving sodium bicarbonate (NaHCO₃) and clays such as nontronite, both of which abundant on the Martian surface, has been found to produce methane. The objective of this project is to test if this reaction could account for the Martian methane and its seasonal variation and be postulate as another plausible source for it.</p> <p>Methods To test whether this clay-sodium bicarbonate reaction could be a plausible source, the reaction was replicated in 25 mL rubber-sealed anoxic flasks (simulating the Martian atmosphere) using Nontronite and wustite-containing basalt, and the gaseous products measured using a GC-FID (Gas Chromatograph with Flame Ionization Detector). Furthermore, the effect of increased temperature and agitation on the reaction were measured by applying them each one hour before sampling.</p> <p>Results Results on a limited number of trials indicate an overall increase in methane production on samples that were heated and stirred. However, there was no statistical significance because of the limited number of trials and the variance among samples.</p> <p>Conclusions Further steps will be taken in the form of substantially more trials at simulated Martian temperatures. The further investigation and characterization of the clay-bicarbonate reaction could not only help researchers further understand Martian methane but could also shed light into methane-producing In-Situ Resource Utilization (ISRU) technologies.</p>	
Summary Statement Tested whether a new geochemical methane-producing reaction could be another plausible source for the mysterious Martian methane and its seasonal variation.	
Help Received Javiera Cervini Silva and the Centro de Ciencias de la Atmósfera, Universidad Autónoma Nacional de México (UNAM) for providing access to the GC-FID.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Anushree Chaudhuri	Project Number S0605
Project Title A Porous Silicon Optical Nanosensor for the Detection of Volatile Organic Compounds	
Abstract Objectives Recent news of the use of nerve agents in global terrorist attacks poses an immediate concern to international security. In addition, Volatile Organic Compounds (VOCs) diminish indoor air quality and can contribute to the formation of smog. Thus, developing cost-effective chemical detection methods is a priority, with applications in border protection and environmental monitoring. This research aims to utilize the optical properties of a porous silicon (pSi) rugate filter to develop a low-cost, real-time sensor for a broad range of VOCs. Methods Sixteen samples of pSi were electrochemically fabricated from p ⁺⁺ -type silicon wafers. These samples were hydroxylated through ozone oxidation and a ring-opening living polymerization reaction with a heterocyclic silane was carried out to stabilize the pSi from oxidation in air, water, and basic media. After confirming pSi stability, a broad range of VOCs (e.g., benzene, chloroform, dichloromethane, ethanol, perchloroethylene, toluene, etc.) were chosen to test the optical rugate filter. Both pure and complex mixtures of vapors were cycled through a flow chamber and a CCD spectrometer continuously monitored for changes in the reflected stopband of the sensor to identify the VOC. Results ATR-FTIR spectra confirmed the ring-opening reaction with grafting via Si-O-Si bonds to the pSi surface. Hydrophobicity was demonstrated by water contact angles of 120-130 degrees. A stable stopband was maintained after varying thermal and alkaline conditions. The VOC sensing for both pure and complex mixtures produced consistent, predictable stopband shifts with a mean precision of 0.03 nm for pure VOCs and 0.79 nm for complex mixtures and a threshold detection concentration of 1 microgram per cubic meter. Conclusions The VOCs under analysis underwent microcapillary condensation in the cavities of the pSi, changing the composite refractive index of the sensor and causing a predictable optical stopband shift which can be used to identify VOCs of interest. With a precision which parallels state-of-the-art chemical detection, as well as high stability and portability, this sensor is viable in chemical detection systems for real-time air quality monitoring and forensic analysis. Future work includes introducing multiparametric dimensions, such as electrical signals, to distinguish similar species, as well as integrating the sensors with a smartphone camera.	
Summary Statement I developed stable, real-time porous silicon optical rugate filters to sense target volatile organic compounds by their unique refractive indices.	
Help Received Dr. Michael J. Sailor and other members of the Sailor Laboratory at the University of California San Diego (UCSD) provided the porous silicon material, laboratory equipment, and guidance. Sensing experiments were conducted independently.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Alan Chen	Project Number S0606
Project Title Colorimetric Detection of Toxic Heavy Metal Ions by Metal Nanoparticles	
Abstract	
Objectives Gold and silver nanoparticles exhibit intense colors, because of surface plasmon resonance. In this project, I demonstrate that this unique property can be exploited for the colorimetric detection of toxic heavy metal ions because of their chemical reactivity with the nanoparticle surface.	
Methods Materials: tetrachloroauric acid (HAuCl ₄), silver nitride (AgNO ₃), sodium citrate, mercuric(II) acetate (Hg(OAc) ₂), lead(II) acetate (Pb(OAc) ₂), barium acetate (Ba(OAc) ₂), cobalt(II) acetate (Co(OAc) ₂), chromium (II) acetate (Cr(OAc) ₂), copper(II) acetate (Cu(OAc) ₂), zinc acetate (Zn(OAc) ₂).	
Method 1. To prepare gold nanoparticles, I added 2.8 mL of 2.15 mM HAuCl ₄ into 20 mL of water. The solution was then heated to boiling on a hotplate. I then added 0.6 mL of sodium citrate (10 mg/mL) into the solution, and continued the boiling for 30 minutes. I found that the solution color changed from yellow to wine red. 2. Silver nanoparticles were prepared by using the same procedure except that AgNO ₃ was used instead of HAuCl ₄ . The eventual solution color was yellow. 3. The obtained nanoparticle solutions were diluted with distilled water such that the maximum optical absorbance was about 1 (by using a ultraviolet-visible absorption spectrometer). 4. The optical spectra were collected with the addition of a different amount of salt solutions.	
Results 1. I measured the size of the gold and silver nanoparticles by using transmission electron microscopy, which were 10 and 20 nm in diameter, respectively. 2. I tested the optical absorption of gold and silver nanoparticles. Gold nanoparticles showed a strong absorption at about 520 nm, and silver nanoparticles at 400 nm. These are due to their unique surface plasmon resonance. 3. I then tested the optical response of the nanoparticles when metal ions were added into the solution. I saw no color change of the gold nanoparticle solution even with the addition of 20 micromolar metal ions. This means that the gold nanoparticles were not a good choice for colorimetric detection of heavy metal ions,	
Summary Statement Metal nanoparticles can be used for the selective colorimetric detection of toxic heavy metal ions.	
Help Received Dr. Bingzhang Lu, University of California Santa Cruz	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Willow Daun-Widner	Project Number S0607
Project Title Lipids and Latex: How Common Lipids Affect the Elasticity of Medical Grade Latex	
<p style="text-align: center;">Abstract</p> <p>Objectives The purpose of this experiment was to determine which common oil had the largest effect on the elasticity medical grade latex.</p> <p>Methods I tested which type of oil decreased the elasticity of latex the most by stretching latex treated with oil. Experiment was conducted with five different oils, latex sheets, and clamps and weights used to stretch the latex.</p> <p>Results Which oil degraded latex the most was determined by measuring and comparing the original length and post-stretch length of latex squares. The mean difference between the original and post-stretch lengths of latex treated with mineral oil was the largest.</p> <p>Conclusions This project tested the effects of common oils on medical grade latex, and found that mineral oil degraded the structural integrity of latex the most. These findings are applicable in many fields, most importantly, medical safety.</p>	
Summary Statement I tested which common oil deteriorated medical grade latex the most.	
Help Received My chemistry teacher helped me research my topic by giving me access to privatized databases.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Rushil Ganguli	Project Number S0608
Project Title A Smartphone-based Low Cost, Portable, and Accurate Optical Tensiometer to Determine Cleaning Power of Soap	
<p style="text-align: center;">Abstract</p> <p>Objectives I used a smartphone to build a low cost, but highly accurate instrument to measure contact angle of soapy water with a surface.</p> <p>Methods A compact, low cost optical tensiometer was built by using smartphones that have high quality camera, level sensors, angle measure apps and image manipulation apps. These capabilities were combined with a high quality macro lens, a stage integrated with the cover of the macro lens, a bright but low power LED flash and a 3-D printed light box to build our instrument. Three liquids with known surface energy, and DI water were used to calibrate the instrument. Three different soaps were tested to determine their cleaning power as a function of concentration.</p> <p>Results (1) Developed instrument was compact, with (a) precision, as measured by std deviation, of 1.8 degrees, (b) accuracy of +/- 2%, and (c) a total cost of \$ 150. Commercial instrument is bulky, with std deviation of 1 degree, accuracy of +/- 1%, and a cost of \$ 14000. The precision and accuracy of developed instrument are acceptable, cost is almost two orders of magnitude lower. (2) Using this instrument, we tested the effect of soap in lowering surface tension of water, and observed: (a)Reduction of surface tension depends on the type of water. (b)Same soap from Dollar Tree (\$1) performs as well as that from Ralph's(\$2). (c)Dawn soap performed better than Palmolive and Ajax for local tap water. Dawn needed only 0.25% soap to reduce surface tension to its lowest value, whereas Ajax needed about four times as much.</p> <p>Conclusions Our project shows that for a given tap water, one can choose the right soap and the minimum amount that cleans effectively, using a low cost instrument based on widely available smartphones. Wide availability and ease of operation of this instrument will increase probability of reusing water by minimizing the use of soap. We believe that smartphones provide a combination of computing power, and a suite of built-in sensors that can be exploited to enable many other low-cost, highly effective sensors and instruments for household use.</p>	
Summary Statement Fabricated a portable contact angle measurement instrument with similar accuracy and precision as a commercially available instrument, but with two orders of magnitude lower cost.	
Help Received I acknowledge Dr. Rahul Ganguli for help with understanding the surface science. All experiments were performed at home.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Aditi Ghalsasi	Project Number S0609
Project Title Development of Functionalized PCL-2000 to Create Ideal 3D Printable Polymers	
<p style="text-align: center;">Abstract</p> <p>Objectives 3D printing promises to produce complex biomedical devices according to computer design using patient-specific anatomical data. However, the application of such techniques in biomedical devices has been slow due to the stringent performance criteria and concerns when new materials, such as biocompatible and printable polycaprolactone (PCL), are in their infancy. PCL is a highly biocompatible aliphatic polyester obtained by the polymerization to the open-loop form of caprolactone. Despite the several attractive qualities of PCL to produce medical devices, PCL is highly viscous, melts at high temperatures and loses accuracy as printing speed increases. Our experiment aimed to decrease the natural viscosity of the polymer.</p> <p>Methods In this study, monomers with varying carbon branch lengths were added to the backbone of the current PCL molecule using DIC/DPTS mediated coupling; the addition was intended to decrease viscosity and lower the melting temperature of the polymer while preserving advantageous physical properties. Monomers were synthesized in the lab with aliphatic carbon chain lengths of 2, 6, and 10, and polymers were synthesized using a step-polymerization reaction between PCL-2000 and each corresponding monomer.</p> <p>Results Gel permeation chromatography (GPC) and nuclear magnetic radiation (NMR) spectra confirmed new structures and molecular weights for testing. Differential scanning calorimetry (DSC), rheology, tensile, and 3D printing tests showed an increased viscosity and similar melting temperatures in the lab-made polymers as compared to PCL-2000, contrary to the expected result. 3D printed scaffold quality varied among polymers.</p> <p>Conclusions The experiment successfully produced lab made PCL polymer, 3 monomers with carbon lengths 2, 6, and 10, and three polymers with varying aliphatic chain lengths via step reaction with monomers. We were unable to decrease the natural viscosity of PCL-2000; instead, results show an increase in viscosity after the addition of side chains. The melting point of PCL decreased, generally improved scaffold quality and ease of printing with modified PCL polymers. These results promise 3D printing possibilities for implants and replaceable parts. Future research includes developing drug developing complexes and fluorescent materials capable of changing 3D printing qualities.</p>	
Summary Statement I created several polymers from a polycaprolactone base that are suitable and sustainable for 3D printing scaffolds and implants.	
Help Received I worked with The University of Akron in Ohio under a qualified mentor. I received guidance from my mentor for reactions and usage of machinery, but conducted the work on my own.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Cathy Kenderski	Project Number S0610
Project Title Using Hydrolysis to Facilitate the Chemical Degradation of PET Plastic	
<p style="text-align: center;">Abstract</p> <p>Objectives The ocean is home to 8 million tons of plastic, which contains polymers that are too large to degrade. Thus, I sought out to find a method of chemically degrading plastic using hydrolysis.</p> <p>Methods 22 grams of PET plastic were heated to various temperatures in 55 mL of ethylene glycol and 12 grams of sodium hydroxide. Sulfuric acid was added in order to react with the alkaline solution and create terephthalic acid in the form of a white precipitate. The precipitate was removed from the remaining liquid and was drained of water. Excess waste liquid was boiled to procure ethylene glycol for future use. This experiment was repeated 3 times at 180, 160, or 140 degrees Celsius.</p> <p>Results In order to test that the product of the hydrolysis reaction was terephthalic acid, I tested for specific chemical properties of the chemical. For ethylene glycol, I tested whether the liquid had an exact boiling point of 197° C, which was proven true. Terephthalic acid was confirmed through analysis of qualitative properties, such as its white color and lack of odor. However, existence of terephthalic acid had already been verified through the creation of a precipitate. I also found that performing the experiment at 180° C dissolved the plastic in 20 minutes, which was the most efficient of the 3 temperatures. 160° C dissolved the plastic in 25 minutes, while 140° C dissolved the plastic in half an hour.</p> <p>Conclusions I was successful in transforming PET plastic into its main component: terephthalic acid. This raw material could be used in the creation of new plastic, which provides the scientific community with an efficient method of recycling plastic. This method can also be applied to ocean cleanup efforts.</p>	
Summary Statement I used a hydrolysis reaction to cleave the chemical bonds in PET plastic, ultimately degrading plastic and creating a method of converting plastic into terephthalic acid monomers.	
Help Received While my science teacher gave me access to our school's fume hood, all experimentation and research was my own and performed independently.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Kellen Lai	Project Number S0611
Project Title Observing the Double Diffusion of Salt and Sucrose	
<p style="text-align: center;">Abstract</p> <p>Objectives My objective is to build a model that can depict an image of the double diffusion occurring in the salt and sugar water solutions. The pictures from the model will then be observed to find the relationships when the concentration of each solution is changed.</p> <p>Methods Sucrose (table sugar), Salt, Acrylic Plexiglass, Scale, Wood and wooden rods(at least 2 sq ft., 2 cm diameter max), Cutting tools for wood and acrylic (Dremel, Saw), Laser, Camera, Mirror, Beakers, Syringe, Hot glue gun. Observing the shapes of the projection created by the model.</p> <p>Results The shapes start to become more pentagonal and even almost quadrilateral, with each shape occurring less and less frequently as the solutions mix over time. Once in the final stages (50-60 minutes), all the shapes are minimized so that less than half of the ones that were there in the beginning are left and most are more quadrilateral than before.</p> <p>Conclusions The sucrose water doesn't need to take more time to diffuse into the salt water even though it is more dense because the diffusion process isn't primarily dependent on the concentration of each solute.</p>	
Summary Statement I observed through the model that the double diffusion process wasn't changed even through altering the concentration of salt and/or sucrose.	
Help Received None, I researched, built, and observed a model of double diffusion.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Jacob Leeman	Project Number S0612
Project Title Trends in Catalytic Properties of Tetra-Ammonium-Based Post-Transitional Metal Chloride Deep Eutectic Solvents	
<p style="text-align: center;">Abstract</p> <p>Objectives This research project aims to find trends, in reactivity and in chain length, among similar deep eutectic solvents (DES) in order to design more catalytically efficient DESs. Currently, though there have been many isolated studies on the qualities of individual DES catalysts, there have been no studies that show trends in catalytic activity. This research will attempt to elucidate the relationship between physical properties of DES and their catalytic performance in biodiesel transesterification.</p> <p>Methods Six transesterification reactions of soybean oil and methanol which produce biodiesel and glycerol were run in parallel along with positive (sulfuric acid) and negative (no catalyst) controls. Six catalysts were prepared by combining three ionic compounds of different carbon-chain length, tetraethylammonium chloride (TEA), tetrapropylammonium chloride (TPA), and tetrabutylammonium bromide (TBA), and two metal chloride ligands (AlCl₃ and InCl₃).</p> <p>Results This study demonstrates that there are significant trends. AlCl₃ was overall more catalytically efficient than InCl₃. AlCl₃-TBA catalyzed 100%, AlCl₃-TPA catalyzed 65%, and AlCl₃-TEA catalyzed 95% of the oil to biodiesel reaction. InCl₃ which was much less efficient at InCl₃-TBA at 70 percent, InCl₃-TPA at 65 percent, and InCl₃-TEA at 49 percent efficiency. As a control, the sulfuric acid catalyzed reaction, the industry standard, was 60% complete at two hours. In addition, longer carbon chain length was correlated with higher catalytic effect. The AlCl₃-TBA was more effective than both the AlCl₃-TPA and AlCl₃-TEA (100 percent compared to 65 and 95 percent). InCl₃-TBA was more efficient than both InCl₃-TPA and InCl₃-TEA (70 percent compared to 65 and 49 percent).</p> <p>Conclusions The trends among type I (quaternary ammonium salts with metal halides) DES that can be exploited to design DES with greater catalytic effect. Primarily, the effect of chain length on catalytic effect is not well explored, yet increasing chain length clearly increases efficiency. A second effect is the increased effect of more reactive metal halide species, namely Al vs In. Furthermore, in larger scale applications, DES are significantly easier to separate compared to H₂SO₄ and other commonly used homogeneous catalysts; this is due to the physical properties of DES. In conclusion, this study has demonstrated that type I DES have carbon chain length trends in activity which should be further explored. Further studies should include explorations of aromaticity, phosphonium-based quaternary ions, other metal halides, and other catalyzed</p>	
Summary Statement I found trends in catalytic efficiency based on carbon chain length and metal ligand, among similar deep eutectic solvents (DES), which allows for improvement of DESs.	
Help Received Greg Murray of Schmahl Science Center helped scope out the project. Francine Farouz and Jeremy Jacquot, of the Nueva High School provided lab space, safety review, chemicals and support.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Benjamin Liu	Project Number S0613
Project Title A Novel Printing Methodology of 3D Inverse Opals from Free-Standing Crystalline Structures for Next-Gen Optical Sensing	
<p style="text-align: center;">Abstract</p> <p>Objectives Inverse opals (IOs) are currently limited to planar, discrete patterns. Although they boast promising applications, knowledge of their properties on a 3D scale is limited and no methods exist to print IOs directly from free-standing, crystalline templates. The three main objectives of this research are: 1) Characterize and study key factors related to the five-step 3D printing methodology for silk IOs; 2) Apply this understanding to novel techniques that enhance cross-linking and infiltration; 3) Functionalize optimized 3D IO structures into metal cation sensors to demonstrate biosensing applications.</p> <p>Methods Direct-write free-form assembly was used to assemble crystalline templates. Mechanical motors positioned with optical cameras controlled a lowering, heat-substrate stage. An upper syringe platform dispensed the colloidal solution onto a silicon wafer. The crystalline templates were infiltrated in various silk-water solutions, cross-linked in methanol, and etched in toluene in aluminum pans under a fume hood. A dessicator was used to facilitate vacuum infiltration and methanol vapor cross-linking. Optical and SEM images were taken after each printing stage to analyze target properties such as structural retention, feature homogeneity, and crystalline arrangements. After quantum dot doping, the functionalized towers were exposed to toxic copper chloride-water drops to observe fluorescent detection.</p> <p>Results Optimal parameters in assembly, infiltration, cross-linking, and etching were determined. A novel vacuum infiltration technique was created to enhance silk infiltration in crystalline templates, and a novel methanol vapor cross-linking method was developed to maximize structural retention in cross-linking. The optimized structures displayed target properties, and the doped structures successfully detected copper chloride at toxic levels in water.</p> <p>Conclusions We have extended IO applications into practical, 3D scales by developing a method to print directly from arbitrary 3D crystalline structures. The developed techniques can be applied to basic materials science research for cross-linking fragile materials and enhancing infiltration. The results reveal a promising path to incorporate the printing methodology into a breadth of scientific fields. Successful functionalization reveals that the structure can be used to detect hundreds of other contaminants in water with respective doping.</p>	
Summary Statement I developed a novel 3D printing methodology for inverse opals, features with extraordinary applications in biology, chemistry, mechanics, and demonstrated a new form of optical sensing using these structures through functionalization.	
Help Received Mr. Alvin Tan at the MIT Mechanosynthesis group trained me on using equipment, operating optical microscopes, and performing basic material science procedures such as spin-coating. He took scanning electron microscope images for me, answered questions, and assisted in interpreting results.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) David Morales-Zapien	Project Number S0614
Project Title Are Expiration Dates Real?	
<p style="text-align: center;">Abstract</p> <p>Objectives I wanted to determine the extent to which the expiration date of iron pills effected the iron content of the pills.</p> <p>Methods I performed a redox titration using potassium permanganate and sulfuric acid to determine the iron level in 5 different iron pills each with different expiration dates.</p> <p>Results The pills with the earliest expiration date had the least amount of iron but they were still legally potent. To be legally potent they had to have 90% of the original potency.</p> <p>Conclusions I concluded that the expiration date does not signal a point at which the medication is unsafe to take because the expired pill still had 90% of its original potency. My project can educate and ultimately save consumers lots of money all around the world.</p>	
Summary Statement Do expiration date really signal a point at which medications are unsafe to use	
Help Received Dr. Sidhu	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Anshul Narain	Project Number S0615
Project Title Developing Metal Electrodes to Replace ITO in Organic Thin Film Solar Photovoltaics	
<p style="text-align: center;">Abstract</p> <p>Objectives Develop a method to effectively replace Indium Tin Oxide (ITO) anodes with inexpensive Silver (Ag) anodes in thin film solar cells.</p> <p>Methods Used spin-coater to deposit polymer films on substrate. Measured % transmittance with a UV/Vis spectrometer. Used thermal evaporator to deposit metal anodes and cathodes in to devices. Measured current density vs. voltage with Keithley JV curve measurer. Analyzed data in MATLAB.</p> <p>Results With the conditions determined through the preliminary testing, the Silver anodes were able to effectively replace the ITO anodes in thin film solar photovoltaics by allowing the devices to function as diodes and abide by the predictions of the Child Langmuir Law. Similar charge mobility in devices developed with ITO and the devices I developed with Silver indicate comparable efficiencies as well.</p> <p>Conclusions The Silver anodes allowed for the devices developed to function effectively without the use of ITO. This means that Silver can be used as a viable alternative to ITO while reducing the cost by almost 13 times per unit mass.</p>	
Summary Statement I developed a method by which expensive Indium Tin Oxide anodes could be effectively replaced with inexpensive Silver anodes in organic thin film solar photovoltaics.	
Help Received I designed the method for replacing ITO with Silver myself with guidance from my lab mentor. My mentor also reviewed the validity of my procedures and results.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Laura Noronha	Project Number S0616
Project Title Z-Scheme Photocatalysis: A More Systematic Approach with alpha-Fe₂O₃@Au@P-SiO₂@Cu₂O Nanostructure	
Abstract Objectives Create a nanostructure using iron oxide nanorods (Fe ₂ O ₃), gold (Au), porous silica (P-SiO ₂), and cuprous oxide (Cu ₂ O) that mimics the Z-scheme mechanism for hydrogen production. Methods First synthesize FeOOH nanorods to be used as template. Apply cystamine solution to modify the surface so gold nanoparticles can be attached. Prepare gold nanoparticles and mix them with cys modified iron oxide template. The next step is to coat the FeOOH@Au with SiO ₂ . Once the silica is coated, the sample must be calcined to convert the iron oxide to its alpha form (hematite). Next, partially etch the silica to create a porous silica shell. Then, prepare the CuCl ₂ stock solution and react with NaOH and NH ₂ OH·HCl. Finally, mix with Fe ₂ O ₃ -Au-SiO ₂ solution to obtain Fe ₂ O ₃ -Au-SiO ₂ -Cu ₂ O. Results A standard photocatalytic chamber was used for the testing. Gas chromatography was utilized to measure the production of hydrogen and oxygen gases. Compared to the amount of hydrogen produced from Au, Cu ₂ O, Au@Cu ₂ O, or Fe ₂ O ₃ @Au@Cu ₂ O, hydrogen production proved most efficient with the alpha-Fe ₂ O ₃ @Au@P-SiO ₂ @Cu ₂ O z-scheme photocatalyst. More than three times the hydrogen was produced compared with the photocatalyst that did not have the porous silica, and about 16 times more was produced compared to using gold alone. Conclusions This z-scheme photocatalyst mimics photosynthesis by using two-light sensitive semi-conductors and a conductor (electron transport chain) to produce hydrogen and oxygen gas. The z-scheme structure enhances photocatalytic activity and is highly efficient in the production of hydrogen gas which can be used as a cleaner and more renewable source of energy.	
Summary Statement I created a photocatalyst that mimics the Z-scheme mechanism in the light reactions phase of photosynthesis. This structure enhances water splitting for hydrogen production.	
Help Received My mentor Rashed Aleisa from Dr. Yin's Lab in UCR helped me design the procedure based on available materials and equipment. TEM images were taken by my mentor.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Nicholas Perez	Project Number S0617
Project Title Facilitating Emergency Thermal Protection via an Integration of Materials Augmented by an Endothermic Process	
Abstract Objectives To extend the endothermic chemical reaction of ammonium nitrate by adding a hydrated polymer and alkaloid to create a survival shelter from a firetruck cab that will not exceed 37°C of heat transfer from a 300°C conductive heat source for 30min. Methods Tested various combinations of ammonium nitrate, hydrated polymer and alkaloid to convert conductive heat transfer into a cooling effect for cab. Tested different insulative materials individually to find the correct order to make interior panels. Once ideal combinations were found, created and tested prototypes with temperatures of up to 300°C for 30min. Recorded times and temperatures to find their insulation value and compared it against the current standard operating procedure. Test was designed to last 30min in a scenario that would have the user exposed to fully immersed flames. Independent variables: different grams of ammonium nitrate, different insulative fibers and alkaloids. Dependent variables: time of fire/heat resistance, amount of polymer and water. Controlled variables (constants): stovetop, aluminum pan, measurement tools (laser digital thermometer and digital thermometer probe), construction materials, and time exposed to flame. Results It was shown that one can create an endothermic gel, but at the cost of a drop in endothermic reaction time and temperature. The ideal way to extend the endothermic reaction is to find the right ratio of ammonium nitrate to water and maintain the separation of insulative materials. Conclusions The ratio of 1:1 ammonium nitrate to water provided the most efficient cooling effect. The most effective way to deliver the catalyst to the polymer and ammonium nitrate was through a hydrating bladder system. The final design used the US Forestry fire shelter as a reflective layer, ceramic fiber and a hydrated polymer as insulative layers, and an activated ammonium nitrate to convert the heat transfer into an endothermic reaction.	
Summary Statement To convert a firetruck cab into a survival shelter through the integration of materials augmented by ammonium nitrate s endothermic process.	
Help Received Mr. Steve Freers provided insight into chemical structures and processes of various materials. Mr. Henry Modregon assisted with experiments.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Kelly Pham	Project Number S0618
Project Title The Effect of pH on the Adsorption Capacity of Wool	
<p style="text-align: center;">Abstract</p> <p>Objectives The objective of this project is to investigate the effect of acidity on the dye sorption of the animal fiber wool.</p> <p>Methods Dyebaths of various vinegar concentrations were prepared, to which Red 40 dye was added, little by little. A spectrophotometer was utilized to find the absorbance of each dyebath at various the concentrations of dye to create a calibration curve, which is based on the principle defined by the Beer-Lambert Law. Microsoft Excel was used to find a calibration equation. This was repeated for each vinegar solution and for each trial (8 total trials). During the dyeing process, the spectrophotometer was used to find the absorbance of each dyebath in half-hour intervals. This data was plugged into each calibration equation to find the concentration of dye adsorbed, which was then used in an equation to find the adsorption capacity of each piece of wool.</p> <p>Results The data shows that the adsorption of dye by wool was more effective in dyebaths with a lower pH value. The adsorption capacity of wool was found to be directly related to the concentration of acid in the dyebath, rather than to the pH.</p> <p>Conclusions Higher adsorption capacity in wool indicates more efficient dyeing. Since wool adsorption capacity increases as pH of the dyebath decreases, it can be concluded that acidity and basicity of the dyebath can be manipulated to achieve better fabric coloring. The implications of this project are most applicable to the competitive textile industry, since understanding the relationship between pH and dye efficiency can allow for more cost-effective use of dyes. This project is also useful in transforming the textile industry into a more environmentally-friendly industry, since dyes used in the coloring process sometimes contain heavy metals which are difficult to eliminate.</p>	
Summary Statement This project explores the relationship between pH of the dyebath and efficiency of dye in fabric coloring.	
Help Received Mr. Paul Hunt provided materials and gave advice; family offered moral support	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) William Porayouw	Project Number S0619
Project Title Constructing Earth-Abundant Core Shell Plasmonic Photocatalysts for Hydrogen Production via Water Splitting	
<p style="text-align: center;">Abstract</p> <p>Objectives Currently, new alternatives for current greenhouse gases are of great interest, and hydrogen is a major player in the race for a new main source of fuel. Hydrogen can be produced through a photocatalytic water splitting process, and although titanium dioxide (TiO₂) is a well known photocatalyst, factors such as its high recombination rate and an absence of a visible light absorption peak hinders its performance. By constructing transition metal-metal oxide core shell nanostructures (CSNs) that introduce copper (Cu) as a co-catalyst core, these issues with the semiconductor material can be addressed.</p> <p>Methods To create efficient photocatalysts for hydrogen production, synthesis methods for earth abundant core shell Cu@TiO₂ nanostructures were designed. In order to construct these CSNs, a Cu core was synthesized through a modified sol-gel method with Hexamethylenediamine (HDA) as a capping agent and glucose (C₆H₁₂O₆) as a reducing agent, and size and morphology was controlled to create uniform nanostructures. Then, titanium isopropoxide (TIP) was hydrolyzed into TiO₂ with a diethanolamine (DEA) base catalyst, and coated on the Cu core with the assistance of HDA as a surfactant.</p> <p>Results The CSNs were characterized through TEM and SEM imaging, UV-vis spectroscopy, and a photocatalytic test based on light irradiation. After 5 hours in a photocatalytic chamber, it was found that industrial grade TiO₂ produced the least amount of hydrogen, while prepared hollow TiO₂ produced twice as much as the industrial type, and Cu@TiO₂ produced the greatest amount of hydrogen, about 100 times as much as industrial TiO₂.</p> <p>Conclusions Cu successfully accelerated the semiconductor-light reactions by expanding the absorption spectra of TiO₂ and optimizing its plasmonic resonance property, lowering the band gap, and reducing recombination. In addition, Cu, is a cost-effective and earth-abundant potential co-catalyst, which makes the metal convenient for large scale manufacturing. Therefore, the Cu@TiO₂ CSNs proved to be efficient photocatalysts that should be further explored.</p>	
Summary Statement I constructed novel core shell nanostructures that utilized titania as a semiconductor shell and copper as a plasmonic core in order to optimize photocatalytic efficiency.	
Help Received This project was completed at the Yin Lab at the University of California, Riverside. Thank you to Dr. Yadong Yin and graduate student Yubo Tan, who offered mentorship and guidance throughout the duration of this project.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Mia Isabel Rodrigo	Project Number S0620
Project Title Determining the Relationship between Oxidation Time for Wine and the Amount of Sulfite Remaining	
Abstract Objectives Understanding the chemistry of sulfites is necessary in viticulture and enology. The use of sulfite is important as it is one of the most safest and widely used preservative (Hanna Instruments) throughout the entire food and beverage industry and should consequently be studied as it has some severe effects on people. I hope to determine the relationship between the time allowed for wine to oxidize and the amount of remaining sulfite through filtration. Methods Transfer wine containing sulfite to a 250 mL flask. Ensure that the bottle is closed right away to avoid additional oxidation occurring in the other samples Acidify wine for one hour by placing on stir plate and using magnet. Repeat four times successively. (Label 2-6) While waiting for the wine to acidify, label and take masses of 15 pieces of filter paper. Transfer 50 mL of wine oxidized for 6 hours into 3 250 mL beakers and add 2 mL of 0.2 M NaOH to increase the pH. Add 2 mL of 0.6 M strontium chloride to mixture. Place funnels into a corresponding beaker and fold the filter paper in such a way where no precipitate will escape and pour the mixture through the funnel. Ensure that you rinse the flask with distilled water into the funnel and repeat for the remaining 14 flasks. Leave flasks to dry. Once a couple of hours go by move the filter paper to a test tube rack. Once all the filter papers are completely dry, record the mass. Complete calculations to find the remaining amount of sulfite. Results There is an inverse correlation between the amount of time the wine is exposed and the amount of sulfite remaining in a linear fashion. This correlation is fairly strong as demonstrated by the 0.898 R ² value. Conclusions My hypothesis was proven correct as my experiment demonstrated that there s an indirect correlation between the amount of sulfite remaining and the level of oxidation. As time progresses when the wine is exposed to air, more oxidation is taking place. Free SO(2) readily reacts with oxygen to inhibit the the wine from being oxidized into ethanoic acid by bonding to the ethanol molecule. The amount of sulfite decreases the longer the wine is exposed to air because more SO(2) binds to the ethanol molecules.	
Summary Statement I used filtration to determine the relationship between the time allowed for wine to oxidize and the amount of sulfite remaining.	
Help Received I asked my teacher for clarification regarding how ksp relates to pH as the concepts are not covered in our curriculum for IB.	



CALIFORNIA SCIENCE & ENGINEERING FAIR 2019 PROJECT SUMMARY

Name(s) Zachary Schneider	Project Number S0621
Project Title Phi of Black Tea and Green Tea	
<p style="text-align: center;">Abstract</p> <p>Objectives In this experiment, increasing steep times were used to analyze the pH of black tea and green tea. A pH probe was used to record pH.</p> <p>Methods Beakers, flask, pipette, hot plate, buffer capsules, tea, pH sensor, temperature probe, pH paper. Measured minutes of steep using stopwatch for 5 different pH measurements of black tea and green tea.</p> <p>Results As minutes of steep increased for black tea, the pH measurement decreased - tea became more acidic - from approximately 5.50 at 1 minute to about 5.20 at 5 minutes of steep. As minutes of steep increased for green tea, the pH measurement decreased - tea became more acidic - from approximately 5.80 at 1 minute to about 5.60 at 5 minutes of steep.</p> <p>Conclusions Repeated trials with black tea and green tea revealed that both teas became more acidic as the teabag was steeped for a longer amount of time. It is concluded that using a pH sensor and increasing steep times are an effective way of measuring the acidity of black and green tea.</p>	
Summary Statement Using a pH sensor, I measured the pH values of black tea and green tea at 1, 2, 3, 4, and 5 minutes of teabag steep.	
Help Received Except for the buffer solutions, I designed and carried out my experiment by myself. My chemistry teacher helped me by teaching me how to create buffer solutions.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Rishi Shah	Project Number S0622
Project Title Analysis of UV Photodegradation of Moxifloxacin in Water Samples	
Abstract Objectives Moxifloxacin, a fluoroquinolone antibiotic, is an emerging water contaminant that is poorly removed by common water treatment processes. The objective of this research was to understand the degradation of moxifloxacin by direct UV photolysis and advanced oxidation processes involving UV/H(2)O(2) and UV/H(2)O(2)/Fe(II). Methods 0.15mM Moxifloxacin samples were radiated for 60 minutes in a UV reactor. 0.5 mL samples were taken at set timepoints during the radiation for analysis. Bovine liver catalase was added after every set timepoint for the UV/H(2)O(2) and UV/H(2)O(2)/Fe(II) experiments to prevent dark oxidation. All the samples were analyzed through high performance liquid chromatography (HPLC). Results Direct UV irradiation resulted in little to no degradation of moxifloxacin. UV/H(2)O(2) and UV/H(2)O(2)/Fe(II) treatments both resulted in moxifloxacin almost entirely degrading in the water samples. UV/H(2)O(2)/Fe(II) treatment resulted in faster degradation kinetics ($k = 0.0782$) compared to UV/H(2)O(2) treatment ($k = 0.0577$). Conclusions Treatment of water samples through advanced oxidation processes resulted in substantial degradation of moxifloxacin. These results suggest potential for photoinduced removal of moxifloxacin in water treatment plants. However, more research needs to be done in order to understand the products of degradation.	
Summary Statement I examined the degradation of moxifloxacin in water through UV, UV/H(2)O(2) and UV/H(2)O(2)/Fe(II) treatments.	
Help Received Dr. Hanoz Santoke from California State University Bakersfield Department of Chemistry and Biochemistry granted me access to his laboratory and the CSUB instrument room. Dr. Santoke also provided me initial guidance for using professional laboratory equipment and performing data acquisition.	



**CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY**

Name(s) Harishankar Subramanian	Project Number S0623
Project Title Synthesis of Luteolin as the Flavonoid Backbone of Hydnocarpins: A Potential Anti-Cancer Agent	
Abstract Objectives The goal of this project was the synthesis of Luteolin (3',4',5,7, tetrahydroxy flavone), from a commercially available flavonoid. Methods I conducted a sequence of three reactions. Each reaction was attempted as a single pot step with stoichiometric quantities and overnight reflux using specific reagents and solvents. Post reaction, each step included extraction of the end product & removal of the solvent. We used Proton NMR (Bruker 300MHz) spectrum to confirm the purity of the product from each of the reaction steps. Results I was able to complete all reactions successfully. The reaction sequence, extraction, purification of product, and procedures for removal of solvents were established. Conclusions The main objective was to produce a repeatable scheme for the reactions. Through this project, I have learned to set-up reactions to synthesize complex molecules, understood the three reaction steps, and developed skills to purify and characterize products through NMR spectroscopy.	
Summary Statement Synthesis of luteolin, the flavonoid backbone for racemic mixtures of Hydnocarpins, with potential anti-proliferative properties against cancer cells.	
Help Received Dr. Qiao-Hong Chen gave me the opportunity to be a part of her research group at California State University, Fresno. Mr. Pravien Rajaram guided me on the daily reaction set-ups, conduct the extractions & use the NMR equipment. My dad helped set up my board presentation.	